UL 970

STANDARD FOR SAFETY

Retail Fixtures and Merchandise Displays

UL Standard for Safety for Retail Fixtures and Merchandise Displays, UL 970

First Edition, Dated February 20, 2020

Summary of Topics

This first edition of the Standard for Retail Fixtures and Merchandise Displays, UL 970, covers non-refrigerated or heated commercial displays and other case goods used in retail establishment, including bakeries and restaurants. The products are used in accordance with the National Electrical Code, ANSI/NFPA 70. They are intended for dry, damp, or wet locations. These displays include both electrified and non-electrified products.

The requirements are substantially in accordance with Proposal(s) on this subject dated September 13, 2019 and December 6, 2019.

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Standard for Retail Fixtures and Merchandise Displays

First Edition

February 20, 2020

This ANSI/UL Standard for Safety consists of the First Edition.

The most recent designation of ANSI/UL 970 as an American National Standard (ANSI) occurred on February 7, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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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PART 1 – ALL DISPLAYS

INTRODUCTION

1 Scope

1.1 These requirements cover non-refrigerated or heated commercial displays and other case goods used in retail establishment, including bakeries and restaurants. The term display(s) will be used to refer to all of the types of products covered by this standard. The products are used in accordance with the National Electrical Code, ANSI/NFPA 70. They are intended for dry, damp, or wet locations. These displays include both electrified and non-electrified products and may include, but are not limited to:

a) Shelving units (Gondolas);

b) Merchandise kiosks (such as the mini-stores in the middle of a mall);

c) Point of Sale (POS);

d) Motorized displays;

e) Hanging displays;

f) Wall systems;

g) Showcases;

h) Display Cases;

i) Cash Wraps, check-out stands (motorized and non-motorized);

j) Temporary Displays; and

k) Product platforms.

1.2 These requirements cover products rated 600 V ac or less, including those powered by primary or secondary batteries.

2 Glossary

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

2.2 ACCESSIBLE PART – A part located so that it is able to be contacted by a person, either directly or by means of the probe illustrated in Figure 14.1.

2.3 ACCESSORY – An optional part that electrically and/or mechanically interfaces with the basic displays and is intended to be attached to the displays by the user or installer. Subassemblies field assembled to form the basic displays are not accessories.

2.4 APPLIANCE CONNECTOR – The mating part of the appliance coupler integral with, or intended to be attached to, the power supply cord.

2.5 APPLIANCE COUPLER – A means of enabling the connection and disconnection at will, of a cord to an appliance or other equipment. It consists of two parts: an appliance connector and an appliance inlet.

2.6 APPLIANCE INLET – The mating part of the appliance coupler integrated or incorporated in the appliance or equipment or intended to be fixed to it.

2.7 APPURTENANCE – Accessory objects on a displays such as a door, drawer, or a sliding work surface.

2.8 BATTERY – General term for:

a) Any single energy cell; or

b) A group of energy cells connected together either in a series and/or parallel configuration.

May be ready for use or may be an installed component. The term "battery(ies)" shall refer to single or multi-cell batteries.

2.9 BATTERY PACK – A battery which is ready for use, contained in a supplemental rigid enclosure, with or without protective devices.

2.10 BATTERY, PRIMARY – A battery that can only be discharged once. It is not designed to be electrically recharged and must be protected from a charging current.

2.11 BATTERY, SECONDARY – A battery that is intended to be discharged and recharged many times.

2.12 BATTERY, TECHNICIAN-REPLACEABLE – A battery intended for use in a product in which service and replacement of the battery will be done only by a person who has been trained to service and repair the product.

2.13 BATTERY, VENTED – A lead acid storage battery the electrodes of which are made of lead and the electrolyte consists of a solution of sulfuric acid in which the products of electrolysis and evaporation are allowed to escape freely to the atmosphere. These batteries have commonly been referred to as flooded or wet.

2.14 BELLOWS – A telescoping guard that hinders someone from contacting a hazardous part.

2.15 BRANCH CIRCUIT – The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).

2.16 BRANCH CIRCUIT, MULTIWIRE – A branch circuit that consists of two or more ungrounded conductors that have a voltage between them, and a grounded conductor that has equal voltage between it and each ungrounded conductor of the circuit and that is connected to the neutral or grounded conductor of the system.

2.17 CASH WRAP (POINT-OF-PURCHASE or CHECKOUT STAND) – Location where the customer pays for the product being purchased.

2.18 CELL, COMPONENT – The basic functional electrochemical unit containing an assembly of electrodes, electrolyte, container, terminals, and usually separators, that is a source of electrical energy by direct conversion of chemical energy. May be ready for use or may be provided as component of battery pack.

2.19 CHANNEL – A passage intended for the routing and holding of communication wiring, low-voltage wiring, and wiring having functional insulation plus a layer of supplementary insulation. A channel is not required to provide mechanical protection, and is not evaluated as an enclosure.

2.20 CHECKOUT STAND – See the definition of Cash Wrap in 2.17.

2.21 CLASS 2 CIRCUIT – A circuit having power and voltage limitations as defined in Article 725 of the National Electrical Code, ANSI/NFPA 70. Such a circuit shall comply with:

a) The Standard for Low Voltage Transformers – Part 3: Class 2 and 3 Transformers, UL 5085-3; or

b) The Standard for Class 2 Power Units, UL 1310.

2.22 COMMERCIAL – A place in which business is transacted, such as an office building, factory, warehouse, retailer, or similar location, and which is not a residence.

2.23 CONNECTOR, UNIT-TO-UNIT MECHANICAL – An assembly that is used to connect two or more adjacent units for the purpose of providing mechanical support between the units.

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

2.25 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 fire, electric shock, or injury to persons during normal or abnormal operation of the end product is considered an auxiliary control.

2.26 CONTROL CIRCUIT – A system of components that may include programmable logic devices other than a thermal protector or a motor current protector that has the ability to detect the condition of a display's operation or that controls a display function.

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

2.28 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 reduce the risk of fire, electric shock, or injury to persons, is considered an operating control.

2.29 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. (During the testing of the protective control/circuit, the protective functions are verified under normal and single-fault conditions of the control.)

2.30 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.

2.31 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.

2.32 CORD CONNECTOR (outlet) – A female contact device that is wired or molded on flexible cord and intended to be installed as part of a display's wiring system to supply current to utilization equipment.

2.33 CRITICAL COMPONENTS – Any component that if changed may have an effect on the safety or performance of the displays or that is restricted by the construction requirements.

2.34 DEAD METAL PART – Any metal part that is not intended to carry current.

2.35 DIRECT AND INDIRECT CONTACT OF LIVE PARTS – A non-metallic part is considered in direct contact of a live part when it is touching the live part or within 1/32 inch (0.8 mm) of the live part. Indirect contact is when a non-metallic part is supporting another non-metallic material that is in direct contact.

2.36 DISPLAY – A product that is intended to dispense, display or store merchandise and may include customer interaction. For this standard it may include any of the items listed in 1.1.

2.37 DISPLAY CASE – See the definition of Showcase in 2.76.

2.38 DISPLAY ELECTRICAL TYPES:

a) FIXED DISPLAYS – Intended to be permanently connected electrically to a source of supply and the building.

b) PORTABLE DISPLAYS – A small display that meets all of the following:

1) Not secured to the building structure unless provided with a securement means that allows the displays to be removed without the use of tools;

2) Connected electrically to an electrical source of supply with a power supply cord and plug; and

3) Likely to be frequently relocated due to its small size and weight (A product that allows an average person to pick it up without tools or equipment. A mass exceeding 40 lbs (18 kg) is not generally considered to be portable.)

c) STATIONARY DISPLAYS:

1) Connected electrically to an electrical source of supply with a power supply cord and plug; and

2) Unlikely to be frequently relocated due to size, weight or configuration or intended to be fastened in place requiring tools for removal.

2.39 DISPLAY SUPPORT SYSTEM – A system of components intended to secure a display to the building or other structure.

2.40 DISPLAY TYPES:

a) Permanent – Displays intended to be in use more than 90 days.

b) Temporary – Displays intended to be in use not more than 90 days.

2.41 ENCLOSURE – An enclosure that serves as an electrical and mechanical enclosure.

2.42 ENCLOSURE, ELECTRICAL – That part of the product that:

a) Renders inaccessible all or any parts of the equipment that may otherwise present a risk of electric shock; and/or

b) Retards propagation of flame initiated by electrical disturbances occurring within.

2.43 ENCLOSURE, MECHANICAL – A part of the equipment intended to reduce the risk of injury due to mechanical and other physical hazards.

2.44 ENTRAPMENT – An area on the display that has the potential for causing personal injury to the user or anyone near the display. It is presumed that children or people with cognitive disabilities are anticipated to be present, but the displays are locked out and only operated by a trained person.

2.45 ENVIRONMENTAL LOCATIONS:

a) DAMP – An exterior or interior location that is normally or periodically subject to condensation of moisture in, on, or adjacent to, the display, and includes partially protected locations.

b) DRY – A location not normally subject to dampness, but may include a location subject to temporary dampness, as in the case of a building under construction, provided ventilation is adequate to prevent an accumulation of moisture.

c) WET – A location in which water or other liquid can drip, splash, or flow on or against the display.

2.46 FIELD-WIRING TERMINAL – A terminal to which a conductor is intended to be connected in the field.

2.47 FURNITURE POWER DISTRIBUTION UNIT – An outlet assembly that complies with the Standard for Furniture Power Distribution Units, UL 962A.

2.48 GLASS, SHEETS – A glass sheet, usually formed from sheet stock, the overall shape of which is essentially flat. The sheet can have a slight curvature or bend, and the surface may be smooth or textured.

2.49 INSULATION, BASIC – Insulation applied to live parts to provide basic protection against electric shock.

2.50 INSULATION, SUPPLEMENTARY – A separate layer of insulation that is provided in addition to the basic insulation to reduce the risk of electric shock in the event of breakdown of the basic insulation.

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

2.52 KIOSK – A small open-fronted cubicle from which newspapers, refreshments, tickets, and other types of merchandise is sold.

2.53 LEAKAGE CURRENT – All currents, including capacitively coupled currents that flow through a person upon contact between accessible conductive surfaces of a product and ground or other accessible surfaces of the product.

2.54 LIMITED POWER SOURCE (LPS) – An isolated limited power source is as defined in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, and shall comply with the requirements of UL 60950-1.

2.55 LINE-OF-SIGHT – The ability to see the displays so that the user can observe the displays is moving to make sure that it will not harm anyone in the area and usually within 20 feet (6 m) of the unit.

2.56 LINE-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 600 V and having circuit characteristics in excess of those of a low-voltage circuit.

2.57 LIVE PART – Any part where current is flowing.

2.58 LOADING:

a) FULLY LOADED – Where the display has the normal test load on the product.

b) PARTIALLY LOADED – The display is partially loaded. It may have a load anywhere greater than zero (unloaded) or less than the complete test load (Fully Loaded).

c) UNLOADED – Where the display has no load being held by the product.

2.59 LOADS, MECHANICAL:

a) ABNORMAL – A foreseeable misuse of loading that is beyond the rated load.

b) RATED – The loading or force intended for normal use as defined by the manufacturer.

2.60 LOCKED-ROTOR – The armature or rotor is prevented from rotating.

2.61 LOW-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 30 volts alternating current (42.4 peak) open circuit supplied by a primary battery, by a Class 2 transformer, or by a combination of a transformer and a fixed impedance that as a unit, complies with all performance requirements for a Class 2 transformer. A circuit derived from a line-voltage circuit by connecting a resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be a low voltage circuit.

2.62 LOW VOLTAGE LIMITED ENERGY (LVLE) – A circuit supplied by a source with no direct electrical connection between input and output, such as provided by a transformer or optical isolator, and with output parameters as follows: source with a maximum output voltage of 42.4 V peak ac (30 V rms) or 60 V dc; and a maximum output current limited to:

a) Maximum 8 amps for 0 – 42.4 V peak ac, or 0 – 30 V dc; or

b) 150/V amps, for a voltage between 30 – 60 V dc.

Measurements for determining LVLE circuit status shall be in accordance with the requirements in 63.2, Determination of Low-Voltage, Limited-Energy Circuit Status. LVLE includes Class 2 and LPS circuits.

2.63 OUTLET (RECEPTACLES):

a) CONVENIENCE – A female connector of one of the configurations covered in the Standard for Wiring Devices – Dimensional Requirements, ANSI/NEMA WD6 that is provided for the connection of an unknown small appliance, a work light, or similar product.

b) DEDICATED – A female connector of one of the configurations covered in the Standard for Wiring Devices – Dimensional Requirements, ANSI/NEMA WD6 that is provided for the connection of a known small appliance, a work light, or similar product that is normally provided with the product or in the field, such as a cash register.

2.64 POINT-OF-PURCHASE – See definition of Cash Wrap in 2.17.

2.65 POWER SUPPLY, REMOTE – A power supply that is not located near the display. It is usually in an equipment room away from the display.

2.66 PRESSURE-RELIEF DEVICES – A device used to control or limits the pressure in a system or vessel.

2.67 RACEWAY – An enclosure (See 2.41) that is intended specifically for the holding and routing of wiring either line voltage or communication and low-voltage with the proper separation between wiring of different voltages.

2.68 RELOCATABLE POWER TAP (RPT) – An outlet assembly that complies with the Standard for Relocatable Power Taps, UL 1363, and is considered for temporary use.

2.69 REMOTELY CONTROLLED – The ability to control a display that is out of sight of the operator.

2.70 RETROFIT KIT – In the context of these requirements, is an accessory that includes all component parts needed, including instructions, for converting a light source from one type to another, changing graphics, or shelving.

2.71 RFID – Radio-frequency identification.

2.72 RISK OF ELECTRIC SHOCK – A risk of shock is considered to exist at parts accessible to the user or operator in a normally dry location during the intended use or servicing if the voltage exceeds 42.4 Vac peak (the peak voltage of a 30-V ac sine wave), 60 V dc and in a normally wet location if the voltage exceeds 21.2 V ac peak (the peak voltage of a 15-V ac sine wave), 30 Vdc and the available current exceeds the leakage current levels specified in the Leakage Current Test, Section 46.

2.73 RISK OF FIRE – A risk of fire is considered to exist at a component part or assembly if an investigation shows that the supply for such part or assembly is capable of delivering a power of more than 15 W into an external resistor connected between the points in question and any return to the power supply.

2.74 SAFETY CIRCUIT – A control circuit designed to guard against or mitigate risk of fire, shock or personal injury.

2.75 SAFETY EXTRA LOW VOLTAGE (SELV) CIRCUIT – An isolated secondary circuit that under normal operating conditions and single fault conditions provides a voltage that is 30 V rms (42.4 V peak) or 60 V dc or less. The current may exceed Class 2 limitations. These circuits are derived from a source evaluated to the SELV requirements in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, for the application of these requirements.

2.76 SHOWCASE (DISPLAY CASE) – An enclosed cabinet like a jewelry or make-up counter intended to display merchandise.

2.77 SMART DEVICE – A device that has the ability to run software such as a smart phone.

2.78 SECURITY LOCKOUT DEVICE – A device that prevents unauthorized users from operating the equipment, such as a lock and key, or a keypad with a code.

2.79 SUB-ASSEMBLY – An individual component or a group of components that when all of the sub-assemblies are combined form the completed display. Sub-Assemblies are normally used when the sub-assemblies are shipped from different manufacturing locations and are assembled in the field by the user or installer.

2.80 TIP OVER – The condition where the unrestricted unit will not return to its normal upright position.

2.81 UPHOLSTERED DISPLAY – A display that is provided with coverings, padding, webbing and/or springs, which can be used as a support for the body of a human being, or his or her limbs and feet when sitting or resting in an upright or reclining position.

2.82 USE:

a) ABNORMAL USE – Foreseeable and likely misuse of a product when the instructions are not followed.

b) NORMAL USE – The intended function applied by the user or operator utilizing the installation and operation instructions for the display.

2.83 VENT or VENTED – A condition that occurs when the battery or cell releases excessive internal pressure in a manner intended by design to preclude rupture, explosion or self-ignition.

2.84 VIDEO MOUNTING SYSTEM TYPES:

a) ADJUSTABLE MOUNT – A mounting system designed with components that may be adjusted once, infrequently or requires a tool be used for adjustment and is intended to support the video display in a fixed position after assembly and installation.

b) ARTICULATING MOUNT – A mounting system intended to allow active movement, adjustment, and repositioning, after installation.

c) MONITOR ARM – A device identified to support a computer video display that is in turn supported by or secured to a desk or table.

2.85 WORKING PRESSURE – The maximum system pressure measured during normal operating conditions. When more than one pressurized system is provided the display is capable of having multiple working pressures.

2.86 WORK SURFACE – A horizontal surface used to perform tasks and/or for storage space.

3 Components

3.1 General

3.1.1 Except as indicated in 3.1.2, a component of products covered by this standard shall comply with the requirements for that component. See Annex A for a list of standards covering components used in the products covered by this standard, but is not all inclusive.

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

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard; or

b) Is superseded by a requirement in this standard.

3.1.3 A component shall be used in accordance with its rating established for the intended conditions of use. Intended use also includes how the component will be used. For instance, a portable power supply shall not be used on a stationary or fixed display unless it can still be considered portable, which means that it can be easily disconnected from the power source and removed.

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

3.1.5 Equipment in a LVLE circuits shall comply with the safety requirements of a standard applicable to the equipment type. Examples of equipment and applicable Standards include:

a) Information, communication or audio/video product:

1) Standard for Audio, Video, and Similar Electronic Apparatus-Safety Requirements, UL 60065.

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

3) Standard for Safety for Audio/video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

b) Wireless charging pad:

1) Standard for Induction Power Transmitters and Receivers for Use with Low Energy Products, UL 2738.

c) Luminaire:

1) Standard for Low Voltage Lighting Systems, UL 2108.

2) Standard for Portable Electric Luminaires, UL 153.

Exception No. 1: LED Strips, LEDs on a printed wiring board or conductive strip, and dimmers used in LVLE circuits shall comply with the requirements in this Standard.

Exception No. 2: Electrical connectors and switches used in LVLE circuits shall comply with the requirements in this Standard.

Exception No. 3: Bluetooth controls shall comply the requirements in this Standard.

3.2 Batteries

3.2.1 General

3.2.1.1 The battery compartment of a display or any accessory, such as a wireless control, incorporating one or more replaceable coin cell batteries of lithium technology shall comply with the Standard for Products Incorporating Button or Coin Cell Batteries of Lithium Technologies, UL 4200A, if the batteries have dimension of:

a) Diameter of 1.25 inch (32 mm) or less; and

b) Height that is less than its diameter.

3.2.1.2 Displays incorporating primary (non-rechargeable) batteries that are limited to a maximum of 15 watts total combined power under any condition of operation (see Section 63, Circuit Power / Voltage Limit Measurement Tests) and that meet the following requirements are not subjected to the performance tests:

a) AAAA, AAA, AA, C, D, or 9 V standardized single cell battery configurations; and

b) Are of a zinc-carbon, zinc-chloride, alkaline/manganese, or silver-oxide type composition.

3.2.1.3 The process of installing or removing a battery from a display or a remote control shall not cause the display to operate in a manner that may cause personal injury.

3.2.1.4 Safe operation of the display shall not be dependent upon the condition of the battery (ies) or stored power in the battery(ies) or battery circuit.

3.2.1.5 Batteries of a type other than specified in 3.2.1.2 shall comply with the requirements of the Standard for Household and Commercial Batteries, UL 2054, and if of the lead acid storage battery type, shall additionally comply with the Pressure Release Test, Flame Arrester Vent Cap Tests in the Standard for Standby Batteries, UL 1989.

3.2.1.6 A battery shall be located and mounted so that the terminals of cells will be prevented from coming into contact with terminals of adjacent cells unless designed to do so or with metal parts of the battery compartment as the result of shifting of the battery. Cells constructed of conductive material shall be installed in trays of nonconductive material.

3.2.1.7 A battery shall be protected by an enclosure in accordance with 12.5 – 12.9.

3.2.2 Battery chargers and circuits

3.2.2.1 A battery charging circuit integral to the display, a battery charger supplied with the display, or available as an accessory to the display operating at a Class 2 or LPS power output level shall comply with the appropriate requirements. See 2.21 and 2.54, respectively.

3.2.2.2 A battery charging circuit integral to the display, a battery charger supplied with the display, or available as an accessory to the display operating at above a Class 2 or LPS power output level shall comply with the requirements in the Standard for Power Units Other Than Class 2, UL 1012 and the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1.

3.2.3 Non-replaceable batteries

3.2.3.1 A display provided with batteries that are not intended to be replaced by the user shall be located within the display enclosure and be non-accessible to the user.

3.2.4 Technician-replaceable batteries

3.2.4.1 Batteries that are only to be replaced by trained technicians shall be marked as indicated on or adjacent to the battery(ies) with a WARNING statement that service and replacement of the battery shall only be done by a person who has been trained to service and repair the product (see 76.4). The same WARNING statement shall be provided in the instruction manual (see 86.6).

3.2.5 Battery compartments

3.2.5.1 A battery compartment with replaceable batteries shall have no accessible contact with batteries, internal wiring or circuits in excess of Class 2 power and isolation. Accessibility is determined by the requirements in Section 14, Accessibility of Uninsulated Live Parts and Film-Coated Wire.

Exception: A battery compartment that allows access to batteries, internal wiring, circuits and components other than a Class 2 circuit shall:

a) If cord and plug connected – be provided with a Caution Marking (76.2), to disconnect all sources of power before opening the compartment. A circuit shall discharge any accessible electrical components in the battery compartment within 2 seconds; other than the battery; or

b) For a permanently connected display – be provided with an interlock device that deenergizes and discharges any accessible electrical components within 2 seconds in the battery compartment; other than the battery; or

c) For a permanently connected display – be provided with a disconnect switch that can be locked in the off position. When placed in the off position any accessible electrical components in the

battery compartment shall be discharged within 2 seconds; other than the battery. Adjacent to the disconnect switch a Caution Marking (76.2) to disconnect all sources of power before opening the compartment.

3.2.5.2 A battery compartment provided with replaceable batteries shall comply with the requirements in 12.3, Mechanical Enclosure and Guards – Mechanical Considerations.

3.2.5.3 A display that utilizes a battery that contains liquid or gel electrolyte shall be provided with a tray that is capable of retaining any liquid that could leak as a result of internal pressure build-up in the battery.

3.2.5.4 The battery tray capacity shall be at least equal to the volume of electrolyte of all the cells of the battery.

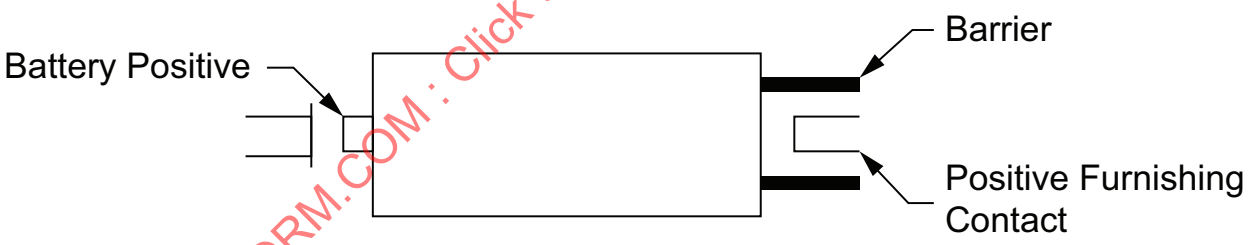
3.2.5.5 An enclosure or part of an enclosure that also serves as a compartment for a rechargeable vented battery shall be provided with ventilated openings to permit dispersion of gases from the battery.

3.2.5.6 Battery polarity installation shall be shown in diagrammatic form in the battery compartment. Black conductor insulation shall be used for negative battery leads and red conductor insulation shall be used for positive battery leads if visible to the user or service person.

3.2.5.7 A battery holder or compartment where more than one AAAA, AAA, AA, C and D cells and other battery configurations can be inadvertently installed in reverse polarity shall be provided with a means that prevents the negative battery terminal from making contact with the intended positive contact in the display battery compartment; for example, a non-conductive barrier. See Figure 3.1.

Figure 3.1

Battery Shown – Installed Reverse Polarity



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3.2.6 Battery circuits

3.2.6.1 A current carrying conductor or component in the battery circuit shall be capable of carrying the full short circuit current of the battery without risk of fire or electric shock.

3.2.6.2 One of the following methods shall be used to determine compliance with 3.2.6.1:

a) Suitable overcurrent protective devices rated for the available current shall be installed in the circuit; or

b) Compliance with the requirements as outlined in Section 57, Abnormal Tests..

3.2.7 Battery charging

3.2.7.1 A display with replaceable (secondary) rechargeable batteries where it is possible to install the batteries in reverse polarity and when so doing completes the battery circuit shall be provided with back feed protection. The back feed protection may be either integral with the battery charger or the battery charging circuit within the display.

3.2.7.2 The output characteristics of a battery charging circuit shall be compatible with its rechargeable battery. The display shall be provided with technical documentation on the compatibility of the rechargeable (secondary) battery with the battery charging circuit.

3.3 Capacitors

3.3.1 A capacitor provided as a part of a capacitor motor and a capacitor connected across-the-line, such as a capacitor for radio-interference elimination or power-factor correction, shall be housed within an enclosure or container that protects the plates against mechanical damage and that reduces the risk of the emission of flame or molten material resulting from malfunction or breakdown of the capacitor. The container shall be of metal providing strength and protection not less than that of uncoated steel having a thickness of 0.020 inch (0.51 mm).

Exception: The individual container of a capacitor is able to be of sheet metal less than 0.020 inch (0.51 mm) thick or is able to be of material other than metal when the capacitor is mounted in an enclosure that houses other parts of the display. The enclosure must be rated for use in enclosing live parts.

3.3.2 When the malfunction or breakdown of a capacitor results in a risk of fire, electric shock, or injury to persons, thermal or overcurrent protection shall be provided in the display to reduce the risk of such a condition.

3.3.3 A capacitor connected from one side of the line to the frame or enclosure of a display shall have a capacitance rating of not more than 0.10 microfarad.

3.3.4 A display that is intended to be controlled by or operated in conjunction with a capacitor or a combination capacitor-and-transformer unit shall be supplied with such capacitor or unit.

3.3.5 Under both normal and abnormal conditions of use, a capacitor employing a dielectric medium more combustible than askarel shall not result in a risk of electric shock or fire and shall be protected against expulsion of the dielectric medium. A capacitor complying with the requirements for protected oil-filled capacitors in the Standard for Capacitors, UL 810, meets the intent of this requirement.

3.4 Connectors

3.4.1 A connector shall comply with one of the following:

a) The Standard for Attachment Plugs and Receptacles, UL 498;

b) The Standard for Insulated Multi-Pole Splicing Wire Connectors, UL 2459;

c) The Standard for Component Connectors for Use in Data, Signal, Control and Power Applications, UL 1977, provided the connector meets voltage and current requirements for the intended load and the material RTI is suitable for the maximum temperature on the connector developed in the Temperature Test. UL 1977 connectors shall meet minimum flammability class

rating of HB, V-2, V-1, V-0, VTM-2, VTM-1, or VTM-0 and be suitable for direct contact of live parts (Section 20, Materials in Direct and Indirect Contact of Live Parts);

d) A connector located in a SELV circuit that during the Temperature Test, Section 49, does not exceed 50° C, shall be manufactured from a polymeric material with a minimum electrical RTI of 70°C, and complies with Section 19, Spacings, for materials in direct contact of live parts; or

e) Any connector may be used located in a LVLE circuit that during the Temperature Test does not exceed 50°C.

3.4.2 A display with multiple LVLE supply or load connections where interconnection could cumulatively exceed LVLE limits shall be provided with polarized connectors that prohibit such interconnection.

3.4.3 Coaxial cable connectors shall not be used for connections.

3.5 Controls

3.5.1 General

3.5.1.1 Controls shall not introduce a risk of fire, electric shock, or injury to persons.

3.5.1.2 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.

3.5.1.3 A controller designed to manage power or signaling to single or multiple loads shall operate so that upon any single component failure the system does not result in a risk of fire, electric shock, or injury to persons.

3.5.1.4 An electronic auxiliary or operating control (e. g. a non-protective control), the failure of which would not increase the risk of fire, electric shock, or injury to persons, need only be subjected to the applicable requirements of this end product standard.

3.5.2 Auxiliary controls

3.5.2.1 Auxiliary controls shall be evaluated using the applicable requirements of this end product standard unless otherwise specified in this end product standard.

Exception: An auxiliary control that complies with a component standard(s) specified in 3.5, Controls, is considered to fulfill this requirement.

3.5.3 Operating controls

3.5.3.1 Operating (regulating) controls shall be evaluated using the applicable component standard requirements specified in 3.5.5 – 3.5.10 and the parameters in 3.5.3.3, unless otherwise specified in this end product standard.

3.5.3.2 Operating controls that rely upon software for the normal operation of the end product where deviation or drift of the operating parameters of the control may result in an increased risk of fire, electric shock, or injury to persons, shall comply with:

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

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

c) The Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, if motorized.

3.5.3.3 The following test parameters shall be among the items considered when judging the acceptability of an operating control , except for (c), if using a standard other than the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 or the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, if motorized:

a) Control action Types 1 or 2;

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

c) Installation class 2 in accordance with the Standard for Electromagnetic Compatibility (EMC) – Part 4-5:Testing And Measurement Techniques – Surge Immunity Test, IEC 61000-4-5;

d) For the applicable Overvoltage Category, see Table 3.1;

e) For the applicable Material Group, see Table 3.2; and

f) For the applicable Pollution Degree, see Table 3.3.

Table 3.1
Overvoltage categories

Display type	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 3.2
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 3.3
Pollution degrees

Display control microenvironment	Pollution degree
No pollution or only dry, nonconductive pollution. The pollution has no influence. Typically a 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

3.5.4 Protective controls

3.5.4.1 Protective (limiting) controls shall be evaluated using the applicable component standard requirements specified in 3.5.5 – 3.5.10, and if applicable, the parameters in 3.5.4.5 – 3.5.4.7.

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

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

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, except Controls Using Software; or

c) The Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, if motorized.

3.5.4.3 Solid-state protective controls that rely upon software as a protective component shall comply with:

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

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

c) The Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, if motorized.

3.5.4.4 An electronic control that performs a protective function shall comply with the applicable requirements in this Section (Controls) while tested using the parameters in 3.5.4.5 – 3.5.4.7. Examples of protective controls are:

a) A control used to sense abnormal temperatures of components within the appliance;

b) An interlock function to de-energize a motor;

c) Temperature protection of the motor due to locked rotor, running overload, loss of phase; or

d) Other function intended to reduce the risk of fire, electric shock, or injury to persons.

3.5.4.5 The following test parameters shall be among the items considered when determining the acceptability of an electronic protective control investigated using the Standard for Automatic Electrical

Controls – Part 1: General Requirements, UL 60730-1, and the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, if motorized:

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 (18° F) and the maximum ambient temperature determined by conducting the Temperature Test, 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:

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

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

g) Thermal Cycling Test shall be conducted at ambient temperatures of 10.0 ±2°C (50.0 ±3°F) and the maximum ambient temperature determined by conducting the Temperature Test, Section 49. The test shall be conducted for 14 days;

h) Overload shall be conducted based on the maximum declared ambient temperature (T_{max}) or as determined by conducting the Temperature Test, Section 49; and

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

3.5.4.6 The test parameters and conditions used in the investigation of the circuit covered by 3.5.3.2(a) and 3.5.4.3(a) shall be as specified in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, using the following test parameters:

a) With regard to electrical supervision of critical components, for attended appliances, a motor operated system becoming permanently inoperative with respect to movement of an exposed portion of the appliance meets the criteria for trouble indication. For unattended appliances, electrical supervision of critical components may not rely on trouble indication;

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

c) The Composite Operational and Cycling Test is to be conducted for 14 days at temperature extremes of 0°C (32°F) and 49°C (120°F) for outdoor displays;

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

Humidity Class	Intended Space
H1	Controls used in equipment intended for occupational spaces such as offices and residence.
H2	Controls used in equipment intended for laundry rooms, basements, etc.
H3	Controls intended for household heating appliances
H4	Controls intended for appliances used in bathrooms and areas exposed to high humidity.
H5	Controls intended for outdoor use.

e) A vibration level of 2 g is to be used for the Vibration Test;

f) When a computational investigation is conducted, I_p shall not be greater than 6 failures/106 hours for the entire system. For external secondary entrapment protection devices that are sold separately, I_p shall not be greater than 0 failures/106 hours. For internal secondary entrapment protection devices whether or not they are sold separately, I_p shall not be greater than 0 failures/106 hours. The Operational Test is to be conducted for 16 days;

g) For the Demonstrated Method Test, the multiplier for the test acceleration factor is to be 576.30 for intermittent use appliances, or 5,763.00 for continuous use appliances. The test acceleration factor equation is to be based on a 25°C (77°F) use ambient;

h) The Endurance Test is to be conducted concurrently with the Operational Test. The control shall perform its intended function while being conditioned for 14 days in an ambient air temperature of 60°C (140°F), or 10°C (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 3 is to be used;

j) Conduct a Failure-Mode and Effect Analysis (FMEA); and

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

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

3.5.5 Electromechanical and electronic controls

3.5.5.1 A control, other than as specified in 3.5.6 – 3.5.10, shall comply with:

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

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

3.5.6 Motor controls

3.5.6.1 A control used to start, stop, regulate or control the speed of a motor shall comply with:

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

b) The Standard for Industrial Control Equipment, UL 508;

c) The Standard for Power Conversion Equipment, UL 508C;

d) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; or

e) The Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1.

3.5.6.2 A component that only supplies power to a motor is not considered a controller, but a power supply.

3.5.6.3 The failure of a motor controller shall not introduce an electrical shock, fire or causality hazard as follows:

a) When a controller is designed to load switch (manage current to multiple loads) the reliability of the switching or load sharing shall be investigated so that under a fault condition an electrical shock, fire or causality hazard is not created.

b) When multiple motors apply a force to a portion of the display the load on each motor shall be determined. Load management (switching) if provided by a controller shall be determined to be suitable for the loads or if it is determined the load management is not reliable then consideration shall be given to each motor applying its force to the display portion singly or in combination whichever is determined to be worse case.

Exception: The above conditions do not apply where electronic drive circuits are determined to be reliable by single component faults as determined by evaluation with Controls, 3.5.

3.5.7 Pressure controls

3.5.7.1 A pressure control shall comply with one of the following:

a) The Standard for Industrial Control Equipment, UL 508, the Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1, the Standard for Low-voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches, UL 60947-5-2, and the Standard for Programmable Controllers – Part 2: Equipment Requirements and Tests, UL 61131-2; or

b) The Standard for Automatic Electrical Controls – Part: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls – Part 2-6: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6.

3.5.8 Remote controls

3.5.8.1 Remote controls or applications on smart devices shall not be provided on any display whose operation could cause personal injury while in motion when using the remote or app unless they can only be used in line-of-sight.

3.5.8.2 Remote controls or applications on smart devices shall comply with the control requirements in this standard based on their application.

3.5.9 Temperature controls

3.5.9.1 A temperature control shall comply with:

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

b) The Standard for Industrial Control Equipment, UL 508, the Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1, the Standard for Low-voltage Switchgear and Controlgear – Part 5-2: Control Circuit Devices and Switching Elements – Proximity Switches, UL 60947-5-2, and the Standard for Programmable Controllers – Part 2: Equipment Requirements and Tests, UL 61131-2; or

c) The 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.

3.5.9.2 A temperature sensing positive temperature coefficient (PTC) or a negative temperature coefficient (NTC) thermistor that performs the same function as an operating or protective control shall comply with:

a) The 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; or

b) The Standard for Thermistor-Type Devices, UL 1434.

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

3.5.9.4 A temperature sensing positive temperature coefficient (PTC) or a 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 an operating device – 6,000 cycles;

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

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

3.5.10 Timer controls

3.5.10.1 A timer control shall comply with the 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.

3.6 Furniture power distribution unit (FPDU) and relocatable power taps (RPT)

3.6.1 The cords of RPTs and FPDUs shall be counted as part of the number of cords provided on the display.

3.6.2 RPTs and FPDUs shall not be daisy-chained where one unit is plugged into another unit.

3.7 Gaskets and bushings

3.7.1 A gasket or bushing employed to comply with the requirements for wet locations shall comply with the requirements of the thermal conditioning test described in Section 69, Thermal Conditioning, and Section 70, Gasket Adhesion Test.

3.7.2 A gasket shall be secured so that normal use and maintenance will not cause the gasket to loosen. Clips or a clamping ring are examples of means of securement. When an adhesive is used to secure a gasket, the gasket assembly shall comply with the Gasket Adhesion Test, Section 70. Other means of securement shall be investigated to determine compliance.

3.8 Lasers

3.8.1 Lasers shall comply with the Code of Federal Regulations (CFR), Title 21, Part 1040.

3.8.2 With reference to 3.8.1, compliance of laser products with the 21 CFR Part 1040, shall be determined by:

a) Determining the Class of the laser product and the Class of the radiation emitted by the laser product (as defined in the CFR) from the manufacturer's Center for Devices and Radiological Health (CDRH) product report;

b) Verifying that the manufacturer's markings and labels having the information specified in the CFR are affixed on the laser product (as defined in the CFR);

c) Determining that the corresponding construction features, such as protective housing, interlocks, and similar features, are provided in accordance with the CFR;

d) Determining that the resulting construction complies with the construction requirements of this standard; and

e) Verifying that the manufacture's safety instructions required by the CFR are provided with the laser product (as defined in the CFR).

3.9 Motors – Construction and overload protection

3.9.1 A motor in a circuit greater than 15 watts under any loading condition shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, and shall be provided with overload protection by one of the following methods:

a) The Standard for Impedance Protected Motors, UL 1004-2;

b) The Standard for Thermally Protected Motors, UL 1004-3;

c) The use of a fuse;

d) A protective control; or

e) The use of a circuit that disconnects power or reduces power from the motor in a sufficiently short time to prevent a fire hazard as determined by Controls, 3.5.

Methods (c), (d), and (e) shall comply with the Running Overload Motor Test, 56.2, and Locked Rotor Test, 56.3. All motor / controller combinations shall be evaluated together to determine the suitability of the motor with the controller.

3.9.2 The construction of LVLE and SELV motors do not need to comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, provided they use a Class A Insulation System as defined in UL 1004-1 and comply with the requirements in this standard.

3.9.3 When a requirement in this standard refers to the horsepower rating of a motor and the motor is not rated in horsepower, use is to be made of the appropriate table of the National Electrical Code, ANSI/NFPA 70, which gives the relationships between horsepower and full-load currents for motors. For a universal motor, the table applying to a single-phase, alternating-current motor is to be used when the display is marked for use on alternating current only; otherwise the table applying to direct-current motors is to be used.

3.9.4 The functioning of a motor-protective device provided as part of a display, whether such a device is required or not, shall not result in an increase in the risk of fire, electric shock, or injury to persons.

3.9.5 Overload devices, including types used for running overload protection, other than those that are inherent in a motor, shall be located in each ungrounded current carrying conductor of a single-phase supply system and in each current carrying ungrounded conductor of a 3-phase supply system.

3.9.6 With reference to 3.9.1, an overload-protective device conforming to the National Electrical Code, ANSI/NFPA 70, is identified as an overload device that is responsive to motor current and is rated or set as specified in column A of Table 3.4. When the rating of the motor-running overload protection determined to comply with the foregoing does not correspond to a standard size or rating of a fuse, nonadjustable circuit breaker, thermal cutout, thermal relay, or heating element of a thermal-trip motor switch, the next higher size, rating, or setting is able to be used, and is not able to be more than that specified in column B of Table 3.4. For a multispeed motor, each winding connection is to be evaluated separately.

Table 3.4
Maximum rating or setting of overload-protective device

Type of motor	Ampere rating of device as a percentage of motor full-load current rating	
	A	B
tor with marked service factor of 1.15 or more	125	140
Motor with marked temperature rise of 40°C (72° F) or less	125	140
Any other motor	115	130

3.9.7 Motor-overload protection in which contacts control a relay coil in a motor starter shall comply with the requirements in 3.9.1.

3.10 Printed-wiring boards

3.10.1 A printed-wiring board shall comply with the requirements in the Standard for Printed-Wiring Boards, UL 796, be suitable for direct contact, and shall be classed V-0, V-1, or V-2 in accordance with the requirements in the Standard for Test for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 1: A printed-wiring board containing only circuitry not exceeding Class 2 limits shall be rated minimum HB in accordance with the requirements in the Standard for Test for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 2: A printed-wiring board comprised of non-combustible materials is not required to comply with the Standard for Test for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

3.10.2 A display that has a receptacle grounding path through traces on a printed wiring board shall comply with the Printed-Wiring Board (PWB) Ground Path Test, 55.1 and the Printed Circuit Board (PWB) Conductor Overcurrent Test, 55.2.

3.10.3 A trace on a PWB providing a current path to an external load operating in excess of Class 2 power levels shall comply with the Printed Circuit Board (PWB) Conductor Overcurrent Test, 55.2.

3.11 Receptacles (Outlets)

3.11.1 A 15- or 20-ampere, nominal 120 volt receptacle in a display shall be of the grounding type. The grounding contact of the receptacle shall be bonded in accordance with 15.4, Bonding.

3.11.2 A non-locking type 125-volt, 15 and 20 ampere receptacle (ANSI/NEMA 5-15R or 5-20R) used in displays shall be a Tamper-Resistant type.

Exception No. 1: This requirement does not apply when receptacles are located more than 5-1/2 feet (1.7 m) above the floor.

Exception No. 2: This requirement does not apply when receptacles are part of a luminaire or appliance.

3.11.3 A non-locking type 125-volt, 15 and 20 ampere receptacle (ANSI/NEMA 5-15R or 5-20R) receptacles that are controlled by an automatic control device, or that incorporate control features that remove power from the receptacle for the purpose of energy management or building automation, shall be marked as shown in 75.17.

3.11.4 A receptacle shall:

a) Be flush with or project beyond a nonconductive surrounding surface; or

b) Project at least 0.015 inch (0.38 mm) beyond a conductive surrounding surface.

3.11.5 Receptacles shall comply with the Spill Test, Section 59.

Exception No. 1: This requirement does not apply to a receptacle that is oriented in a position so its face is in a vertical plane ±5 degrees.

Exception No. 2: This requirement does not apply to a receptacle that is covered or otherwise protected from spillage when not in use.

Exception No. 3: This requirement does not apply to a receptacle that is located at least 3 in (76 mm) above the work surface, measured from the lower edge of the receptacle, when the work surface is adjusted to its highest position.

Exception No. 4: This requirement does not apply to a receptacle that is located adjacent to a seating surface and the receptacle is oriented in a position so its face is in a vertical plane ±5 degrees and located at least 3 inches (76 mm) above the uncompressed seating surface.

3.11.6 A display intended to be permanently wired and provided with a receptacle installed within 6 ft (1.8 m) of a sink shall either be protected by an installed Class A type GFCI receptacle protecting all receptacles mounted within 6 ft (1.8 m) of the sink or shall specify in the installation instructions to connect the receptacle circuit to a branch circuit protected with a Class A GFCI device. See 83.15.

3.11.7 A receptacle provided in a display with a seating surface shall comply with one or more of the following. See Figure 3.2:

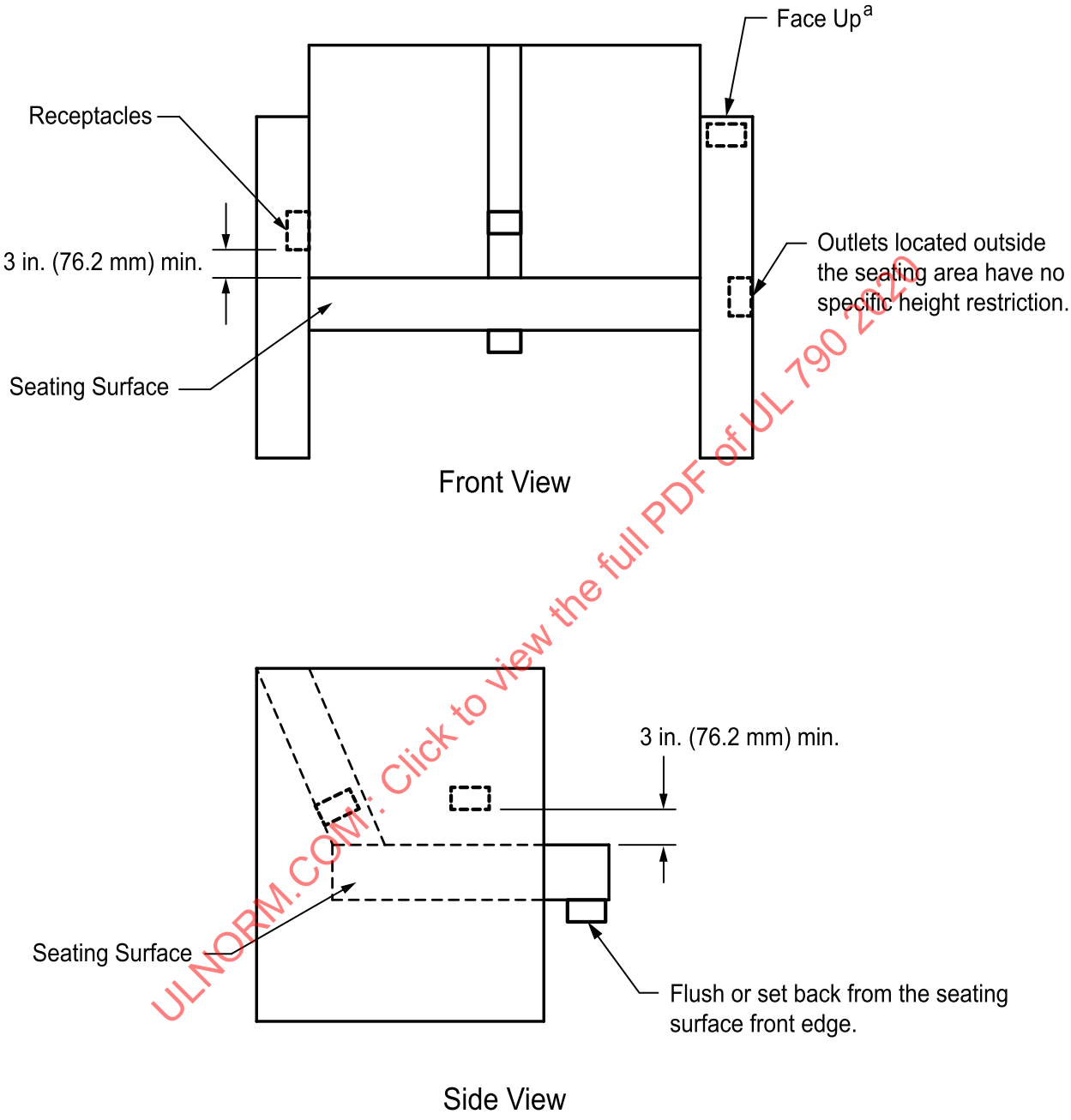
a) Be located at least 3 inches (76 mm) above the uncompressed seating surface.

b) The receptacle shall be located underneath the bottom edge of the seating surface flush with or recessed from the edge.

c) A receptacle mounted face up in an upholstered display shall comply with 3.11.4.

Figure 3.2

Receptacle locations for seating surfaces



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[a] See 3.11.4.

3.11.8 A receptacle shall not be provided in any storage area that is intended to store or hold liquids.

3.11.9 A receptacle shall not be mounted in an area that holds liquid containers that if the container breaks the liquid would directly enter a receptacle or if the display is able to retain the liquid the liquid would flood the receptacle.

3.11.10 For a cord and plug connected display provided with one or more convenience receptacles overcurrent protection (OCP) shall be provided in accordance with Table 3.5. For a display that has a convenience receptacle and additional loading such as lighting or a fan, OCP must be provided, such that the total rating of the product is not exceeded. For example, a product rated 12 amps and provided with a light that draws 2 amps, either the overall device shall be protected with a 12 amp OCP or the receptacle shall be provided with a 10 amp OCP.

Table 3.5
Guide to construction requirements for convenience receptacles in displays

Display rating (Amps)	Minimum power supply cord size (AWG)	Number of receptacles	Supplementary OCP required?	Supplementary OCP rating[a] (Amps)	Temperature test load (Amps)	Minimum internal wiring size (AWG)
13 – 16	12	<6		20	20	12
13 – 16	12	6	YES	20	20	12
12	14	<4	NO	15[c]	15	14
12	14	≥4	YES[c]	15	15	14
<12	14	<4	NO	15[b]	15	14
<12	14	≥4	YES	15	15	14

[a] OCP shall not trip when the display is operated at the marked rated current.

[b] When provided with an OCP.

[c] An OCP is not required for a 12 amp rated display with four receptacles as long as:
Internal wiring is 12 AWG;
The power-supply cord is 12 AWG;
All other components are evaluated for use at 20 A; and
The Temperature Test, Section 49, load is 20 A.

3.11.11 Required overcurrent protection shall either be a supplementary overcurrent protector or a replaceable fuse.

3.11.12 A user replaceable fuse shall not allow the user to contact an electrically energized part during the replacement of the fuse.

3.11.13 A fuseholder shall be of the lock out type and prevent insertion of a fuse larger than that specified.

3.11.14 A convenience receptacle shall be visible to the user.

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Exception: The receptacle may be hidden if:

a) It can be made visible by opening a hinged door or the like; and

b) The supply cord to a display will not be subject to abrasion because of the location of the receptacle.

3.11.15 Receptacle circuits shall not be provided with a dimmer.

3.12 Receptacles, wet locations

3.12.1 Receptacles shall be of the grounding type and weather resistant type.

3.12.2 Receptacles shall be supplied with a cover plate or hood intended to be used with a receptacle. Receptacle covers are relied upon to prevent the ingress of water and shall comply with the requirements for wet location type rain resistant or rain proof receptacle box covers in accordance with the Standard for Cover Plates for Flush-Mounted Wiring Devices, UL 514D.

3.12.3 Cord and plug connected displays supplied with receptacles or connectors for the interconnection of displays shall be supplied with a portable GFCI (cord GFCI) suitable for wet locations that complies with the requirements in the Standard for Ground-Fault Circuit-Interrupters, UL 943.

Exception: Displays that are powered from NEC Class 2 or LPS power sources operating at 15 volts AC or less or 21.2 Volts peak or less.

3.12.4 Wet location displays provided with receptacle outlets and intended to be electrically interconnected shall utilize electrical connectors suitable for outdoor wet location use and shall be designed so that the electrical power must be supplied through the GFCI.

Exception: Displays that are powered from NEC Class 2 or LPS power sources operating at 15 volts AC or less or 21.2 Volts peak or less.

3.12.5 Permanently connected displays provided with receptacles shall either incorporate a class A GFCI receptacle as the first in the series of outlets or shall specify in the installation instructions to connect the display to a class A GFCI circuit. See 90.2.

3.13 Switching devices

3.13.1 General

3.13.1.1 These requirements apply to controls that perform any electrical switching function, either automatically or manually controlled, such as switches, relays, contactors, thermostats, thermal cutoffs, and circuit breakers.

Exception: They do not apply to a switching device in secondary circuits when:

a) The circuit in which the switching device is located is not a safety circuit; or

b) The switching device does not have a marked "off" position and is not used as part of the circuit to disconnect power when a switch with a marked "off" position is turned to the "off" position.

3.13.1.2 All manually operated or adjustable switching devices shall be of the indicating type. The indicating means shall be incorporated on the device or knob, on an attached plate, or on the panel on which the device is mounted.

3.13.1.3 With reference to 3.13.1.2 a switching device that has only ″on″ and ″off″ positions is not prohibited from being provided with the international symbols ″I″ and ″O″ to signify ″on″ and ″off″ when the significance of these symbols is explained in the instructions packaged with the display.

3.13.1.4 When a switching device with a marked ″off″ position is mounted such that movement of the operating handle is vertical, the lower position shall be the ″off″ position.

Exception: This requirement does not apply to a switching device having two or more positions in addition to the "off" position, such as a double-throw switch.

3.13.1.5 A switching device shall be judged with respect to the temperature limitations of the materials employed.

3.13.1.6 A manually-operated motor-control switch shall be provided in a cord-connected motor-operated display that employs a motor rated more than 1/3 horsepower (250 W output).

3.13.2 Switch electrical ratings

3.13.2.1 switching device shall have a current and voltage rating not less than that of the load that it controls when the display is operated as described in the normal Temperature Test – General, 49.1.

3.13.2.2 The current rating of a switching device that controls a solenoid, a magnet, a transformer, an electric-discharge-lamp (such as fluorescent and HID) ballast, or any inductive load other than a motor shall be at least twice the rated full-load current of the component that it controls, unless the switch has been found acceptable for the control of an inductive load at least equal to the rated full-load current of the component.

3.13.2.3 A switching device that controls a motor load shall have a motor rating (full-load/locked rotor amps or horsepower) at least equivalent to the load.

3.13.2.4 A switching device that controls a screwshell-type lampholder or another tungsten-filament load shall:

a) Have a tungsten-filament lamp rating at least equivalent to the rating of the anticipated load, but not less than 25 W;

b) Have a current rating equivalent to at least six times the rating of the anticipated load, but not less than 150 W, for alternating-current circuits; or

c) Have a current rating equivalent to at least ten times the rating of the anticipated load, but not less than 250 W, for direct-current circuits.

Exception: This requirement does not apply to pilot or indicating lamps, or to lampholders for pilot or indicating lamps.

3.13.2.5 A switching device controlling any combination of a tungsten-filament load, a motor or other inductive load, and a resistive load, shall have a current rating at least equal to the sum of any ratings required by 3.13.2.1 – 3.13.2.4, as applicable, and the rated current of the resistive load.

3.13.2.6 A switching device provided as part of a display intended to be connected to a power-supply circuit involving a potential to ground of more than 150 volts shall be acceptable for the maximum potential to ground of the circuit.

3.13.3 Specific applications

3.13.3.1 A switching device in a fixed or stationary display that has a marked "off" position shall open all ungrounded conductors.

3.13.3.2 An automatically reset protective device shall not be employed when automatic resetting results in injury to a person.

4 Units of Measurement

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

4.2 Values of voltage and current are rms values, unless otherwise stated.

5 Undated References

5.1 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.

6 Environmental Considerations

6.1 General

6.1.1 unit intended for dry locations only shall be so identified and shall not be provided with any information such as markings, instructions, or illustrations that implies or depicts damp or wet use.

6.1.2 A unit intended for damp locations shall be:

a) Subjected to the Environmental Conditioning – Humidity Exposure Test, 64.1 unless all live parts and traces on the printed wiring board are potted (see 6.2, Potting Compound) or (see 6.3, Conformal Coating);

b) If provided with a polymeric enclosure, comply with the Resistance to Impact test of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, using a preconditioning temperature of 0 ±2.0°C (32 ±3.6°F); and

c) Eligible to be marked as suitable for damp locations, and not be provided with any information such as markings, instructions, or illustrations that implies or depicts wet use.

Exception: A circuit operating at LVLE power levels in which voltage levels are below those that present a risk of electric shock in accordance with 2.72 is not required to be subjected to (a) and (b) above.

6.1.3 A unit intended for use in wet locations shall:

a) Be subjected to the environmental tests of Sections 64 – 70 unless all live parts and traces on the printed wiring board are potted (see 6.2, Potting Compound) or (see 6.3, Conformal Coating);

b) If provided with a polymeric enclosure, comply with the UV Light Exposure and Cold Impact Test of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, using a preconditioning temperature of minus 35.0 ±2.0°C (minus 31.0 ±3.6°F); and

c) Be eligible to be marked as suitable for wet locations.

Exception: A circuit operating at LVLE power levels in which voltage levels are below those that present a risk of electric shock in accordance with 2.72 is not required to be subjected to parts (a) and (b) above.

6.2 Potting compound

6.2.1 Potting compound shall not leak, drip, or be released from a unit during any test conducted in accordance with this standard.

6.2.2 During the Temperature Test, Section 49, a potting compound shall comply with (a) or (b) as applicable:

a) Unless the material is thermosetting, a polymeric potting compound shall not exceed its Relative Thermal Index (RTI).

Exception No. 1: A thermoplastic polymeric potting compound may be used if the maximum potting compound temperature does not exceed 90°C (194°F) during the Temperature Test, Section 49.

Exception No. 2: A thermoplastic polymeric potting compound may be used if the maximum potting compound temperature is at least 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 Pine Chemicals and Hydrocarbons, by Ring-and-Ball Apparatus, ASTM E28.

Exception No. 3: A thermoplastic polymeric potting compound may be used if the maximum potting compound temperature is at least 25°C (77°F) less than the softening point of the compound as determined by the Standard Test Methods for Vicat Softening Temperature of Plastics, ASTM D1525.

b) An asphalt potting compound shall remain at least 15° C (27° F) below its softening point as determined by the Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus), ASTM D36/D36M.

6.3 Conformal coating

6.3.1 Where a conformal coating is used to meet the requirements of this standard, it shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and be suitable for use in combination with the printed wiring board.

Exception: Conformal coatings applied to PWBs that contain only LVLE circuits need not comply.

7 Assembly

7.1 A display shall be completely wired with all splices and electrical connections before the display leaves the factory. The display itself is not prohibited from being shipped unassembled.

Exception: Electrical connections made by connectors instead of splices are not required to be wired before the display leaves the factory.

7.2 Displays shipped unassembled where all individual pieces are shipped from the same manufacturing location shall be shipped from the factory in a carton or as an unpackaged complete assembly. Unassembled parts, when required elsewhere in the standard to accompany the display, shall be included. Glassware is not required to be actually mounted in a frame or holder; it is able to be separately wrapped to protect it from breakage during shipment.

7.3 Displays shipped unassembled where the individual pieces, (sub-assemblies) are shipped from more than one manufacturing location and shipped to the field for assembly shall be constructed so that each sub-assembly is capable of being incorporated into the final assembly without requiring alteration by the installer. Subassemblies that must bear a definite relationship to each other for the intended operation of the product shall be arranged and constructed to permit them to be incorporated into the complete assembly only in the correct relationship with each other, without requiring alteration or realignment. See Section 80, Markings for Sub-Assemblies, and instructions for subassemblies in Section 89, Sub-Assemblies.

7.4 When wires pass through a joint between sections of a display that are separable for packing purposes, the joint shall be such that rotation of one section with respect to the other during the assembly of the sections is limited to not more than 360 degrees. Friction alone does not meet the intent of the requirement to prevent rotation.

Exception: When all of the following conditions exist, rotation between sections of a display is not limited to 360 degrees:

a) The internal diameter of the tubing through which the wires pass is 1/2 inch (12.7 mm) or more;

b) The rotation during assembly is limited to not more than one revolution for each 3 inches (76 mm) of unobstructed tubing length through which the wires pass, when such rotation does not place any stress on the conductors; and

c) The conductors do not involve splices unless the splices are:

1) Inaccessible during assembly in accordance with Figure 14.1, Articulate Probe; and

2) Secured and provided with strain relief that has been shown to be reliable and not easily defeated by the user.

7.5 When a splice or an electrical connection is located in a section of a display that is separable for packing purposes, as noted in 7.1, the unit shall be provided with strain relief to reduce the risk of stress being transmitted to the splice or electrical connection during unpackaging and assembly of the display. The strain relief shall be reliable and not easily defeated by the user. See the Strain Relief for Internal Conductors and Connectors Test, 51.2.

7.6 When wires pass through a joint between sections of a display that are separable for packing purposes the joint or section shall comply with 11.7, Protection of Cord and Wiring, while unassembled.

7.7 When in any position of adjustment a spring-loaded or adjustable section of a display shall not transmit stress to a splice or wiring within any section of the unit either during assembly or when completely assembled. For example, the stem of an adjustable height floor-display unit shall raise and lower without binding or crimping the wiring of the unit.

7.8 As specified in 7.2, a carton is a box of cardboard, pasteboard, shrink film, or similar material (but not newspaper, wrapping paper, tissue paper, or similar paper products). It is not required to be rectangular in form, since the ″pinch pack″ of cardboard wrap with the ends pinched together and stapled is determined to be a carton.

7.9 A part that must be removed to assemble a display in the intended manner to the supply circuit is not required to be fastened, but the construction shall be such, and the hardware shall be provided, to allow field assembly.

7.10 Any display that is not completely assembled shall be provided with assembly instructions.

8 Accessories

8.1 A display having provision for the use of an accessory shall be constructed so that the use of the accessory does not introduce a risk of fire, electric shock, or injury to persons.

8.2 A display shall comply with the requirements in this Standard with or without the accessory installed.

8.3 Installation of an accessory by the user shall be restricted to an arrangement by which the electrical connections are accomplished by means of mating connectors, attachment plugs and receptacles, or attachment plugs and cord connectors that maintain correct polarity.

8.4 Installation of an accessory shall not require, splicing, cutting of wiring, or the soldering of connections by the installer.

Exception: Accessories that are intended to be hard-wired to the building electrical system and intended to be connected and installed by a trained individual, such as an electrician, may be cut and spliced to connect to the building wiring system.

8.5 Strain-relief means shall be provided for the wiring of an accessory where stress may be transmitted to the connections during or after installation.

8.6 The mounting method and location of an accessory shall be specified in the installation instructions for the display. See Section 84, Instructions – Accessory.

8.7 Instructions shall be provided with the accessory covering the model number or series of display the accessory is intended for use with. See Section 84, Instructions – Accessory.

8.8 The instructions shall be sufficiently detailed and accurate so that installation is feasible, and that the furnishing complies with the requirements of this standard with the accessory installed. See 28.2, Trial Installation.

8.9 An accessory may be shipped with or separately from the basic display.

8.10 A part that is required for the display to perform its basic function is not considered an accessory and shall be supplied with the basic display.

9 Retrofit Kits

9.1 A retrofit kit will comply with all requirements in this standard and after installation of the retrofit kit, a display shall comply with the requirements in this standard.

9.2 After installation of a retrofit kit, all components of the retrofit kit and all components of the display that were affected by the installation of the retrofit kit shall be secured in place so that lamp replacement, inspection of splices to the branch-circuit supply wires, and routine maintenance will not loosen components or joints in the assembly.

9.3 Supplemental wiring including wires for interconnection of kit components and connectors required for installation of the retrofit kit shall be included in the kit.

9.4 LED lamps included in the retrofit kit shall comply with the Standard for Self-Ballasted Lamps and Lamp Adapters, UL 1993.

9.5 Tubular LED lamps that are intended to replace fluorescent lamps and use existing lampholders only for mechanical support and are powered by separate supply connections shall comply with the requirements for tubular lamps in the Standard for Self-Ballasted Lamps and Lamp Adapters, UL 1993.

CONSTRUCTION

10 General

10.1 Each electrical device and insulated conductor shall have ratings (voltage, current, wattage, temperature, etc.) at least equal to the parameters that are applied to it during intended use.

10.2 Means shall be provided to reduce the risk of contact between the surface of a cabinet and a cabinet light other than at the intended mounting means so that the temperature of the mounting surface or the surface where the light falls does not exceed its temperature limit. The means provided shall have strength and rigidity to reduce the risk of distortion which facilitates installation in a manner other than intended.

10.3 When wires pass through a joint between sections of a display the construction shall comply with the requirements in 7.4.

10.4 A display shall be formed and assembled so that it has the strength, stability, and rigidity required to resist the abuses during normal use and maintenance to which it is subjected without increasing the risk of fire, electric shock, or injury to persons.

10.5 A display shall be smooth and rounded and shall not be so sharp as to constitute a risk of injury to persons during intended use and maintenance of a product, when investigated in accordance with the Standard for Tests for Sharpness of Edges on Equipment, UL 1439.

10.6 A display or part of a display is considered to be subjected to physical abuse if a 2-in (51-mm) diameter sphere is able to contact the part.

Exception: If the location of the part makes it unlikely that the part will be accidently contacted it is not considered to be subjected to mechanical abuse, such as directly underneath a fixed work surface.

10.7 When conductors are stranded, the connection means shall be such that loose strands are minimized.

10.8 All connections and splices shall be mechanically and electrically secure. Soldering alone is not considered to provide mechanical securement.

10.9 LED Drivers are considered power supplies. Products that require a power supply to operate shall be provided with the power supply and shall be marked in accordance with 75.34.

11 Power-Supply Connections

11.1 Permanently connected display

11.1.1 A permanently connected display shall be provided with field-wiring terminals or leads for the connection of conductors having an ampacity rated as intended for the display, and in accordance with the National Electrical Code, ANSI/NFPA 70 and the Canadian Electrical Code, C22.1. A display shall be provided with a splice compartment, junction box or length of raceway to make connections.

11.1.2 A lead that is intended to be connected in the field to a power-supply circuit conductor shall not be smaller than 18 AWG (0.82 mm^2), and shall be sized based on the rated current of the display.

11.1.3 A terminal or splice compartment shall be complete and shall enclose all field-wiring terminals and splices to be made in the field.

11.1.4 Each terminal or splice compartment in which power-supply connections are to be made in the field shall be located so that the connections are able to be readily accessible for inspection after installation of the display.

11.1.5 The compartment specified in 11.1.4 shall be located so that, when making conduit connections, internal wiring and electrical components are not exposed to mechanical abuse or strain.

11.1.6 A terminal compartment intended for connection of a supply electrical enclosure shall be attached so as to be prevented from turning with respect to the supporting surface.

11.1.7 A wiring terminal shall be prevented from turning or shifting in position.

11.1.8 A wire-binding screw at a wiring terminal shall not be smaller than No. 10 (4.8 mm diameter). If a pre-tapped hole is not provided, a thread-forming screw shall be used.

Exception: A No. 8 (4.2 mm diameter) screw is able to be used at a terminal intended only for connection of a 14 AWG (2.1 mm^2) or smaller conductor.

11.1.9 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 in (1.27 mm) thick.

Exception: A plate not less than 0.030 inch (0.76 mm) thick is able to be used when the tapped threads comply with the Tightening Torque Test, Section 42.

11.1.10 A wire-binding screw shall be provided with an upturned lug, cupped washer, or equivalent means that retains a supply conductor of the size intended.

11.1.11 A terminal (for example, a plate and screw) intended for the connection of the grounded supply conductor shall be formed of or plated with metal that is substantially white in color and shall be readily distinguishable from other terminals or shall be clearly identified in some other manner, such as on an attached wiring diagram.

11.1.12 A lead intended for the connection of the grounded power-supply conductor shall be finished to show a white or gray color, and shall be readily distinguishable from other leads.

11.1.13 The free length of a lead located inside an outlet box or field-wiring compartment and intended for field connection to a branch circuit shall not be less than 6 in (152 mm).

11.1.14 When a terminal block is provided, it shall be suitable for field wiring.

11.1.15 An opening for conduit shall have dimensions as indicated in Table 11.1.

Table 11.1
Dimensions associated with openings for conduit

Nominal trade size of conduit	Unthreaded opening diameter[a]		Throat minimum		Diameter maximum		Minimum diameter of flat surface	
inches	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
1/2	0.875	(22.2)	0.56	(14.2)	0.62	(15.7)	1.15	(29.2)
3/4	1.109	(28.2)	0.74	(18.8)	0.82	(20.8)	1.45	(36.8)
1	1.375	(34.9)	0.94	(23.9)	1.05	(26.7)	1.80	(45.7)
1-1/4	1.734	(44.0)	1.24	(31.5)	1.38	(35.1)	2.31	(58.7)

[a] Plus tolerance of 0.031 inch (0.79 mm) and a minimum tolerance of 0.015 inch (0.38 mm) applies to the knockout diameter. Knockout diameters are measured other than at points where a tab remains after removal of knockout.

11.1.16 The minimum unobstructed diameter of the flat surface surrounding the back of an opening for unthreaded conduit shall be as indicated in Table 11.1.

11.1.17 When threads for the connection of threaded conduit are tapped all the way through a hole, there shall be no fewer than 3-1/2 or more than 5 threads. The construction of the hole shall be such that a conduit bushing is able to be properly attached and the minimum unobstructed diameter surrounding the back of the hole shall be as indicated in Table 11.1.

11.1.18 When threads for the connection of threaded conduit are not tapped all the way through a hole, there shall be no fewer than five full threads. The unthreaded parts of the hole and the back edge shall be smooth and well-rounded for protection of the conductors. The unthreaded throat diameter of the hole shall have an internal diameter as noted in Table 11.1.

11.1.19 The minimum usable volume of a field wiring compartment shall be as specified in Table 11.2.

Table 11.2
Minimum usable volume of terminal compartment

Size of conductors		Volume for each conductor that originates outside the compartment and terminates or is spliced within the compartment, and each conductor that passes through the compartment without splice or termination, including a grounding conductor	
AWG	(mm^2)	cm^3	(in^3)
18	(0.8)	24.6	(1.50)
16	(1.3)	28.7	(1.75)
14	(2.8)	32.77	(2.00)
12	(3.3)	36.87	(2.25)
10	(5.3)	40.97	(2.50)
8	(5.5)	49.2	(3.0)
6	(6.5)	81.9	(5.0)

11.1.20 Conduit shall only be used as permitted by the National Electrical Code, NFPA 70. For example, flexible metal conduit shall not be used where it is subject to physical abuse and flexed after installation.

11.2 Cord-connected display

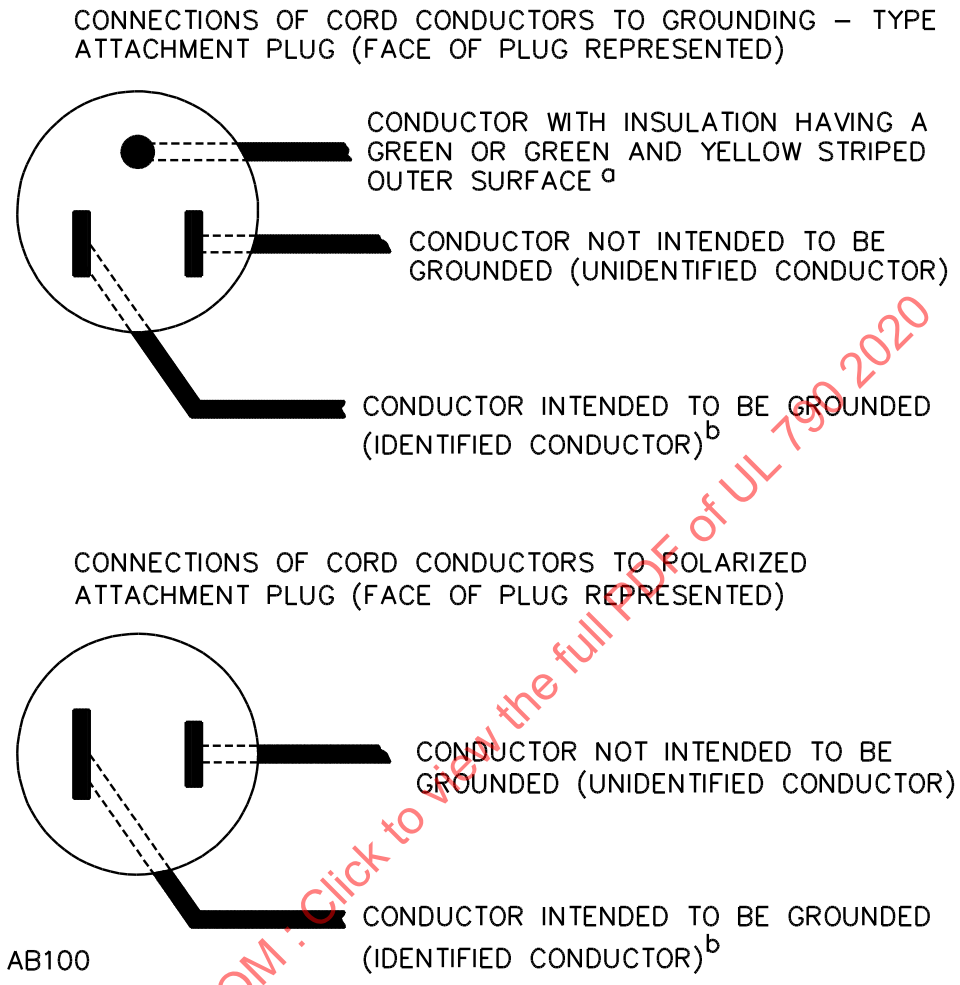
11.2.1 A display intended to be connected to the power-supply source by means of a flexible cord and plug shall be provided with a flexible cord and an attachment plug for connection to the supply source. Displays supplied with more than one power supply cord shall comply with 11.3, Multiple Power Supply Cords.

11.2.2 When a 3-wire grounding-type or a 2-wire polarized attachment plug is provided, the circuit conductors in the flexible cord shall be connected to the plug and to the wiring in the product so that any of the following devices used in the primary circuit shall be connected in an ungrounded current carrying conductor: the center contact of the Edison-Base lampholder, a single pole switch, an automatic control with a marked off position, a single fuseholder, and any other single-pole overcurrent protective device.

11.2.3 When a 3-wire grounding-type attachment plug or a 2-wire polarized attachment plug is provided, the attachment plug connection shall comply with Figure 11.1 and the polarity identification of the flexible cord shall comply with Table 11.3. See Section 92, Instructions – Operating.

Figure 11.1

Connections to attachment plugs



[a] IIn the above illustration, the blade to which the green conductor is connected is able to have a U-shape instead of a circular cross section.

[b] Signifies a conductor identified in accordance with Table 11.3. The grounded (identified) conductor is the neutral supply conductor.

Table 11.3
Polarity identification of flexible cords

Method of identification	Usable combinations	
	Wire intended to be grounded[a,b]	All other wires[a]
Color of braid on individual conductors	Solid white or gray – without tracer	Solid color other than white or gray – without tracer
	Color other than white or gray, with tracer in braid	Solid color other than white or gray – without tracer
Color of insulation on individual conductors	–	Solid color other than white or gray
	Light blue[c]	Solid color other than light blue, white, or gray
Other means	–	No tin or other white metal on the strands of the conductor

[a] A wire finished to show a green color with or without one or more yellow stripes or tracers is to be used only as an equipment-grounding conductor. See 15.3, Grounding Identification and Figure 11.1.

[b] The grounded conductor is the neutral supply conductor.

[c] For jacketed cords.

11.2.4 A display required o be grounded shall be provided with a grounding-type attachment plug.

11.2.5 If the cord includes an equipment grounding conductor, the grounding conductor shall be connected to all exposed or accessible un-energized metal parts that may become energized of the display by a mechanical means in accordance with Section 15, Grounding and Bonding, and to the grounding pin of a grounding attachment plug. See Figure 11.1.

11.2.6 The power-supply cord shall be rated for use at a voltage not less than the rated voltage of the product. The power-supply cord shall be sized in accordance with Table 11.4. A display provided with a 20 amp rated receptacle shall be provided with a minimum 12 AWG (3.3 mm^2) conductor cord or when provided with a 15 amp receptacle with a minimum 14 AWG (2.1 mm^2) conductor cord.

Table 11.4
Power supply cord ampacity

Cord size AWG (mm^2)	Display maximum rating (Amperes) per cord	
	3 current-carrying conductors	2 current-carrying conductors
6 (13.3)	45	55
8 (8.4)	35	40
10 (5.3)	25	30
12 (3.3)	20	25
14 (2.1)	15	18
16 (1.3)	10	13
18 (0.82)	7	10

11.2.7 The flexible cord shall be of a type indicated in Table 11.5 or shall have properties such that it will be at least equally as serviceable for the particular application. Products intended for wet locations shall have cords suitable for outdoor use (A “W” on the cord).

Table 11.5
Acceptable types of cord and applicable limitations on their use

Display type	Cords acceptable where temperatures of more than 121°C (250°F) are attained on any surface the cord can contact	Cords acceptable where 121°C (250°F) or lower temperatures are attained on any surface the cord can contact[a]
Permanent where cord may be on the floor	HSJ, HSJO, HSJOW	SJ, SJT, SJE, SJEO, S, SO, SOW, SOO, SOOW, STO, STOW, STOO, STOOW, SEO or SEOW or equivalent
Permanent where cord will not touch the floor such as a countertop display with the cord plugged into a receptacle on the counter or wall or a temporary display.	Same as above	Same as above and NISP-2, NISPT-2 SP-2, SPE-2, SPT-2, SPT-3, SV, SVE, SVO, SVT, SVTO

Note:
[a] If the application is outdoor use or indoor use where exposed to water, then cords shall also be suitable for wet locations.

11.2.8 A power supply with a supply cord input shall comply with 11.2.6 and 11.2.7.

11.2.9 When a display employs a power supply with a supply cord input and output conductors, the combined length of the supply cord and the output conductors shall be in compliance with Table 11.6 requirements.

11.2.10 The length of a power supply cord shall be within the limits specified in Table 11.6.

Table 11.6
Length of power supply cord

Cord exit point (based on the construction or the use instructions)	Minimum acceptable length		Maximum acceptable length	
	ft	(mm)	ft	(mm)
Displays not intended to be along a wall and powered by a receptacle on or near the floor.	0.5	(152)	1.0	(305)
Displays not intended to be along a wall and powered by a receptacle on or near the ceiling	5.0	(1524)	25	(7620)
Displays intended to be along a wall where the cord exit point is lower than 3 feet from the floor	5.0	(1524)	25	(7620)
Displays intended to be along a wall where the cord exit point is greater than 3 feet from the floor	9.0	(2743)	25	(7620)

11.2.11 When the intended means of mounting or other features or constructions of a display warrants other than the required length of power-supply cord, a shorter cord is able to be provided. Instructions shall be provided in accordance with 83.12.

11.2.12 The current rating of the attachment plug of a display shall not be less than 125 percent of the maximum current input of the display or the marked rating when no electrical load is provided as part of the display.

11.2.13 Means shall be provided to support the cord to reduce risk of contact with a cabinet light at a location other than the cord exit.

Exception: If the temperature rating of the cord is equal to or above the maximum temperature measured during the Temperature Test, Section 49.

11.2.14 The display shall be constructed so that neither the cord nor plug is damaged when the display is placed against a wall. Examples of constructions include, but are not limited to wood blocks to hold the display out from the wall and right angle (flat) cord/plugs.

11.2.15 Power supply cords and interconnecting cords that constitute a risk of injury, which includes shock and fire, from damage shall be protected from moving parts of a display.

11.2.16 Cords subject to flexing shall be subjected to the Conductor Cycling Endurance Test, Section 52 unless:

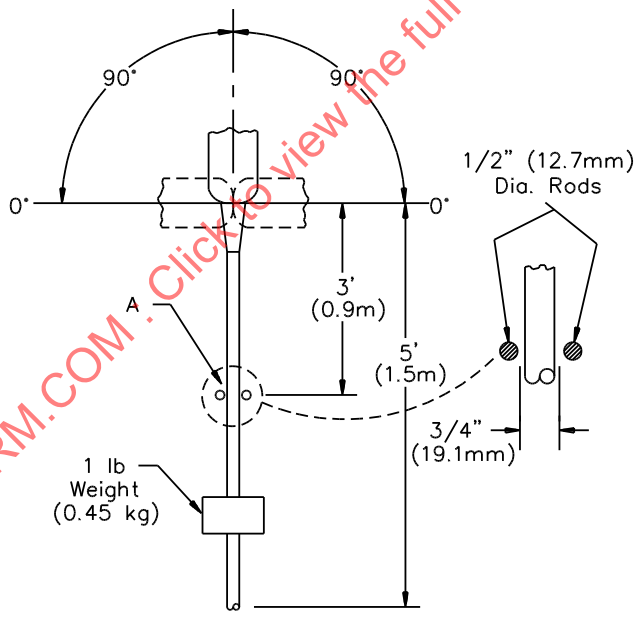
a) The cord is not flexed more than 90 degrees as shown in Figure 11.2;

b) The cord is provided with a strain relief at each end of the cord where it enters an enclosure; and

c) The cord is not subject to a twisting motion along its longitudinal axis.

Figure 11.2

Cord flexing



A – Portions of the cord damaged by contact with the guides or attachment of the weight may be removed prior to the electrical tests.

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11.2.17 Cord and plugs shall not be used where recessed into the wall.

11.3 Multiple power supply cords

11.3.1 Cord connected displays shall not be provided with more than one power supply cord unless all of the following conditions are met:

a) Not more than two cords are provided;

b) Each flexible cord is of the type, size, and rating required for the type of product and the load supplied;

c) Each attachment plug cap's rating is:

1) Not less than that of the display and not less than the maximum current input of the display when tested in accordance with the Input Test, Section 48.

2) The current rating of the attachment plug of a display rated more than 15 amperes shall not be less than 125 percent of the maximum current input of the display when tested in accordance with the Input Test, Section 48, and not less than 125 percent of the rated current of the display.

d) The total current input in accordance with Input Test, Section 48, (including current through all cords) is not more than 80 percent of the branch circuit supply for the single branch circuit to which it is connected (based on the plug configuration);

Exception No. 1: The current is not required to be less than 80 percent of the single branch circuit when the plugs are supplied by separate branch circuits, evidenced by any of the following:

a) The attachment plugs are not the same configuration or rating and the instructions contain the information in 91.6 (a) and (b);

b) The rating of either or both plugs is greater than 20 amps; or

c) The product is marked in accordance with 75.14, and the instructions contain the information in 91.6 (a) and (c).

Exception No. 2: The current is not required to be less than 80 percent of the branch circuit rating when:

a) Both attachment plugs are rated 15 amps or less; and

b) The total current input is equal to or less than the attachment plug rating.

e) With reference to Exception No. 1 of 11.3.1(d), where detachable power supply cords are used, both the attachment plugs and the inlets shall have different configurations.

f) The product is provided with a single accessible control or switch with a marked "off" position that disconnects all ungrounded conductors of the product;

Exception: The display is not required to have a single disconnect when multiple disconnect means are provided in accordance with any of the following:

a) There is a control or switch for each of the two power supply cords, and the controls or switches are grouped and identified;

b) Both power supply cords are of the detachable type, the only supplied loads are receptacles, and the cord attachment points are grouped and identified;

c) The product is provided with a mechanical or electrical interlock system that results in all ungrounded conductors of the supply being disconnected in the event that either cord is disconnected; or

d) A marking is provided and located adjacent to each switch in accordance with 75.15.

g) The display is rated in accordance with 74.3;

h) The product contains the markings in 75.14; and

i) The display is provided with instructions as indicated in 91.6.

11.4 Detachable power supply cords

11.4.1 Detachable power supply cords hall comply with the following:

a) Shall either be provided with an ANSI/NEMA WD-6 configuration mating attachment cord connector body and inlet; or

b) Be provided with a Standard for Appliance Couplers for Household and Similar General Purposes – Part 1: General Requirements, UL 60320-1, configuration mating appliance attachment cord connector body and inlet.

11.4.2 The power supply cord ampacity shall be rated for the maximum current rating of the appliance inlet configuration provided.

11.4.3 Adjacent to the inlet shall be marked the maximum voltage and current rating of the display and a WARNING statement as specified in 75.23.

11.4.4 A display required to be supplied with a cord GFCI is required to have the cord permanently attached to the display or shall be connected to the display with a proprietary connector suitable for outdoor wet location use (a nonstandard NEMA connector).

11.5 Secondary connections

11.5.1 A display powered by a direct plug-in power supply with a Class 2 or LPS output shall comply with the output cord conductor requirements specified for the power supply.

11.5.2 When a display employs a direct plug-in power supply the length of the output conductors shall be in compliance with Table 11.6 requirements.

11.5.3 A display powered by a remote power supply shall be provided with a means of connection for each circuit in accordance with Section 11, Power-Supply Connections.

Exception No. 1: A LVLE display is permitted to provide a means of connection suitable for power limited cable such as CL2, CL3, CAT6 (for a Power Over Ethernet (POE)), or equivalent.

Exception No. 2: A LVLE display unit may be used with an exposed bare conductor system provided that all low voltage current-carrying parts that extend through or are located behind a wall, ceiling surface, or other enclosed area after installation shall be enclosed in material that complies with 12.5 – 12.9.

11.5.4 An exposed bare conductor power unit shall be provided with an output connection means which provides an electrically and mechanically secure connection for the low voltage exposed bare conductors.

11.5.5 For a LVLE display employing an interconnecting wiring system that is included as part of the system, the wiring method is permitted to be other than specified in 11.2, Cord-Connected Display, provided the wiring complies with Section 18, Internal Wiring. Flexible cord shall not be used for a supply connection means that is intended to be:

a) Concealed or extended through a wall, floor, ceiling, or similar building structure such as a cabinet;

b) Located above a suspended ceiling or dropped ceiling;

c) Not visible for its entire length; or

d) Subject to strain or physical damage.

11.6 Strain relief

11.6.1 A strain-relief means shall be provided so that mechanical stress placed on a flexible cord or flexible conduit is not transmitted to terminals, splices, or internal wiring. When a clamp is employed with a cord, auxiliary insulation is required when the clamp is able to damage the cord insulation.

Exception: Cord or wiring totally within a LVLE circuit does not require strain relief.

11.6.2 Insulating bushings serving as strain relief shall comply with the Standard for Insulating Bushings, UL 635. Tests specified in this Standard (e.g. Strain Relief Test, Section 51) may still need to be performed to confirm the combination of the insulating bushing and the supporting parts are suitable in combination.

11.6.3 If wood, pressed board, or other fibrous material is used to secure the strain-relief assembly, the fibrous material shall be secured to the display by a positive means.

11.6.4 Means shall be provided to reduce the likelihood of an attached supply cord or lead from being pushed into the enclosure of a display through the cord-entry hole if damage to cord could result from contact with internal mechanical and electrical components or systems, or displacement of internal components that can result in a hazard.

11.6.5 To determine compliance with 11.6.1, a strain relief means is to be subjected to the applicable tests described in Strain Relief Tests, Section 51.

11.6.6 A metal strain relief clamp or band shall not be used unless it has been evaluated to the Standard for Conduit, Tubing, and Cable Fittings, UL 514B, for the size of, number of and type of cord or conductor.

11.7 Protection of cord and wiring

11.7.1 The point where a flexible cord passes through an opening in a wall, barrier, or enclosure, shall be an opening that is free from sharp edges, burrs, and fins that are able to damage the conductor insulation.

11.7.2 The cord shall be provided with mechanical means that prevent the cord being pushed inside the enclosure and contacting:

a) A lamp or heated surface;

b) A sharp edge; or

c) A moving part.

11.7.3 An insulating bushing shall be provided where the flexible cord or wiring enters a display, and at the ends of metal tubing where the cord or wiring are pulled during the adjustment of the unit.

Exception: A smooth, metal bushing is able to be used when Type SJ, or heavier cord is used.

11.7.4 Cord or wiring that passes through tubing or contacts the edge of a sheet-metal wall 0.042 inch (1.07 mm) or less thick shall be reliably held away from the edges of the metal or shall be protected by a non-rubber bushing or a grommet or by rolling the edge of the metal not less than 120 degrees.

11.7.5 When cords or wires pass through or contact the edges of sheet metal thicker than 0.042 inch (1.07 mm), the metal shall be treated by reaming or the equivalent to remove burrs, fins, or sharp edges that are able to damage insulation.

11.7.6 When the material through which the cord or wiring passes is wood, porcelain, phenolic composition, or other insulating material, not less than 3/64 inch (1.2 mm) thick, a smoothly rounded surface is determined to be equivalent to a bushing.

11.7.7 Ceramic materials and molded urea, phenolic, and melamine compositions are determined to meet the intent of the requirement for insulating bushings; a bushing of wood or rubber is not usable. Other compositions are able to be used when they have been investigated and found usable for the application.

11.7.8 A hard-fiber bushing or grommet form is able to be employed when the bushing is not less than 3/64 inch (1.2 mm) thick. A rubber bushing is not suitable for use.

11.7.9 An insulated metal grommet is usable in place of an insulating bushing when the insulating material used is not less than 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the metal in which it is mounted.

11.7.10 Polymeric sleeving shall not be used for reducing the risk of cutting or abrasion of wiring. Fiberglass sleeving not less than 0.010 inch (0.25 mm) thick is capable of being used.

11.7.11 A bushing shall be securely held in place.

11.7.12 When a power supply cord is routed internally or externally along a display or a cord is utilized for the interconnection of electrical components provided with the display the cord shall be protected from damage by any of the following means:

a) Recessing the cord in a channel or a complete enclosure;

b) Providing projections extending out from the display at least equivalent to the depth of the diameter of the cord; or

c) Providing a removable protective cover.

12 Enclosures and Guards

12.1 General

12.1.1 Among the factors taken into consideration in determining the acceptability of an enclosure are its:

a) Physical strength;

b) Resistance to impact;

c) Moisture absorptive properties;

d) Combustibility;

e) Resistance to corrosion; and

f) Resistance to distortion at temperatures to which the enclosure may be subjected under conditions of normal or abnormal use.

For a nonmetallic enclosure, all of these factors are to be considered with respect to thermal aging.

12.2 Personal injury, entrapment, pinch points, and shear considerations

12.2.1 When the operation and maintenance of a display by the user or bystanders involves the risk of injury to persons, protection shall be provided to reduce the risk.

12.2.2 When investigating a display with respect to the requirement in 12.2.1, conditions of foreseeable misuse shall be evaluated.

12.2.3 Among the factors to be evaluated with respect to both intended operation of the display and any foreseeable misuse in investigating an exposed moving part are:

a) The degree of exposure required to perform the intended function;

b) The sharpness of the moving part;

1) Moving parts shall have edges rounded to a radius of 0.8 mm (0.03 inches) and corners to 1.6 mm (0.06 inches).

c) The risk of unintentional contact;

d) The speed of the moving part;

1) Moving parts traveling less than 1 inch / second (2.54 cm/second) are not considered an entrapment hazard. If two parts are in motion, the combined speed of the parts shall be considered. The speed for rotating parts shall be measured at the fastest moving point. Space around accessible pinch points should not be constrained such that a user is unable to retract a body part quickly from the space to avoid further exposure.

e) The risk that a part of the body is endangered or that clothing is able to be entangled by the moving part, resulting in a risk of injury to persons; and

f) The force involved when loaded with the rated load.

12.2.4 When considering entrapment or pinch points, consideration should be given to the body part(s) that may become trapped. See Table 12.1 for dimension requirements for spacing to prevent entrapment.

Table 12.1
Entrapment space requirements

Body Part	Child Inches (cm)	Adult Inches (cm)
Arm	>4.72 (12.0)	>4.72 (12.0)
Body	>19.7 (50.0)	>19.7 (50.0)
Finger	Either >1.0 (2.5) or <0.16 (0.4)	Either >1.0 (2.5) or <0.32 (0.8)
Foot	Either >4.72 (12.0) or <1.0 (2.5)	Either >4.72 (12.0) or <1.4 (3.5)
Hand	>4.0 (10.0)	>4.0 (10.0)
Head	Either >12.0 (30.0) or <2.4 (6.0)	Either >12.0 (30.0) or <4.8 (12.0)
Leg	>7.1 (18.0)	>7.1 (18.0)
Toes	>2.0 (5.0)	>2.0 (5.0)

12.3 Mechanical enclosures and guards – Mechanical considerations

12.3.1 Bellows shall:

a) Require the use of tools for their removal;

b) Be removable for servicing;

c) Have sufficient strength and rigidity to avoid the articulate probe with web stop (Figure 14.1) from being inserted to a depth that causes entrapment or damages the guard when pressed with a force of 10 lbs (44.5 N);

d) Be complete; and

e) Not present a risk of injury to persons such as a pinch point, during additional handling because of required service, such as cleaning, unjamming, or similar service.

12.3.2 A functional attachment that is made available or specified for use with a display shall be included in the investigation of the display. Unless the instructions specify the use of two or more attachments at the same time, only one attachment at a time is to be investigated with the display.

12.3.3 Whether a guard, a release, an interlock, or similar device is required and whether such a device is adequate shall be determined from an investigation of the complete display, its operating characteristics, its intended installation location, the intended user group (youth, adult, persons with diminished capacity, elderly), trained or untrained users and the potential risk of injury to persons. The investigation shall include evaluation of the results of breakdown or malfunction of any one component, and not more than one component at a time, unless one event contributes to another. When the investigation shows that breakdown or malfunction of a particular component results in a risk of injury to persons, that component shall be investigated for reliability.

12.3.4 A moving part, lifting or reclining mechanism, the rotor of a motor, a pulley, belt, gear, fan, or other part that constitutes a risk of injury shall be enclosed or provided with means to reduce the risk of injury. Such a part shall not be able to be contacted by the user or someone in the area. Compliance shall be determined by the probe illustrated in Figure 14.1 unless the display is provided with a safety system and complies with 12.3.5. A force greater than 40 pounds between a moving part and any object that can be entrapped by the moving part is considered a hazard. The furnishing shall be subjected to the Entrapment Force Measurement and Operator Attended Tests, Section 39.

12.3.5 Displays that present a risk of injury as described in 12.3.4 shall be provided with either an active safety circuit or passive guard to prevent injury.

12.3.6 A mechanical safety system, such as a guard, shall comply with 12.3.8.

12.3.7 During the investigation of a display to determine compliance with 12.3.4, a part of the mechanical enclosure that is removable without the use of a tool shall be removed.

Exception: A part that is removable without the use of a tool is not required to be opened or removed when the display is marked in accordance with 75.11.

12.3.8 Guards shall:

a) Require the use of tools for their removal;

b) Be removable for servicing;

c) Have sufficient strength and rigidity;

d) Be complete;

e) Not present a risk of injury to persons such as a pinch point, during additional handling because of required service, such as cleaning, unjamming, or similar service; and

f) Be self-restoring.

12.3.9 A mechanical enclosure or guard over a rotating part shall retain a part that, because of breakage or other reasons, becomes loose or separates from a rotating part, and shall retain a foreign object that is able to be struck and propelled by the rotating part.

12.3.10 When breakage or deterioration of material adjacent to a moving part results in an increased risk of injury, the material shall have such properties as to withstand the loads it is subjected to during use of the display.

12.3.11 A display that does not incorporate a shade shall comply with Lamp Drape Test, Section 58, and shall be marked with the maximum wattage lamp intended for use with the display.

12.3.12 When unintentional operation of a switching device results in a risk of injury to persons, the actuator of the switch shall be located or guarded so that such unintentional operation does not occur. A switch that is located or guarded so that it cannot be turned on by moving a 2 inch (51 mm) diameter sphere at any angle to the switch or actuator complies with this requirement.

12.4 Mechanical connectors

12.4.1 Whether a release, a mechanical connector (joining two displays), or similar device is adequate shall be determined from an investigation of the complete display, its operating characteristics, and the potential risk of injury to persons. The investigation shall include evaluation of the results of breakdown or malfunction of any one component, and not more than one component at a time, unless one event contributes to another. When the investigation shows that breakdown or malfunction of a particular component results in a risk of injury to persons, that component shall be investigated for reliability.

12.4.2 A mechanical connector shall be constructed to withstand the strain to which it is subjected during normal use.

12.4.3 When two or more displays are capable of being used in combination, a mechanical means of securement between tables shall be provided.

12.4.4 All non-metallic mechanical connectors shall comply with the Mechanical Connector Test, 44.1. All flexible connectors shall comply with the requirements in 44.2, Flexing.

12.5 Electrical enclosures – General

12.5.1 A part such as a splice, tap, wire, transformer, capacitor, ballast, current-carrying part, or device with an exposed live part shall be contained in an electrical enclosure constructed of metal, glass, ceramic, porcelain, or polymeric material. Such parts shall be contained in the enclosure during normal maintenance and use.

Exception No. 1: A current-carrying part of a wiring device (such as the screw shell and center contact of a lampholder, the lampholder contacts, starter holder contacts, or similar components of a fluorescent luminaire) that are normally fitted with a functional component (a lamp, a starter, or similar component) during use of the display is not required to be additionally enclosed.

Exception No. 2: A component, such as a ballast, that has an integral outer housing that has been evaluated as an enclosure is not required to be additionally enclosed.

Exception No. 3: A power-supply cord is not required to be contained within the display other than at the connection point to internal components.

Exception No. 4: Components in a Class 2 or LPS circuit do not need to be in an enclosure, but if one is provided it shall comply with 12.5 – 12.9.

12.5.2 The location of the terminal box or compartment in which the power supply connections to a showcase are to be made shall be such that the connections are readily accessible for inspection after the cabinet has been installed.

12.6 Wet location enclosures

12.6.1 An enclosure or enclosures shall be so constructed as to prevent the wetting of live parts or electrical components or wiring not identified for use in contact with water, and to reduce the risk of electric shock due to weather exposure. Parts identified for use in contact with water include flexible cords marked "W", liquid tight flexible metal conduit, outlet boxes marked for use in outdoors, and rigid conduit.

Exception: Wetting of the outer surface of the glass envelope of a lamp is not prohibited.

12.6.2 To determine compliance with 12.6.1, a complete assembly is to be subjected to the rain and sprinkler tests as specified in Sections 64 – 70, Performance.

12.7 Metallic electrical enclosures

12.7.1 A display shall be formed and assembled so that it will have the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without increasing the risk of fire, electric shock or injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

12.7.2 For unreinforced, flat surfaces in general, cast metal shall not be less than 1/8 inch (3.2 mm) thick, except that malleable iron may be not less than 3/32 inch (2.4 mm) and die cast metal may be not less than 5/64 inch (2.0 mm) thick. Corresponding thicknesses of not less than 3/32 inch (2.4 mm), 1/16 inch (1.6 mm), and 3/64 inch (1.2 mm), respectively, may be acceptable if the surface under consideration is curved, ribbed, or otherwise reinforced, or if the shape or size, or both, of the surface is such that the necessary mechanical strength is provided.

12.7.3 Sheet metal shall comply with Table 12.2.

Table 12.2
Thicknesses of sheet-metal electrical enclosure

Material	Minimum thickness, inch (mm)					
	Knockouts and other points of connection for a wiring system		Sheet-metal electrical enclosure		Recessed sheet-metal electrical enclosure	
Uncoated sheet steel	0.036	(0.91)	0.025	(0.64)	0.023	(0.58)
Sheet aluminum	0.050	(1.27)	0.035	(0.89)	0.029	(0.74)

12.8 Knockouts

12.8.1 A knockout for a 1/2-in or larger trade-size conduit shall be surrounded on both the inside and outside surfaces by a concentric flat surface to permit installation of a locknut. The flat surface shall extend in all directions beyond the edge of the knockout for a distance not less than that specified in Table 12.3.

Table 12.3
Diameter of knockout and width of surrounding flat surface

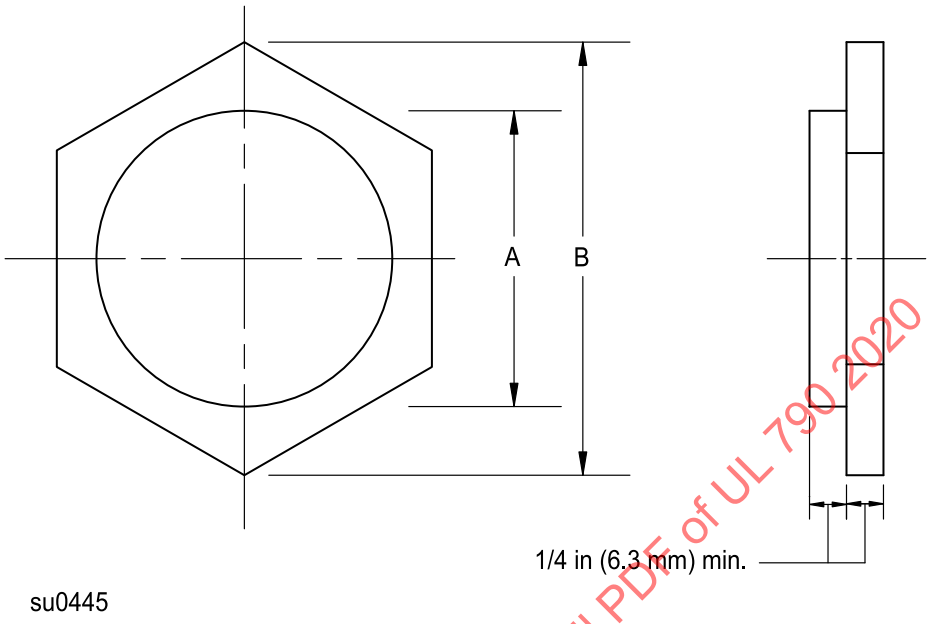
Trade Size of Conduit	Knockout diameter		Minimum width of flat surface surrounding knockout	
	Inches[a]	(mm)	Inches	(mm)
1/2	0.875	(22.23)	0.133	(3.38)
3/4	1.109	(28.17)	0.156	(3.96)
1	1.375	(34.93)	0.198	(5.03)
1-1/4	1.734	(44.04)	0.274	(6.96)

[a] A plus tolerance of 0.031 in (0.79 mm) and a minus tolerance of 0.015 in (0.38 mm) applies to the knockout diameter. Knockout diameters are to be measured other than at points where a tab remains after removal of a knockout.

12.8.2 When the concentric flat surface required in 12.8.1 is not provided, the acceptability of the flat surface surrounding a knockout on both the inside and outside surfaces is able to be determined by application of a test gauge as illustrated in Figure 12.1 which has the dimensions specified in Table 12.4. To use the gauge, the knockout is to be removed and the appropriate trade size of test gauge is to be inserted in the resulting opening from either side of the enclosure. It is not prohibited that the gauge be offset from the center of the opening, and rotated so that the flat surface including all points of the hexagonal portion of the gauge will be in intimate contact with the surface of the enclosure. The test gauge is then to be inserted in the resulting opening from the opposite side of the enclosure with the same degree and position of offset from the center used on the other side. The flat surface, including all points of the hexagonal portion of the gauge, is to be in intimate contact with the surface of the enclosure as the gauge is rotated through an angle of at least 60 degrees. The test gauge is not to be canted or tilted to make the required contact with the surface of the enclosure.

Figure 12.1

Dimensions of test gauges for flat surfaces



A – Nominal diameter of conduit

B – Maximum diameter of locknut

Table 12.4
Dimensions of test gauges for flat surfaces surrounding knockouts

Trade Size of Conduit	Nominal Knockout diameter		Nominal diameter of conduit		Maximum diameter of locknut	
	Inches	(mm)	Inches[a]	(mm)	Inches[b]	(mm)
1/2	0.875	(22.23)	0.133	(3.38)	1.140	(28.96)
3/4	1.109	(28.17)	0.156	(3.96)	1.420	(36.07)
1	1.375	(34.93)	0.198	(5.03)	1.770	(44.96)
1-1/4	1.734	(44.04)	0.274	(6.96)	2.281	(57.94)

[a] Nominal outside diameter of rigid conduit. Tolerances for test gauge: ±0.001 inch (0.03 mm).

[b] Maximum diameter of locknut. Tolerances for test gauge: plus 0.001 inch (0.03 mm), minus 0.000 inch (0.00 mm).

12.9 Electrical enclosures of polymeric material

12.9.1 A polymeric material enclosure of electrical parts shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, as applicable to polymeric enclosures including tests.

Exception No. 1: Components in a SELV circuit shall comply with UL 746C but only the HWI needs to be evaluated under the electrical properties.

Exception No. 2: Components in a LVLE circuit do not need to be in an enclosure, but if one is provided it shall comply with UL 746C, except the flame rating and electrical properties shall be in accordance with Table 12.5.

Table 12.5
Non-Metallic Material Requirements for LVLE and 15 Watt Circuits

Display type	Energy source		
	Minimum flammability ratings for enclosure material[a]		Electrical properties
	15 watts or less[b]	LVLE	LVLE
Portable	HB	HB	HWI only
Stationary	HB	V-1	HWI only
Fixed	HB	V-1	HWI only

[a] Complies with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, 12 mm flame test for HB, 20 mm flame test for V-0, V-1, V-2 materials, and 127 mm flame test for 5V materials.

[b] 15 watts as measured under any condition of loading including open circuit and short circuit.

12.9.2 A polymeric material used for electrical insulation or an enclosure shall be fabricated in accordance with the Standard for Polymeric Materials – Fabricated Parts, UL 746D.

Exception: A polymeric material that is fabricated in the same location where final assembly takes place and where no blending or compounding operations are involved is not required to comply with this requirement.

12.10 Barriers

12.10.1 The enclosure of a display shall reduce the risk of molten metal, burning insulation, flaming particles, or similar materials falling on combustible materials, including the surface upon which the display is supported.

12.10.2 The requirement in 12.10.1 necessitates that a switch, a relay, a solenoid, or similar device be individually and completely enclosed, except for terminals, unless it is shown that malfunction of the component does not result in a risk of fire, or there are no openings in the bottom of the display enclosure. It also necessitates the use of a barrier:

a) Under an electrical component unless:

1) The structural parts of the display provide the equivalent of such a barrier;

2) The protection provided with the electrical component is such that no burning insulation or molten material falls to the surface that supports the display when the electrical part is energized under each of the following fault conditions:

i) Open main winding;

ii) Open starting winding;

iii) Starting switch short-circuited;

iv) Capacitor of permanent-split capacitor motor short-circuited – the short circuit is to be applied before the motor is energized, and the rotor is to be locked; and

v) A component fault condition.

3) A motor complying with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1; and

i) The Standard for Impedance Protected Motors, UL 1004-2; or

ii) The Standard for Thermally Protected Motors, UL 1004-3 as appropriate for the over temperature protection incorporated with the motor construction:

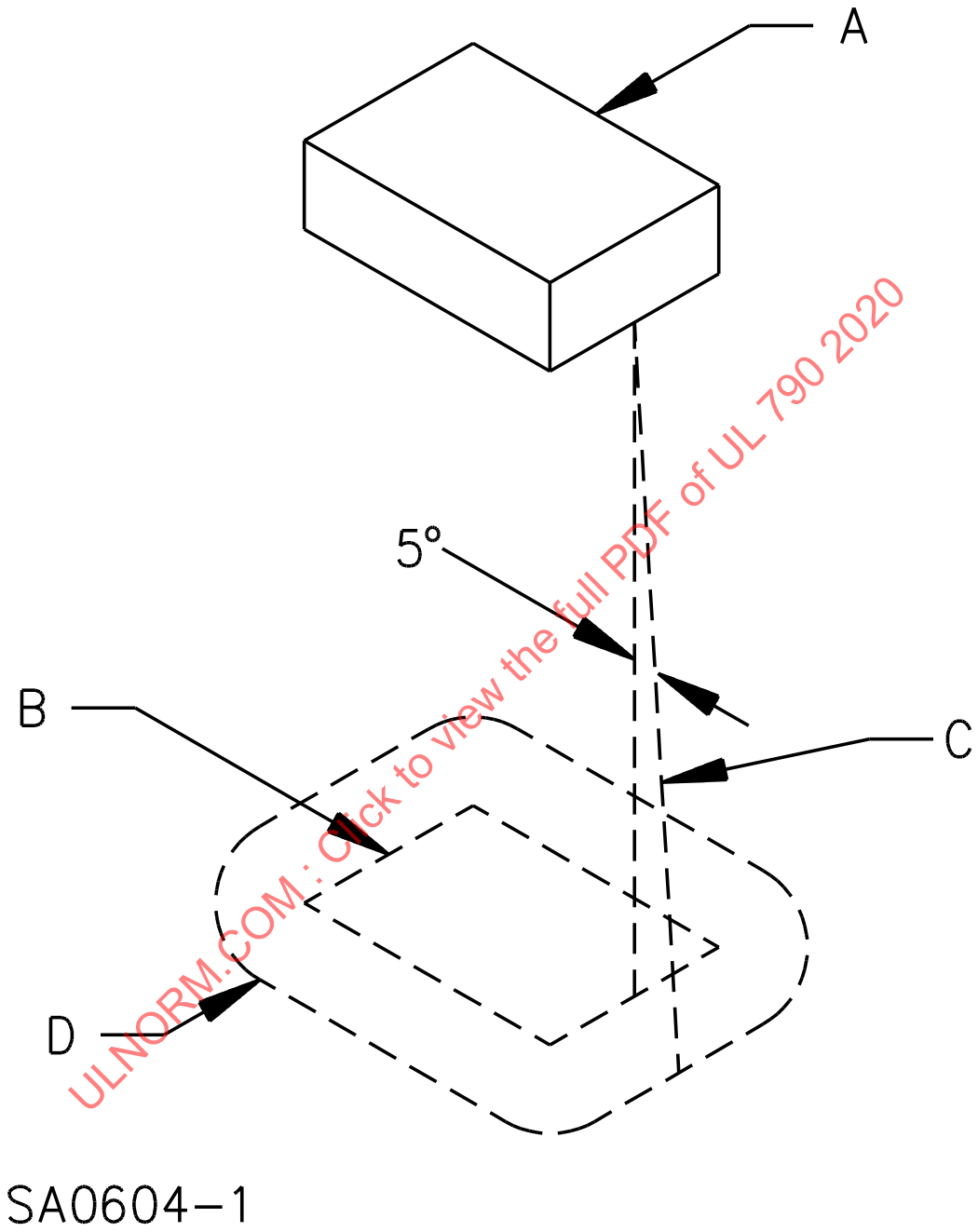
b) Under wiring, unless rated VW-1.

12.10.3 The barrier specified in 12.10.2 shall be of noncombustible material or shall comply with the Internal Barriers Section in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and shall have a comparative tracking index (CTI) of 3.

12.10.4 The barrier specified in 12.10.2 shall be horizontal, shall be located as illustrated in Figure 12.2, and shall not have an area less than that described in Figure 12.2. Openings for drainage, ventilation, or similar condition, are not prohibited from being employed in the barrier, when such openings do not allow molten metal, burning insulation, or similar materials to fall on combustible material.

Figure 12.2

Location and extent of barrier



A – Region to be shielded by barrier. This consists of the entire component when it is not otherwise shielded and consists of the unshielded portion of a component that is partially shielded by the component enclosure or equivalent.

B – Projection of outline of component on horizontal plane.

C – Inclined line that traces out minimum area of barrier. The line is always tangent to the component, 5 degrees from the vertical, and oriented so that the area traced out on a horizontal plane is maximum.

D – Location (horizontal) and minimum area for barrier. The area that is included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

12.11 Openings

12.11.1 General

12.11.1.1 General purpose open holes, such as ventilating open holes, shall be located more than 13 mm (0.5 in) from the mounting surface of a display and shall comply with the following:

a) The area of each open hole shall not exceed 10 cm^2 (1.5 in^2).

b) The total area of holes shall be not more than 15 percent of the total area of the surface in which the hole or holes are located.

c) The open holes shall not be located in the mounting surface, in a canopy, or directly below electrical parts, as shown in Figure 12.2, that are required to be enclosed, unless the parts:

1) Are protected by a barrier in accordance with 12.10;

2) Have demonstrated compliance with the applicable normal and abnormal test requirements; or

3) Are constructed so as not to present a risk of fire under any foreseeable conditions.

12.11.2 Openings, wet locations

12.11.2.1 An opening for the connection of conduit or for an auxiliary part shall be threaded.

Exception No. 1: If the rain and sprinkler tests as described in Sprinkler Test, Section 67 and Rain Test, Section 68, show no entrance of water into the display with the opening(s) open, the opening(s) are not required to be threaded.

Exception No. 2: If a conduit fitting intended for use in wet locations is provided that complies with the requirements in the Standard for Conduit, Tubing, and Cable Fittings, UL 514B, the opening(s) are not required to be threaded.

12.11.2.2 An open drain hole shall be provided on all displays to prevent the accumulation of water above a level that results in the wetting of an electrical part or opening for the connection of conduit for an auxiliary part. The hole shall be as specified in Table 12.6.

Exception: A display that has been subjected to the rain or sprinkler test are not required to be provided with a drain hole if no water enters the display.

Table 12.6
Size of drain holes

Opening Shape	Minimum Dimensions		Minimum Area		Maximum Dimensions		Maximum Area	
	Inch	(mm)	$Inch^2$	(mm^2)	Inch	(mm)	$Inch^2$	(mm^2)
Slot (Width)	1/8	(3.2)	0.012	(7.74)	3/8	(9.6)	1-1/2	(9.68)
Square (Side)	1/8	(3.2)	–	–	1/2	(12.7)	–	–
Round (Diameter)	1/8	(3.2)	–	–	1/2	(12.7)	–	–
Irregular	–	–	0.012	(7.74)	–	–	1-1/2	(9.68)

12.12 Doors or covers

12.12.1 A door or a cover of an electrical enclosure that provides access to any overload protective device requiring resetting or renewal shall be hinged or otherwise attached in an equivalent manner.

12.12.2 Means shall be provided for holding the door or cover over a fuseholder in a closed position, and the door or cover shall be tight-fitting.

12.13 Mounting means

12.13.1 An opening provided for mounting shall be located or guarded so that a nail, hook, or similar part does not reduce spacings, displace a part that creates a risk of fire or electric shock, and does not contact one of the following:

a) An uninsulated live part;

b) Magnet wire;

c) Internal wiring; or

d) Any other part that creates a risk of fire or electric shock.

12.13.2 A display intended to be mounted shall employ a mechanical means of mounting that does not rely on friction.

12.13.3 An adhesive used as the sole means of support to secure a display or part of a display which if displaced could cause a risk of injury shall be investigated to determine that it reliably secures the product. General – Adhesives, Function Analysis, and Program of Investigation, in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, shall be used when performing the investigation. The maximum force as defined in UL 746C shall be four times the weight of the part or loaded display under investigation as received and two times the weight of the part or display after the adhesive has been subjected to the environmental conditioning.

12.14 Polymeric supporting devices

12.14.1 A polymeric device which provides mechanical support or electrical insulation or separation whose deterioration would reduce spacings between uninsulated live parts or could result in a risk of injury created due to softening or melting of the support means shall comply with mechanical RTI temperature limits (with and without impact) for the material in the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B.

12.15 Glass components

12.15.1 Edges of glass accessible during normal use or maintenance shall be seamed, swiped, fire-polished, or similarly treated to eliminate sharpness. The Standard for Tests for Sharpness of Edges on Equipment, UL 1439, shall be used to determine compliance.

12.15.2 Glass components less than or equal to 1 ft^2 (0.09 m^2) or that are irregular shaped and fit within a 1 ft^3 (0.03 m^3) box do not have minimum thickness, securement or impact resistance requirements.

12.15.3 Glass components larger than specified in 12.15.2 but less than 9 ft^2 (0.84 m^2) shall have a minimum thickness of 1/8 inch (3.2 mm) and shall meet the requirements of the Standard for Safety Glazing Materials Used in Buildings – Safety Performance Specifications and Methods of Test, ANSI Z97.1, Class A, the Standard for Glass in Building – Thermally Toughened Soda Lime Silicate Safety

Glass, EN 12150, or have a minimum thickness of 1/8 inch (3.2 mm) and perform according to the requirements specified in the Impact Test, 34.1.

12.15.4 Glass components larger than or equal to 9 ft^2 (0.84 m^2) shall have a minimum thickness of 1/8 inch (3.2 mm) and meet the Standard for Safety Glazing Materials Used in Buildings – Safety Performance Specifications and Methods of Test, ANSI Z97.1, Class A or the Standard for Glass in Building – Thermally Toughened Soda Lime Silicate Safety Glass, EN 12150, requirements.

12.15.5 Glass components larger than 1 ft^2 (0.09 m^2) shall be subjected to the glass Retention Test, 34.2.

12.16 Joints

12.16.1 A method of making joints between metal parts and of fastening arms and supports shall be such as to provide strength and rigidity to prevent turning that could result in the movement of a wire or wiring device after the assembly is completed.

12.16.2 A screw joint may be locked by solder, a setscrew, sealing, or the equivalent.

12.16.3 Friction alone between parts is not an acceptable means of preventing turning. Turning may be prevented by a lock washer, applied as intended, a locknut seated against another nut, or by an equivalent method.

12.16.4 Sheet metal nuts may be used to prevent turning when supplied as part of an armored-cable or flexible-conduit connector. Sheet metal nuts made of heat-treated steel may be used for assembly, to prevent turning of threaded tubing not larger than 1/8-inch (3.16-mm) pipe size, and on 1/4-inch (6.35-mm) and smaller diameter bolts and studs.

12.16.5 A swivel joint shall be constructed so that turning will not damage the insulation on the wires. If wires passing through the joint are concealed, the joint shall be constructed so that rotation is limited to no more than 360 degrees.

13 Protection Against Corrosion

13.1 Dry locations

13.1.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, powder coating, or other equivalent means, when corrosion of such parts results in a risk of fire, electric shock, or injury to persons.

Exception: This requirement does not apply to bearings, laminations, or minor parts of iron or steel, such as washers, screws, or similar parts.

13.1.2 Copper, aluminum, and alloys of copper and aluminum, stainless steel, and similar materials having inherent resistance to atmospheric corrosion may be used without additional corrosion protection.

13.1.3 All exposed, exterior and interior, surfaces of ferrous metal parts shall be protected by one of the following:

a) A coating of nonferrous metal applied by the hot dip process method;

b) A plating of nonferrous metal applied either by electro-deposition or by chemical means;

c) A coating of vitreous enamel;

d) Baked paint, powder coating or similar type of coating; or

e) Air-dry paint.

13.1.4 When deterioration of a liquid container provided as a part of a display results in a risk of fire or electric shock, the container shall be of a material that is resistant to corrosion by the liquid with which it is intended to be used.

13.2 Damp and wet locations

13.2.1 The inside and outside surfaces of cast ferrous metal, sheet steel, or ferrous tubing shall be protected against corrosion by one of the coatings described in Table 13.1.

Exception No. 1: Other finishes, including paints, special metallic finishes and combinations of the two that have, by comparative tests with galvanized-sheet steel conforming with item (A) Type G90 of Table 13.1, indicate they provide equivalent protection, are not prohibited from being used.

Exception No. 2: A metal part, such as a decorative part, that is not required for conformance with this standard is not required to be protected against corrosion.

Exception No. 3: Stainless steel is not required to be additionally protected against corrosion.

Exception No. 4: Edges, fasteners, and welds complying with 13.2.1 – 13.2.5 are not required to be additionally protected against corrosion.

Exception No. 5: If the inside surfaces of the display are protected from the elements such that no water enters the display during the rain and sprinkler tests of Sprinkler Test, Section 67 and Rain Test, Section 68, the inside surfaces may be provided with corrosion protection equivalent to that specified in 13.1, Protection Against Corrosion – Dry Locations.

Table 13.1
Sheet steel coatings

Type of Coating	Inches	(mm)	Type or Thickness[a] Description
(A) Hot-dipped mill galvanized steel	G90[b]	–	–
	G60[b]	–	with 1 coat of outdoor paint[c]
	A60[b]	–	with 1 coat of outdoor paint[c]
(B) Zinc coating other than Type (A)	0.00061	(0.0155)[d]	–
	0.00041	(0.0104)[d]	with 1 coat of outdoor paint[c]
(C) Cadmium coating	0.0010	(0.0254)	–
	0.00075	(0.01905)	with 1 coat of outdoor paint[c]
	0.0005	(0.0127)	with 1 coat of outdoor paint[c]
(D) Vitreous enamel[e]	–	–	–

[a] As determined by the Standard Guide for Measurement of Electrodeposited Metallic Coating Thicknesses by the Dropping Test, ASTM B555.

[b] Conforming with the coating designation G90, G60, or A60 in Table 1 of the Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M, with no less than 40 percent of the zinc on any side based on the minimum single spot test requirement in this ASTM standard.

[c] Identified as outdoor paint by paint manufacturer.

[d] Average thickness with a spot minus tolerance of 0.00007 inch (0.00178 mm).

[e] Acceptable on sheet steel at least 0.026 inch (0.66 mm) thick.

13.2.2 Hinges, bolts, and fasteners made of ferrous materials shall be protected against corrosion as described in 13.1, Protection Against Corrosion, Dry Locations.

Exception: Hinge pins need not be provided with the corrosion protection required in 13.2.1.

13.2.3 The adequacy of a coating on hinges, bolts, and fasteners is not prohibited from being determined by visual inspection.

13.2.4 Punched holes and cut edges in ferrous material are not required to be corrosion protected.

13.2.5 Welds in iron or steel (other than stainless steel) shall be painted with one coat of any outdoor paint.

Exception: One coat of any indoor paint is acceptable over a spot weld on galvanized steel.

14 Accessibility of Uninsulated Live Parts and Film-Coated Wire

14.1 To reduce the risk of unintentional contact that results in a risk of electric shock from an uninsulated live part or film-coated wire, an opening in an enclosure shall comply with either:

a) For an opening that has a minor dimension (see 14.5) less than 1 inch (25.4 mm), such apart or wire shall not be contacted by the probe illustrated in Figure 14.1.

b) For an opening that has a minor dimension of 1 inch (25.4 mm) or more, such a part or wire shall be spaced from the opening as specified in Table 14.1.

Exception No. 1: A motor is not required to comply with these requirements when it complies with the requirements in 14.2.

Exception No. 2: Does not apply to circuits in LVLE or SELV circuits.

Figure 14.1

Articulate probe with web stop

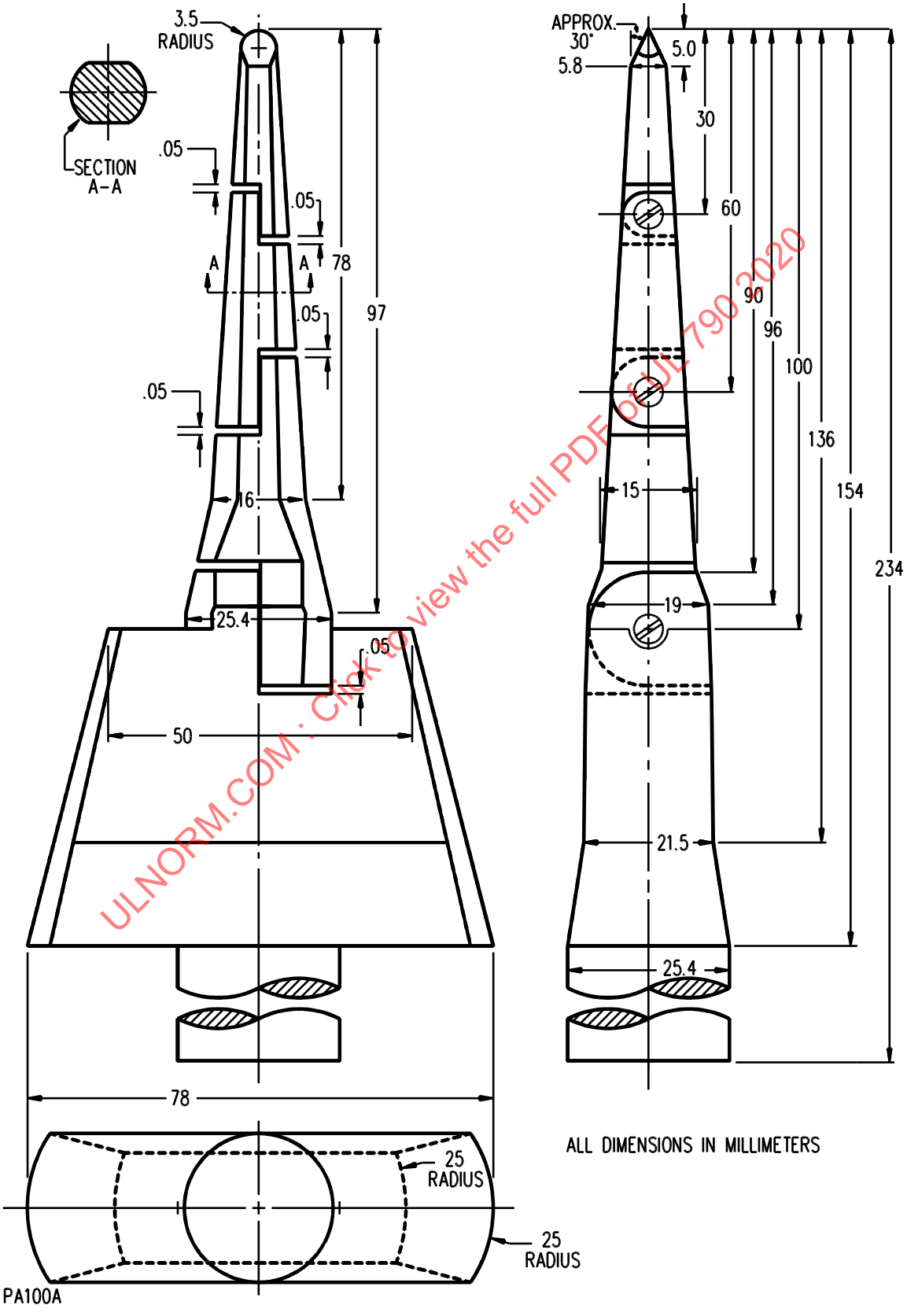


Table 14.1
Minimum required distance from an opening to a part involving a risk of electric shock

Minimum dimension[a] of opening		Minimum distance from opening to part	
inches	(mm)[b]	inches	(mm)[b]
3/4[c]	(19.1)	4-1/2	(114)
1[c]	(25.1)	6-1/2	(165)
1-1/4	(31.8)	7-1/2	(191)
1-1/2	(38.1)	12-1/2	(318)
1-7/8	(47.6)	15-1/2	(394)
2-1/8	(54.0)	17-1/2	(445)
d	d	30	(762)

[a] See 14.5.

[b] Between 3/4 and 2-1/8 inches (19.1 and 54.0 mm), interpolation is to be used to determine a value between values specified in the table.

[c] Any dimension less than 1 inch (25.4 mm) applies to a motor only.

[d] More than 2-1/8 inches (54.0 mm), and not more than 6 inches (152 mm).

14.2 With respect to a part or wire as specified in 14.1, in an integral enclosure of a motor as specified in the Exception to 14.1:

a) An opening that has a minor dimension (see 14.5) less than 3/4 inch (19.1 mm) is able to be used when:

1) Film-coated wire is not able to be contacted by the probe illustrated in Figure 14.3;

2) In a directly accessible motor (see 14.6), an uninsulated live part is not able to be contacted by the probe illustrated in Figure 14.3; and

3) In an indirectly accessible motor (see 14.6), an uninsulated live part is not able to be contacted by the probe illustrated in Figure 14.2.

b) An opening that has a minor dimension of 3/4 inch (19.1 mm) or more is able to be used when a part or wire is spaced from the opening as specified in Table 14.1.

Figure 14.2

Straight probe

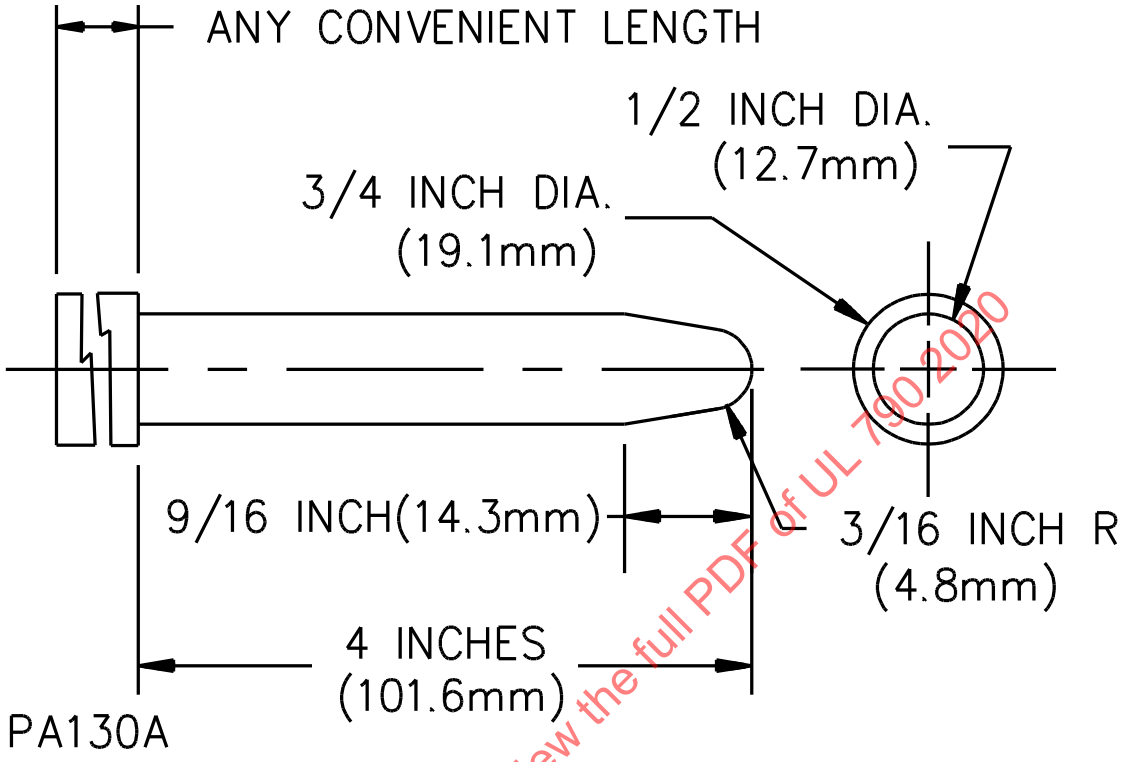
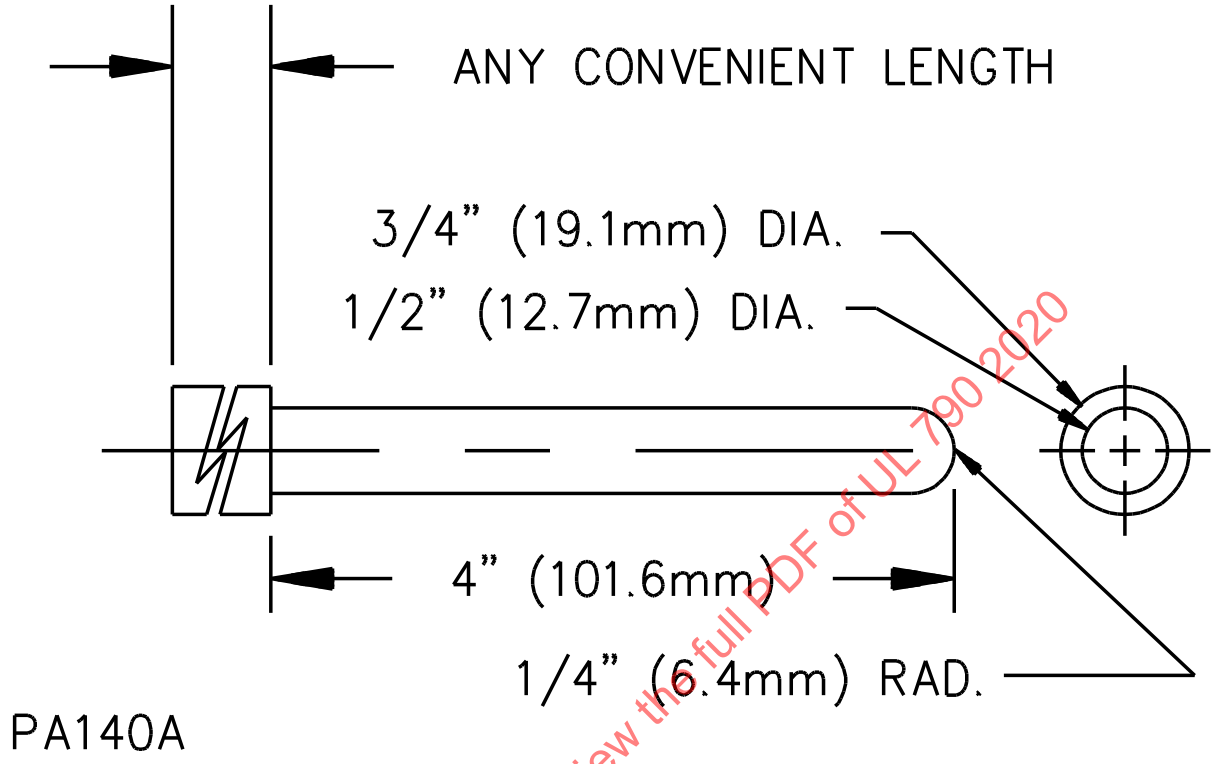


Figure 14.3

Straight probe



14.3 The probes specified in 14.1 and 14.2 and illustrated in Figure 14.1 – Figure 14.3 shall be applied to any depth that the opening allows, and shall be rotated or angled before, during, and after insertion through the opening to any position required to examine the enclosure. The probe illustrated in Figure 14.1 shall be applied in any configuration allowed by the construction; and, when required, the configuration shall be changed after insertion through the opening.

14.4 The probes specified in 14.2 and 14.3 shall be used as measuring instruments to investigate the accessibility provided by an opening, and not as instruments to investigate the strength of a material: they shall be applied with the minimum force required to determine accessibility.

14.5 With reference to the requirements in 14.1 and 14.2, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that is able to be inserted through the opening.

14.6 With reference to the requirements in 14.2, an indirectly accessible motor is a motor that is accessible only by opening or removing a part of the outer enclosure (such as a guard or panel) that is able to be opened or removed without using a tool, or that is located at such a height or is otherwise guarded or enclosed so that it is not contacted during normal use of the display. A directly accessible motor is one that is able to be contacted without opening or removing any part or that is located so as to be accessible to contact during normal use of the display.

14.7 During the examination of a display to determine compliance with 14.1 or 14.2, a part of the enclosure that is able to be opened or removed by the user without a tool (such as an accessory, the cover over an opening for an operating adjustment, or similar components) is to be opened or removed.

14.8 With reference to the requirements in 14.1 and 14.2, an insulated brush cap is not required to be additionally enclosed.

15 Grounding and Bonding

15.1 General

15.1.1 Does not apply to circuits in LVLE or SELV circuits.

15.2 Grounding

15.2.1 A product shall have provision for grounding all exposed non-current carrying conductive parts that may become energized and any receptacles. There shall also be provision for grounding all internal, uninsulated non-current carrying parts that can become energized and that can be contacted during servicing by the user or service personnel. A part shall be considered capable of becoming energized if failure of electrical spacing or insulation or both can result in conductive connection to a current carrying part.

Exception: A display provided with a means of double insulation in accordance with the applicable requirements in the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097, or the Reference Standard for Double Insulation Systems for Use in Electronic Equipment, UL 2097, shall not be provided with grounding. A display that complies with the requirements for double insulation shall also be marked with the double insulation symbol. See 75.10.

15.2.2 When a grounding means is provided, whether required or not, it shall be in accordance with 15.2.4. When the display is cord connected, the grounding means shall also comply with the requirements in 15.2.7. All exposed un-energized metal parts and all un-energized metal parts within the enclosure that are exposed to contact during user servicing and are able to become energized during or after a fault condition shall be reliably connected to the means for grounding.

15.2.3 The following are able to be used as a means for grounding:

a) In a display intended to be permanently connected, an equipment-grounding terminal or lead. See 15.2.8 and 15.2.9; or

b) In a cord-connected display, an equipment-grounding conductor in the power-supply cord.

15.2.4 The grounding conductor shall be secured to the frame or enclosure of the display by means of a screw, other than sheet metal, that is not removed during any servicing operation not involving the power-supply cord, or by other equivalent means. Servicing includes repair of the display by a qualified service person. The grounding connection shall penetrate nonconductive coatings, such as paint or power coating and shall have two full turns in the metal.

15.2.5 The grounding conductor of a cord-connected display shall be connected to the grounding member of an attachment plug. The grounding member shall be fixed.

15.2.6 A separable connection, such as that provided by an attachment plug and a mating connector or receptacle, shall be such that the equipment-grounding connection is made before or at the same time as the connection to and broken after or at the same time as the disconnection from the supply conductors.

Exception: Interlocked plugs, receptacles, and connectors that are not energized when the equipment-grounding connection is made or broken are able to be used without the grounding connection described above.

15.2.7 When a display is intended to be grounded and is provided with means for separate connection to more than one power supply, each separate connection shall be provided with a means for grounding. The means for grounding shall be bonded together.

15.2.8 A terminal intended solely for the connection of an equipment-grounding conductor shall be capable of securing a conductor of the size required for the application.

15.2.9 A connection device that depends on solder alone shall not be provided for connecting the equipment-grounding conductor.

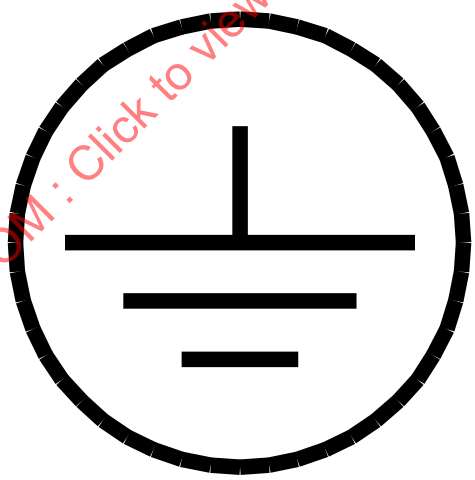
15.3 Grounding identification

15.3.1 The surface of an insulated lead intended solely 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.

15.3.2 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal or slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified, such as by being marked with the grounding symbol in Figure 15.1, ″G″, ″GR″, ″GRD″, ″Green″, ″Ground″, or ″Grounding″, or by a marking on a wiring diagram provided on the display.

Figure 15.1

Grounding symbol



15.4 Bonding

15.4.1 Accessible non energized metal or other conductive parts that may become energized and are not connected directly to the grounding conductor shall be bonded to the ground connection point.

15.4.2 A ground path for electrical current shall be provided between all parts of a metal electrical enclosure containing electrical parts or wiring. See Grounding-Impedance Test, Section 53.

15.4.3 Flexible metal conduit longer than 6 ft (1.8 m) in total length shall not be relied upon for the ground path through an individual display or between displays that are connected during installation.

15.4.4 The grounding means through an individual display and between displays that are connected during installation shall have an ampacity at least equivalent to that of the supply conductors.

15.4.5 A display that employs quick-connect means for electrically connecting the branch-circuit power supply from display to display shall be constructed so that the grounding connection is made prior to all other supply connections.

15.4.6 A non-energized metal part that is able to become energized shall be bonded to the ground return path by means of a conductor not smaller than the supply wires of the display.

16 Polarity and Identification

16.1 A supply cord conductor that is intended to be grounded shall be marked in accordance with Table 11.3 and shall be connected to the wide blade of a 2-wire attachment plug, or the left-hand blade of a 3-wire attachment plug when looking at the face of the plug with the grounding pin up. See Figure 11.1.

16.2 The screwshell or screwshell contact of each Edison-Base lampholder shall be connected to the grounded supply conductor.

16.3 A switch, fuse or other protective device shall not be connected to the grounded supply conductor.

Exception: When the switch, fuse or other protective device simultaneously interrupts all non-grounded conductors of the supply circuit, it is not prohibited from also being connected to the grounded supply conductor.

16.4 Any portion of a display that is able to be detached, thereby breaking electrical connections – such as a detachable power supply cord, interlocking connectors, or cord a connector – shall be constructed such that it is only able to be assembled in the manner that maintains correct electrical polarity.

17 Separation of Circuits

17.1 Conductors of circuits operating at different voltage potentials shall be reliable separated from each other unless they are each provided with insulation acceptable for the highest voltage potential involved.

17.2 An insulated conductor shall be reliably retained so that it cannot contact an uninsulated energized part of a circuit operating at a different potential.

17.3 In a compartment that is intended for the field installation of conductors, and that contains provision for connection of Class 2, Class 3, Class 1, power, or lighting circuit conductors, a barrier shall be provided to separate the conductors operating at different circuit voltage potentials, or the arrangement of the compartment shall be such that a minimum spacing of 1/4-inch (6.4-mm) can be maintained between the conductors of the different circuits including the conductors to be field installed.

18 Internal Wiring

18.1 Conductors

18.1.1 A passage in a sheet metal wall through which insulated wires are routed, shall be provided with provision to avoid contact with sharp edges or burrs, screw threads, sharp fins, moving parts, drawers, or similar components that are able to abrade or otherwise damage the wire insulation in accordance with Protection of Cord and Wiring, 11.7.

18.1.2 A metal clamp used for routing or securing internal wiring shall be provided with smooth, rounded edges. Auxiliary non-conducting mechanical protection shall be provided under a clamp at which pressure is exerted on an insulated conductor.

18.1.3 Internal wiring shall consist of wires of a type or types that are determined to meet the requirements for the intended use with respect to flexibility, mechanical abuse, temperature, ampacity, and voltage.

18.1.4 Conductors that can be flexed after installation, including during repositioning of the display, shall be stranded, secured in a manner that prevents cutting of or abrasion, and mechanically spaced apart so that current-carrying parts of opposite polarity are not inadvertently shorted.

Exception: Solid conductors are able to be employed between displays when they form fixed angles and the raceway allows for inspection and replacement of the wiring when configurations are changed.

18.1.5 Conductors operating at different voltage potentials shall be separated from each other by one or more of the following:

a) Enclosing the different voltage conductors in a separate wiring channel;

b) Providing a partition of grounded metal or material that complies with the requirements for internal barriers in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, between the conductors of the different voltages;

c) Providing reliable physical separation of at least 1/4-inch (6.4-mm) between conductors of the different voltages; or

d) Insulation provided on all conductors rated for the highest voltage potential of any conductor.

18.1.6 Internal conductors and connectors provided for wiring between components shall be subjected to the Strain Relief Test, Section 51.

Exception No. 1: This test is not required if the conductors and connectors are provided with a suitable electrical enclosure such that they are not subject to mechanical strain.

Exception No. 2: Wiring totally within a Class LVLE circuit does not require strain relief.

18.1.7 Conductors of any size are permitted when the conductors are in LVLE circuits only and are physically separated from all other non-LVLE circuits, such as by a barrier or reliably fixed spacing of minimum 6.4 mm (0.25 in).

18.1.8 LVLE circuit conductors shall comply with any of the following:

a) Be a jacketed type CL3, CL3R, CL3P, Power-limited Circuit Cable;

b) Be a jacketed type cord with a minimum 0.33 mm (0.013 inch) jacket thickness and the combined conductor and jacket thickness of not less than 0.33 mm (0.013 inch); or

c) The load side conductors provided with a power supply that complies with the Standard for Low Voltage Transformers – Part 3, Class 2 and Class 3 Transformers, UL 5085-3, or the Standard for Information Technology Equipment Safety – Part 1: General Requirements, UL 60950-1.

18.2 Splices

18.2.1 A splice or connection shall be mechanically secured and provide electrical continuity. A soldered connection shall be mechanically secured before being soldered. A splice shall not be made in an area other than a specified wiring compartment. For example, a splice shall not be located inside conduit.

18.2.2 A splice shall be provided with insulation equivalent to that of the conductors involved.

18.2.3 In determining when splice insulation consisting of fabric, thermoplastic, or other type of tubing is able to be used, factors to be evaluated include its dielectric properties, use temperature, and similar conditions. Thermoplastic tape wrapped over a sharp edge shall not be used.

18.2.4 Stranded internal wiring that is connected to a wire-binding screw shall be provided with a means to restrict loose strands of wire from contacting other uninsulated energized parts not always of the same polarity or non-energized metal parts. This is able to be accomplished by use of a pressure-type spade terminal connector with turned-in or turned-up ends, by a closed loop connector, or other equivalent means.

18.3 Cord used for internal wiring

18.3.1 Cord may be used for internal wiring if a strain relief is provided where the cord enters or exits the interior of the display or cord may be routed within a display provided that it is visible along its length, or a removable cover, without the use of tools, is provided that allows visual inspection of the cord.

18.3.2 When cord is provided for internal wiring, it shall comply with the requirements in 18.1, Conductors, for the protection of conductors.

18.4 Conductors subject to flexing

18.4.1 Individual conductors or conductors assembled into groups that are subject to flexing in the normal use of the display shall be stranded.

18.4.2 Conductors subject to flexing in the normal use of the display shall comply with the Conductor Cycling Endurance Test, Section 52.

Exception: Conductors utilized in a LVLE circuit are not required to be subjected to the conductor cycling endurance test unless the circuit is relied upon for the safe operation of the display.

19 Spacings

19.1 Other than at wiring terminals, the spacing between uninsulated energized parts of opposite polarity and between an uninsulated energized part and a non-energized metal part that is exposed to contact by persons or that is able to be grounded shall not be less than the value specified in Table 19.1.

Exception No. 1: The inherent spacings of a component, such as a snap switch, are investigated on the basis of the requirements for the component.

Exception No. 2: This requirement does not apply when a spacing complies with the requirements in 19.4.

Table 19.1
Spacings at other than field-wiring terminals

Potential involved	Over surface		Through air	
Volts	inch	(mm)	inch	(mm)
0 – 50	1/16	(1.6)	1/16	(1.6)
51 – 125	1/4	(6.4)[a]	1/8	(3.2)[a]
126 – 250	1/4	(6.4)[a]	1/4	(6.4)[a]
251 – 600	1/2	(12.7)	3/8	(9.5)[a]

[a] Film-coated wire is identified as an uninsulated energized part. However, a spacing of not less than 3/32 inch (2.4 mm) over surface and through air between film-coated wire, rigidly supported and held in place on a coil, and a non-energized metal part is able to be used.

19.2 When an uninsulated energized part is not rigidly fixed in position by means other than friction between surfaces, or when a movable non energized metal part is in proximity to an uninsulated energized part, the construction shall be such that the required minimum spacing is maintained with the part in any position.

19.3 When an isolated non energized metal part is interposed between or is in close proximity to energized parts of opposite polarity, to an energized part and an exposed non energized metal part, or to an energized part and a non-energized metal part that is able to be grounded, the spacing shall not be less than 3/64 inch (1.2 mm) between the isolated non energized metal part and any one of the other parts previously specified, when the total spacing between the isolated non energized metal part and the two other parts complies with the value specified in Table 19.1.

19.4 An insulating lining or barrier of vulcanized fiber employed to maintain required spacings shall not be less than 1/32 inch (0.8 mm) thick, and shall be so located that it is not adversely affected by arcing.

Exception No. 1: Vulcanized fiber not less than 1/64 inch (0.4 mm) thick is able to be used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

Exception No. 2: Thinner vulcanized fiber or other insulating material is able to be used, when it complies with the Internal Barriers section of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C.

19.5 All uninsulated energized parts connected to different voltage potential circuits shall be spaced from one another as though they were parts of opposite polarity, in accordance with the requirements in 19.1 and 19.8 and shall be investigated on the basis of the highest voltage involved.

19.6 The spacing between uninsulated energized parts of opposite polarity and between such parts and non-energized metal that is able to be grounded in service is not specified for parts of low-voltage circuits.

19.7 The spacing between wiring terminals of opposite polarity, and between a wiring terminal and any other uninsulated metal part not of the same polarity, shall not be less than that specified in Table 19.2.

Table 19.2
Spacings at wiring terminals

Potential involved, volts	Minimum spacings, inch (mm)					
	Between wiring terminals, through air, or over surface		Between terminals and other uninsulated metal parts not always of the same polarity[a]			
			Over surface		Through air	
250 or less	1/4	(6.4)	1/4	(6.4)	1/4	(6.4)
More than 250	1/2	(12.7)[b]	1/2	(12.7)[b]	3/8	(9.5)

[a] Applies to the sum of the spacings involved where an isolated dead part is interposed.

[b] A spacing of not less than 3/8 inch (9.5 mm), through air and over surface, is able to be used at wiring terminals in a wiring compartment or terminal box when the compartment or box is integral with a motor.

19.8 At terminal screws and studs to which connections are made in the field by means of wire connectors, eyelets, or similar devices, spacings shall not be less than those specified in Table 19.1 when these devices are positioned at the minimum spacing.

19.9 As an alternative to the spacing requirements of Table 19.1, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, and are able to be used. The spacing requirements of UL 840 shall not be used for field wiring terminals and spacings to a non-energized metal enclosure.

19.10 It is anticipated that the level of pollution for indoor use equipment is pollution degree 2. Hermetically sealed or encapsulated enclosures, or coated printed wiring boards in compliance with the Printed Wiring Board Coating Performance Test of the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, are identified as pollution degree 1.

19.11 It is anticipated the equipment is rated overvoltage category II as defined in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

19.12 In order to apply Clearance B (controlled overvoltage) clearances, control of overvoltage shall be achieved by providing an overvoltage device or system as an integral part of the product.

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

20 Materials in Direct and Indirect Contact of Live Parts

20.1 Material in direct or indirect contact with uninsulated live parts other than magnet wire shall be porcelain or another material investigated and found acceptable in accordance with the requirements covering mechanical/electrical property considerations of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. These materials shall withstand the most severe conditions likely to be met in service.

Exception: Small parts and adhesives need not be investigated if they are:

a) Not relied upon to maintain the proper functioning of the device with regard to the likelihood of fire, electric shock, and injury to persons; and/or

b) Not relied upon to maintain separation between uninsulated live parts of opposite polarity, live parts, and accessible metal parts and/or uninsulated live parts and earth ground.

20.2 The material of any part of a base or body shall not introduce a risk of fire or shock by warping, creeping, or distorting under conditions of arcing, temperature, and mechanical stress that are likely to occur in service.

20.3 Material in contact with live parts other than magnet wire shall comply with Table 20.1 with respect to resistance to flame propagation, resistance to arc tracking, resistance to ignition from electrical sources, resistance to moisture absorption, dielectric strength, and mechanical strength. A material shall not display a loss of these properties beyond the minimum required level as a result of aging. It is presumed that the product is operating in a clean and dry environment. If another environment is involved, the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, shall be consulted.

Exception No. 1: Small parts and adhesives need not be investigated if they are:

a) Not relied upon to maintain the proper functioning of the device with regard to the likelihood of fire, electric shock, and injury to persons; and/or

b) Not relied upon to maintain separation between uninsulated live parts of opposite polarity, live parts, and accessible metal parts and/or uninsulated live parts and earth ground.

Exception No. 2: The application of the provisions of Section 9, Creepage Distances, of the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, may be used as an alternative to a material having the CTI (PLC) required by Table 20.1.

Exception No. 3: Commutator insulation material made of phenolic is acceptable with no further testing.

Exception No. 4: Materials in LVLE and SELV circuits shall only have an appropriate temperature rating, a dielectric value as specified in Table 20.1 and the defined HWI value.

Table 20.1
Performance levels

Flame Rating	Volume Resistivity (ohm-cm)	Dielectric Strength (Volts)	CTI (PLC)	HAI (PLC)	HWI (PLC)
HB	50×10^6	5,000	4	1	2
V-2, VTM-2	50×10^6	5,000	4	2	2
V-1, VTM-1	50×10^6	5,000	4	2	3
5V, V-0, VTM-0	50×10^6	5,000	4	3	4

20.4 A polymeric material shall have a mechanical with impact RTI and electrical temperature RTI of at least the temperature of the part measured during the normal Temperature Test – General, 49.1.

Exception: When the temperature measured during the normal Temperature Test – General, 49.1, is 50°C (122°F) or less, the polymeric material is not required to have an RTI rating.

20.5 Material used to support live parts or an insulating barrier shall be acceptable for continuous operation at the maximum temperature measured on the material during the Temperature Test, Section 49.

20.6 A small molded part such as a terminal block shall have mechanical strength and rigidity that withstands the stresses of actual service.

20.7 A molded part shall not exhibit softening of the material determined by handling immediately after the condition specified in 29.1, Conditioning of Polymeric Components, nor shall there be shrinkage, warpage, or other distortions as determined after cooling to room temperature that results in any of the following:

a) Reduction of spacings between uninsulated live parts of opposite polarity, uninsulated live parts and accessible dead or grounded metal, and uninsulated live parts and the enclosure below the minimum acceptable values;

b) Uninsulated live parts or internal wiring accessible to contact, or defeating the integrity of the enclosure so that acceptable mechanical protection is not afforded to internal parts of the equipment; or

c) Interference with the intended operation or servicing of the equipment.

21 Displays with Extendable Elements

21.1 A drawer or other pullout component shall incorporate a stop to reduce the likelihood of unintentional dislocation from the display.

21.2 A display that has multiple extendable elements shall be provided with a mechanism that only allows one pullout component at a time.

Exception: The display does not need to be provided with a mechanism provided it complies with the loading and stability tests in any configuration permitted.

22 Operator Attended Products

22.1 A display that requires the operator to be present to perform the intended function complies with the requirements in 12.2, Personal Injury, Entrapment, Pinch Points, and 12.3, Shear Considerations, and Mechanical Enclosures and Guards – Mechanical Considerations when all of the following conditions are met:

a) A display that is accessible to the public when the trained operator is not present shall be provided with a security lockout device that disables operation of the display to prevent nonqualified persons from operating the display;

1) A trained operator is considered present when they are within line-of-sight of the display and are within 20 ft (6.1 m) of the display.

2) The lockout device may be a passcode, proximity sensor that require a unique sensor to activate (such as RFID), a physical key, or other means that would prevent an untrained person to operate the display.

3) Where multiple displays are located within the same space and a proximity activation device is used as the access to allow movement of the display, each display shall have a separate code or equivalent restriction to allow movement of only the intended display within the specified proximity.

4) A passcode activation system shall automatically reset and lockout the movement of the display after a maximum of 2 minutes of inactivity. Inactivity is when the operator is no longer present.

b) Any point or part of the display that is considered to present an entrapment or personal injury hazard shall be visible to the operator such that they can determine the proximity of an individual to

the entrapment area when positioned at the operator controls while performing the intended function;

c) A control for the operation of the exposed movable part shall be a momentary contact type that when released all moving parts of the device that constitute a hazard are stopped. Non-momentary contact memory and remote controls shall not be used;

d) A switch that controls the direction of travel shall be capable of being stopped and the direction of travel reversed at any point in the operation of the display;

e) A switch that is used to control a movable part that can result in personal injury shall be guarded or located to prevent unintentional movement of the part; and

f) Upon power failure the display shall remain in the existing position. Upon reinstatement of power the display shall not move until the operator activates the switch controlling movement.

22.2 A product that complies with 22.1 shall be provided with installation and operation instructions in accordance with Section 87, Operator Attended Products Instructions.

23 Parts Subject to Pressure

23.1 Factory sealed systems

23.1.1 A component or system that is pressurized with fluids or gasses from the factory shall be subjected to the normal and abnormal test series for that display without rupture of the system or resulting in a risk of fire, shock or injury to persons.

23.1.2 A component or system with a polymeric containment part such as a hose, tubing, enclosure and the like, relied upon to contain the pressure, shall be subjected to the conditioning specified in 29.1, Conditioning of Polymeric Components, before subjecting the component or system to the normal and abnormal test series for the display.

23.2 Open systems and systems with pumps

23.2.1 A system other than specified in 23.1 or one that is intended to move the fluid or gas with a pump shall withstand, without rupture, a hydrostatic pressure equivalent to five times the maximum working pressure in accordance with Hydrostatic Pressure Test, Section 38.

Exception: The use of a pressure relief device is acceptable to release pressure before rupture provided the pressure relief device is determined to be reliable and the device shall relieve the pressure without presenting a risk of fire, shock or injury to persons.

24 Abnormal Conditions – General

24.1 When the conditions of intended operation are not representative of all conditions possible in service, a product shall not present a risk of fire, electric shock, or injury to persons when operated under such abnormal conditions and foreseeable misuse (likely using the display in a manner not intended by the manufacturer).

24.2 Continuous operation, malfunction of components, shorting of output circuits, failure of cooling fans, and likely misuses of the product are conditions to be simulated.

24.3 Abnormal conditions (See Abnormal – Tests, Section 57) shall be considered when evaluating displays.

24.4 The failure of a component in a display circuit shall not result in a risk of fire, electric shock, or injury to persons.

24.5 A controller designed to manage power or signaling to single or multiple loads shall operate so that upon any single component failure the system does not result in a risk of fire, electric shock, or injury to persons.

24.6 A product that requires operations in a specific sequence shall operate so that upon any single component failure the product does not result in a risk of fire, electric shock, or injury to persons.

24.7 A product that requires limited operation time shall operate so that upon any single component failure the product does not result in a risk of fire, electric shock, or injury to persons.

25 Safety Circuits

25.1 A safety circuit shall be suitable for the application. Components that have been determined to be reliable through previous investigation are not subject to further evaluation unless review of the use, or specific use within a circuit, requires additional evaluation to determine the device or circuit will perform reliably. An electro/mechanical device intended to control the safety functionality of the display such as but not limited to a relay, contactor, position switch, reed switch and similar devices shall be capable of functioning properly through 100,000 cycles of operation at rated load.

25.2 When the investigation in accordance with Abnormal – Tests, Section 57, determines that a component or circuit fault results in a risk of fire, electric shock, or injury to persons or the display as a safety circuit, then the component(s) or circuit(s) in question shall be investigated to determine that they possess the necessary reliability for the anticipated product service life. The circuit(s) shall comply with the requirements in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

25.3 When the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, is used to determine compliance with 25.2, only the following criteria shall be applied:

a) Supervised safety circuits as defined by UL 991 may not rely on a trouble signal or indicator to prevent the risk of injury.

b) Composite Operational and Thermal Cycling Tests in accordance with UL 991 is not required on indoor displays.

c) Humidity tests on safety control circuits shall be conducted in accordance with UL 991 as defined under Humidity Classes for the products intended use.

d) A product relying on a safety circuit shall be supplied, for the investigation of the product, with a failure-mode and effect analysis in accordance with Failure-Mode and Effect Analysis (FMEA) requirements of UL 991.

e) With regard to electrical supervision of critical components, a motor operated system being inoperative with respect to movement of the device meets the criteria for trouble indication.

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

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

h) When a Computational Investigation is conducted, I_p shall not be greater than 6 failures/106 hours for the entire system. For external secondary entrapment protection devices that are sold separately, I_p shall not be greater than 0 failures/106 hours. For internal secondary entrapment

protection devices whether or not they are sold separately, I_p shall not be greater than 0 failures/106 hours. The Operational Test is to be conducted for 16 days.

i) The Endurance Test is to be conducted concurrently with the Operational Test. The control shall perform its intended function while being conditioned for 16 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 the full range of motion of the mounting system.

j) For the Electrical Fast Transient Burst Test, test level 3 is to be used for systems.

25.4 If software or firmware is part of the safety feature, it shall be evaluated to the Standard for Software in Programmable Components, UL 1998.

26 Flammability

26.1 Upholstered seating

26.1.1 Upholstered seating displays shall comply with the State of California Department of Consumer Affairs Bureau of Home Displays and Thermal Insulation, Technical Bulletin 117-2013, Requirements, Test Procedure and Apparatus for Testing the Flame Retardance of Resilient Filling Materials Used in Upholstered Furniture (March 2013). If the size is greater than 10 ft^2 (0.93 m^2), it shall also comply with 26.2, Other Display Types.

26.2 Other display types

26.2.1 A display or combination of displays that are intended to be used together, such as a row of displays ganged together within one foot, with a combustible surface area greater than 10 ft^2 (0.93 m^2) of a flat planer surface shall comply with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723. The product literature shall be reviewed to determine the intended use. Surface area calculation shall be determined as follows:

a) Surface areas are calculated based on only one side of the surface;

b) All surfaces between vertical and 45 degrees including 45 degrees from vertical are considered vertical surfaces. All surfaces between horizontal and up to 45 degrees from horizontal are considered horizontal surfaces;

c) Edges (Examples – Front edge of a shelf, vertical stile or horizontal rail of a unit) of surfaces 2 inches or less in dimension are not added into the area calculation unless they can be positioned directly adjacent to each other;

d) Removable and optional portions of the display are to be included in the area determination;

e) Merchandise or electrical equipment on the display or separately investigated portions of the display such as a conductor, cable, luminaire, power supply, amplifier, speaker, TV, monitor etc. are not to be included in the surface calculation or test; and

f) The areas of the vertical and horizontal surfaces shall be added together on a single side.

26.2.2 Products tested to the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723, shall have a maximum flame-spread rating of 200 and if the smoked developed rating is over 450 the product shall be marked as specified in 75.24.

26.2.3 Furnishings that are not a flat planer surface and the overall size of one side is greater than 10 ft^2 (0.93 m^2) shall be subjected to either the Standard for Fire Tests for Foamed Plastics Used for Decorative Purposes, UL 1975 or the Standard Method of Fire Test for Individual Fuel Packages, NFPA 289.

26.2.4 Products tested to the Standard for Fire Tests for Foamed Plastics Used for Decorative Purposes, UL 1975 or the Standard Method of Fire Test for Individual Fuel Packages, NFPA 289 shall have a maximum heat release rate not greater than 100kW (105 Btu/h) and shall be marked as specified in 75.24.

26.2.5 A decorative molding, cover, shelf, top cap, or a similar component that is formed of combustible material and runs at least the full width of one unit, such as the length of a table, shall have a flammability rating of HB in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: Materials that are tested in combination with a sample evaluated to 26.2.1 do not need to comply with UL 94 unless used for other purposes defined in this standard.

26.2.6 A combustible material used to form a small (less than 1 square inch) decorative part or mechanical connector is not required to have a flammability rating of HB or better in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. This requirement also applies to fabric and adhesive systems employed as a decorative covering on inter-panel poles and posts.

26.2.7 An individual fabric material used without a backing material shall comply with the Standard Test Methods of Fire Tests for Flame Propagation of Textiles and Films, NFPA 701.

27 Water Shields

27.1 A material, not including wood, used as a water shield, whether provided as a lens, diffuser, or opaque part, shall:

a) Be classified at least HB in accordance with the Standard for Test for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, if of polymeric material;

b) Comply with the exposure to ultraviolet light test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, if of polymeric material; and

c) Be subjected to impact conditioning as specified in 64.2, Water Shield Impact Conditioning, before the display is subjected to the rain, sprinkler, or immersion tests.

27.2 A wood water shield shall be subjected to the impact conditioning described in 64.2, Water Shield Impact Conditioning, before the display is subjected to the rain, sprinkler, or immersion tests.

Exception: Wood that is at least 1/2 inch (12.7 mm) thick is not required to be subjected to the impact conditioning.

PERFORMANCE

MECHANICAL TESTS

28 General Conditions

28.1 General

28.1.1 Where an angle is referenced, the tolerance shall be ±0.2 degrees.

28.1.2 For displays that are intended to incorporate audio or video equipment, the tests specified in Table 28.1 and described in the Standard for Household, Commercial, and Institutional-Use Carts, Stands and Entertainment Centers for Use with Audio and/or Video Equipment, UL 1678, shall be performed as defined in UL 1678.

Table 28.1
Tests for Audio or Video Equipment

UL 1678 Reference	Test Name
15	Temperature Stability
16.2	Carts or stands intended to support or store audio and/or video equipment other than a television or having other general storage
16.3	Carts, stands and entertainment centers having a support surface or mounting surface for a television
16.4	Dynamic tip stability test for tall institutional carts and stands
16.5	Force stability (Considered the same as 33.8)
16.6	Appurtenance stability (Considered the same as 33.7)
16.7	Multiple audio and video support surface test
17	Loading
18	Handle Strength
19	Appurtenance Strength (Considered the same as 32.4)
21	Wheel, Roller, or Caster Securement (Considered the same as Section 36)
22	Braking

28.2 Trial installation

28.2.1 A display shipped disassembled or an accessory shall be trial-installed to determine that the installation instructions are applicable, that the instructions are detailed and accurate, and that the use of the display or accessory does not introduce a risk of fire, electric shock, or injury to persons.

29 Conditioning of Products

29.1 Conditioning of polymeric components

29.1.1 A polymeric material used to support or carry a weight load shall be conditioned in accordance with 29.1.2 prior to conducting loading or mounting tests.

29.1.2 An unloaded representative display support system employing polymeric parts and its accessories are to be placed in a full-draft circulating-air oven. The air temperature within the oven is to be maintained at 70°C (158°F) or 10°C higher than the temperature obtained on the polymeric parts during

the temperature test, whichever is higher, for 7 hours. The support system and its accessories are to be allowed to cool to room temperature before conducting the following tests:

a) Stability Test, Section 32;

b) Loading Test Requirements for Displays, Section 31;

c) Cycling Test for Displays with Articulating Components, Section 37; or

d) Structure Mounted or Secured Display Tests, Section 33.

29.2 Conditioning of components secured by adhesives

29.2.1 An adhesively secured component used to support or carry a weight load shall be conditioned as described in 29.2.2 prior to conducting the stability, loading tests or adhesive securement test.

29.2.2 Two representative display support systems employing adhesives as the sole support shall be conditioned as follows:

a) One display support system shall be placed in an air-circulating oven for seven days at 100 ±1.0°C (212 ±1.8°F); and

b) One display support system shall be conditioned for seven days in an environment of 85 ±5 percent relative humidity at 32.0 ±2.0°C (89.6 ±3.6°F).

The support system and its accessories are to be allowed to cool to room temperature before conducting the required test.

30 Adhesive Securement Test

30.1 A component of a display secured by an adhesive that would create a risk of fire, electrical shock or injury to persons upon adhesive failure shall comply with the test specified in 30.2. The adhesive is considered satisfactory when the adhered surfaces do not separate.

30.2 The joined components shall be subjected to the conditioning specified in 29.2, Conditioning of Components Secured by Adhesives.

30.3 The display shall be installed in accordance with the installation instructions. A weight equal to 4 times the weight of the adhered component is to be attached to any point on the adhered component that subjects the adhesive to the weight load. The component shall remain affixed to the display for 1 minute.

31 Loading Test Requirements for Displays

31.1 General

31.1.1 A display shall be subjected to the structural loading tests and shall not collapse or deform to a degree that presents a risk of fire, electric shock, or injury to persons.

a) A risk of injury to persons is determined to exist when the display or part of a display collapses, partially collapses or is damaged to the extent that there are sharp edges or corners exposed which do not comply with the Standard for Tests for Sharpness of Edges on Equipment, UL 1439; and

b) Electrical components within the display shall comply with the requirements in Section 14, Accessibility of Uninsulated Live Parts and Film-Coated Wire, and the Dielectric Voltage Withstand Test, Section 54.

31.2 Rated load

31.2.1 All supporting surfaces shall be loaded with the rated load. The configuration tested is to be that in which the surface is least supported. The load is to be maintained for 15 minutes after complete loading is attained. Each load is to be uniformly applied centered on the line of 8 inches along the entire perimeter edge of the surface.

31.2.2 For drawers, the load is to be uniformly applied by volume using a material that has a density of 42 ±8 lbs/ft^3 (673 ±128 kg/m^3). (Bound copier paper and particle board have been found to meet this requirement).

31.2.3 For clothes rods, the load is to be uniformly applied along the width of the rod.

31.2.4 For hooks, the load to be applied to each hook.

31.2.5 Vegetation containers or vegetation container supports intended to support vegetation containers shall be loaded with soil or equivalent. Products not supplied with the vegetation containers shall be tested with the maximum size and weight of container specified in the use instructions and shall be loaded such that dry soil shall be considered to weigh 100 pounds (45.36 kg) per 1 ft^3 (0.028 m^3) ±10 pounds (4.53 kg) per 1 ft^3 (0.028 m^3). Soil shall be additionally saturated with water.

31.2.6 Loading systems that use polymeric material either to support a loading surface or as the loading surface shall be subject to 1,000 hours at 25°C (77°F) for indoor use and -20°C (-4°F) for outdoor use, while loaded. The test time may be lowered by half for every 10°C (18°F) increase in temperature. Besides the requirements in 31.1.1, there shall be no warping or distortion that:

a) Interferes with normal operation or servicing;

b) Results in accessibility of live parts;

c) Reduces electrical spacings below the level necessary to comply with the applicable requirements pertaining to dielectric strength and leakage current;

d) For outdoor-use products, exposes internal components to the effects of weathering or water; and

e) Results in an unacceptable reduction of the pressure involved in metal-to-metal joints relied upon for safety including joints providing a bonding path and joints serving as current carrying parts.

31.3 Abnormal load

31.3.1 Following the rated loading test the test loads shall be removed and each supporting surface, one surface at a time, independently, shall be loaded with 3 times the rated load for 15 minutes.

31.4 Appurtenance strength test

31.4.1 A display shall be constructed such that deformation or damage does not result in a risk of injury to persons, fire, or electrical shock when each appurtenance located within 30 inches (76.2 cm) of the floor (such as a shelf, drawer, door, slide out, flaps, drop fronts, and the like) is subjected to the test. The display if intended to support a load shall be loaded with the rated load. Appurtenances, such as a small drawer or

a hook, with a total weight of less than or equal to 5 lbs (2.3 kg) including the intended load is not considered a risk of injury if only the appurtenance is damaged and there are no sharp edges. If the complete furnishing is affected, it would still be considered a risk of personal injury.

31.4.2 Each appurtenance is to be separately subjected to a 50 lbf (222 N) force applied in the downward direction for one minute. The force shall be applied:

a) With the appurtenances in the position that results in the maximum stress to the appurtenance; and

b) At a point on the appurtenance which will produce the most severe results.

c) Door surfaces shall be manipulated and loaded by applying a 50-pound (22.68-kg) weight to the top edge of the door at a point 3 inches (7.62 cm) in from the top edge. See Figure 32.4. A door surface located above 30 inches (762 mm) from the floor but accessible to a child by climbing up extendable appurtenances shall be subjected to the test.

d) For multiple appurtenances each appurtenance is to be loaded with 50 pounds one at a time.

32 Stability

32.1 General test criteria

32.1.1 A display when subjected to the stability requirements shall not present a risk of fire, electric shock, or injury to persons.

a) A risk of injury to persons is determined to exist when the display or part of a display overturns, is displaced or dislodged from its support surface or when the display or support surface is damaged to the extent that there are sharp edges or corners exposed which do not comply with the Standard for Tests for Sharpness of Edges on Equipment, UL 1439.

b) Electrical components within the display shall comply with the requirements in Section 14, Accessibility of Uninsulated Live Parts and Film-Coated Wire, and the Dielectric Voltage Withstand Test, Section 54.

Exception: Based on visual observation that no damage has occurred to the electrical components these tests do not need to be performed.

32.1.2 A display is to be tested on a smooth hard surface such as concrete or smooth wood. The display shall be assembled or set up in accordance with the instruction manual provided with the display.

32.2 Stability configuration test requirements

32.2.1 A display shall be assembled in accordance with the installation or assembly instructions.

32.2.2 A display that requires an addition of a component or material in order to perform its intended function, including the intended load, shall be tested for stability with the component or material in place. (Examples: A container that requires dirt to be in place to plant a plant, a decorative water feature where the user needs to add water for the unit to function, a patio shade umbrella that requires a ballast material in its base to remain upright in accordance with the instructions).

32.2.3 If a display can perform its intended function with or without the component or material in place as referenced in Section 31, Loading Test Requirements for Displays, the display shall be subjected to the stability test in any or all of the following conditions considered being most severe:

a) Unloaded;

b) Partially loaded with the rated load; and/or

c) Fully loaded with the rated load.

When testing for partially loaded, the full normal load shall be placed on the display as defined under Section 31, Loading Test Requirements for Displays. Then portions of the load are removed so that the display is tested in the least stable position. Examples:

1) Rectangular Table with Wheels: With the table on a 10° angle, the portions of the functional load that are on the opposite side of the 10°, are removed.

2) Vertical Case: With the case on a 2° angle, portions of the normal load on the bottom shall be removed first, and then the lowest shelf load shall be removed. Each shelf shall be unloaded until only the highest load is in place.

3) Display Needing Ballast: The display shall not be filled with the ballast. The display shall be placed on a 10° angle.

32.2.4 Articulated parts shall be positioned and loaded to represent worst case. This may require multiple tests to determine. (Example: A display which is intended to be used with or without a video display or converts from an entertainment center to an armoire, wardrobe or shelving unit.)

32.2.5 The load may be secured to the display for test purposes. The rated load shall be used.

32.2.6 A display that is comprised of an assembly that allows for portions of the assembly to be used without being completely assembled shall comply with the stability test both assembled and with the usable portion of the assembly alone without the other attachments. (Example: A patio umbrella and table assembly where the umbrella or table can be used without the other component).

32.2.7 A display provided with a means to level the display shall be adjusted to level or as closely to level as the adjustment allows in accordance with the use instructions.

32.2.8 A display provided with a coordinating device that only allows the opening or extending of drawers, doors or appendages in a specific combination or sequence shall be used for the conduct of the stability test if found to function as intended when attempts are made to manually defeat the device by opening and closing the operable elements of the display in any combination.

32.2.9 Doors shall be manipulated to a point that provides the least stability for the display (typically perpendicular, 90 degrees, to the front plane of the display). Other positions shall be investigated if 90 degrees to the front plane of the display is determined not to be the worst case position for stability. All doors shall be manipulated singly or in combination. Positioning of doors or other appurtenances shall not be used to prevent tip over.

32.3 Stability test for portable displays

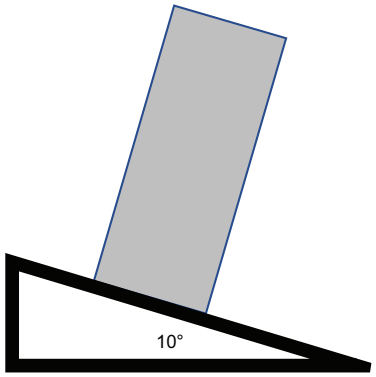
32.3.1 A portable display shall be constructed so that there is no risk of fire, electric shock or injury to persons when subjected to the test specified in 32.3.2 and 32.3.3. The display shall not overturn.

32.3.2 Storage or work areas shall be loaded or unloaded with the rated load as specified in Section 31, Loading Test Requirements for Displays, as appropriate, whichever is considered worse case. Loads shall be applied in accordance with Section 31, and may be secured to the display for test purposes.

32.3.3 The portable display is to be placed in any orientation on an incline plane at an angle of 10 degrees to a level horizontal plane. Displays with articulating features are to be adjusted to the least stable position. See Figure 32.1.

Figure 32.1

Stability test



32.4 Stability tests for other stationary and fixed displays

32.4.1 A stationary and fixed display shall be constructed so that there is no risk of fire, electric shock or injury to persons when subjected to the tests specified in 32.4.2. The display shall not overturn.

32.4.2 Storage or work areas shall be loaded or unloaded with the rated load specified, whichever is considered worse case. Loads shall be applied in accordance with Section 31, Loading Test Requirements for Displays, as appropriate, and may be secured to the display for test purposes. The display is to be placed in any orientation on the incline plane. Displays with articulating features are to be adjusted to the least stable position.

a) A display without casters, rollers or wheels is to be placed on an incline plane at an angle of 2 degrees to a level horizontal plane. The display may be loaded or adjusted before or after being placed on the incline. The glides, feet, and similar parts are to be blocked or otherwise restricted from moving along the surface. The means used to restrict movement are not to restrict tipping of the assembly.

b) A stationary display with casters, rollers or wheels is to be placed on an incline plane at an angle of 10 degrees to a level horizontal plane. The casters, rollers or wheels shall be rotated to the least stable position. The display may be loaded or adjusted before or after being placed on the incline. The casters, rollers or wheels are to be blocked or otherwise restricted from moving along the surface. The means used to restrict movement shall not restrict tipping of the assembly.

32.5 Stability test for displays provided with a step

32.5.1 A display with an intentional step or a surface that is likely to be used as a step shall be constructed such that there is not a risk of fire, electric shock or injury to persons when subjected to the test specified in 32.5.2. The display shall not over turn or if secured to a structure shall not separate from the structure.

32.5.2 The display shall be configured as described in Section 31, Loading Test Requirements for Displays, as appropriate. A fully assembled display is to be subjected to a 300-pound (435-N) load applied straight down through a flat rigid structure 4 by 4 inches (102 by 102 mm) in any position along the display structure element under investigation. The load is to be applied for 1 minute.

32.6 Stability test for displays provided with a foot or leg rest

32.6.1 A display with a foot or leg rest or a surface that is likely to be used as a foot or leg rest shall be constructed such that there is not a risk of fire, electric shock or injury to persons when subjected to the tests specified in 32.6.2. The display shall not overturn or if secured to a structure shall not separate from the structure.

32.6.2 The display shall be configured as described in Section 31, Structural Test Requirements for Displays (Loading), as appropriate. A fully assembled display is to be subjected to a 50 pound (222.4 N) load applied straight down through a flat rigid structure 4 by 4 inches (102 by 102 mm) in any position along the display structure element under investigation. The load is to be applied for 1 minute.

32.7 Appurtenance stability test

32.7.1 A display shall be constructed such that deformation or damage does not result in a risk of fire, electrical shock or injury to persons. For each appurtenance located within 30 inches (762 mm) of the floor, or when multiple appurtenances are provided with the lower ones within 30 inches (762 mm) of the floor, the appurtenance is to be separately subjected to a 50 lbf (222 N) force applied in the downward direction for one minute. Appurtenances, such as a small drawer or a hook, with a total weight of less than or equal to 5 lbs (2.3 kg) including the intended load is not considered a risk of injury if only the appurtenance is damaged and there are no sharp edges. If the complete furnishing is affected, it would still be considered a risk of personal injury.

32.7.2 For horizontal sliding and extending appendages (drawers, slide outs, flaps, drop fronts and the like):

a) The appurtenance shall be extended from the display until it reaches its fully extended position.

b) Appurtenances such as a drawer shall be loaded with the rated load. The weight shall be equally distributed over the area of the drawer bottom. If determined to be less stable the appurtenances may be unloaded and may be extended in any combination.

c) Each appurtenance:

1) The appurtenance shall be subjected to a 50-pound (22.7-kg) weight applied to the top edge anywhere along the width of the appurtenance. See Figure 32.2 and Figure 32.3.

2) When multiple appurtenances are provided with the lower ones within 30 inches (762 mm) of the floor, the following procedure shall be used:

i) The lowest appurtenance is to be fully extended and loaded with 50 pounds (22.7 kg).

ii) The weight is then to be removed and divided in to two 25-pound (11.35-kg) loads between the lowest and next highest appurtenance. The appurtenances are to be fully extended so that 25 pounds (11.35 kg) is placed on the lowest and next highest appurtenance.

iii) The weight is then to be removed from the lowest appurtenance and the next highest appurtenance is to be loaded with the two 25 pound (11.35 kg) loads while

the lowest appurtenance is left in the open position but without the simulated weight of the child.

This process is to be repeated from each appurtenance. This test is to simulate a child ascending a display utilizing the appurtenances to climb. See Figure 32.4.

Figure 32.2

Appurtenance loading

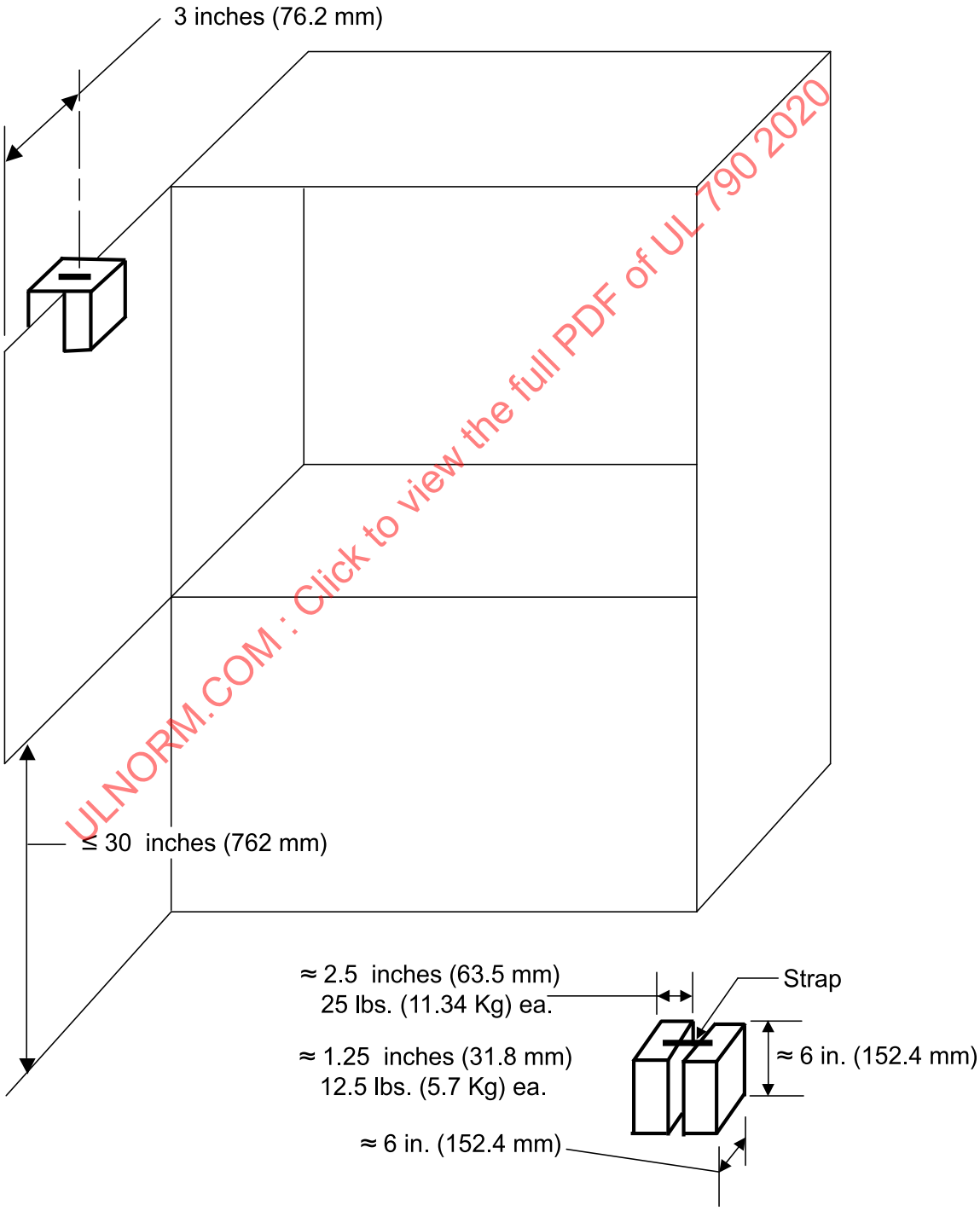


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Figure 32.3

Appurtenance loading – 32.7.2(c)(1)

Example: Side view – chest of drawers

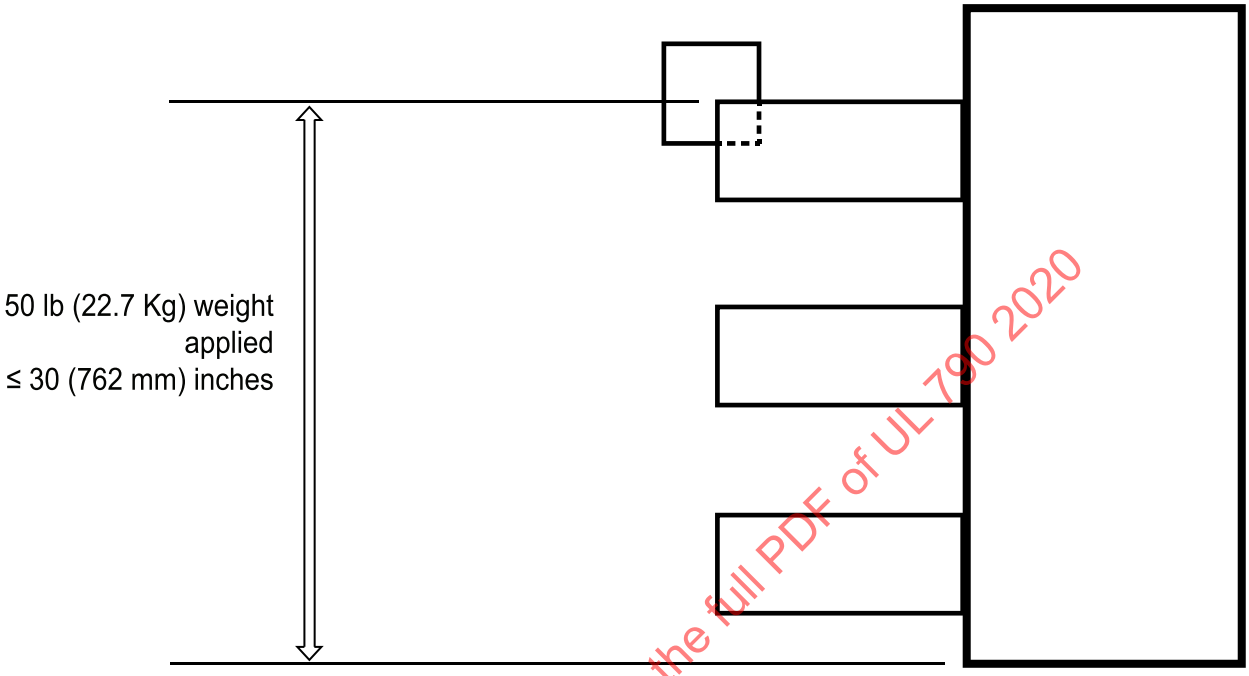

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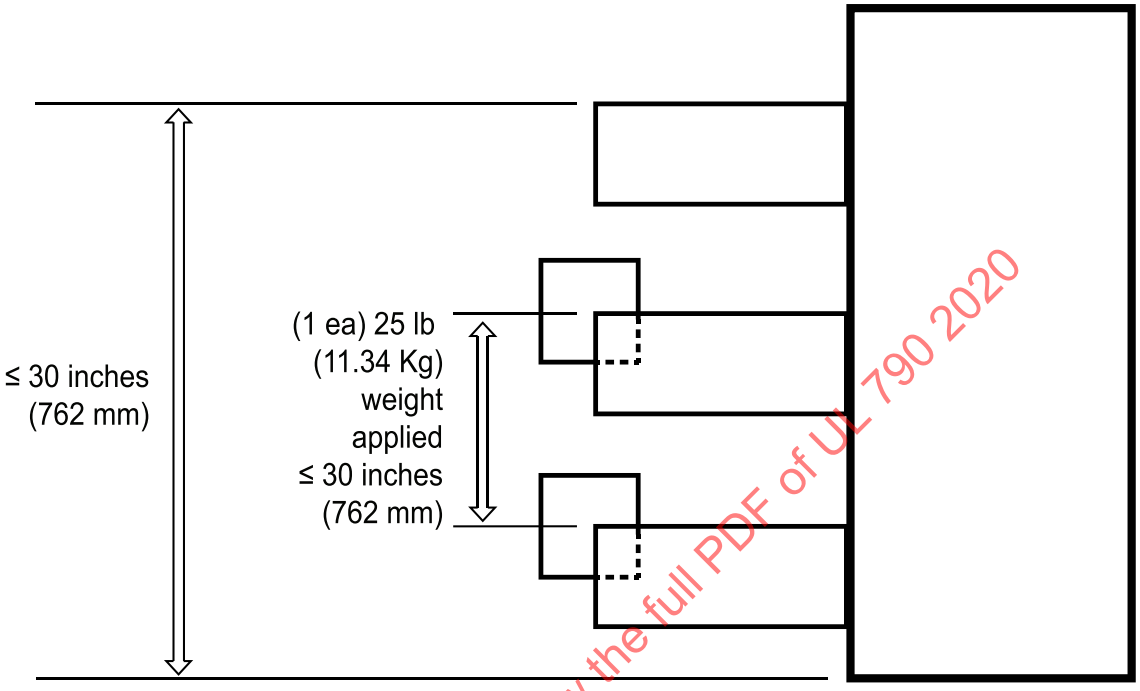
Figure 32.4

Appurtenance loading – 32.7.2(c)(2)

Example: Side view – chest of drawers



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32.8 Force stability test

32.8.1 A display 42 inches (1067 mm) or taller shall be constructed such that there is no risk of fire, electric shock or injury to persons when subjected to the tests specified in 32.8.2 and 32.8.3. The display shall not overturn.

Exception: Installation instructions specifying a specific side or sides to be placed against a fixed structure are not to have the force applied toward the fixed structure. The display shall be marked in accordance with 75.33.

32.8.2 A display shall be unloaded and is to be subjected to a gradually increasing horizontal force applied through the center of an 8 inch (203 mm) diameter disc to at least the locations specified in 32.8.3 at any location centered along a horizontal line 54 inches (1371.6 mm) above the floor or 4 inches (102 mm) down from the top edge whichever is higher. The force is to be increased until either a 40 pound (180 N) force is attained or the assembly inclines to an angle of ten degrees without tipping over, whichever occurs first. The force is then to be gradually reduced to zero. See Figure 32.5.

32.8.3 The force shall be applied as follows:

a) To front of the product at its left side;

b) To front of the product at its right side;

c) To back of the product at its left side;

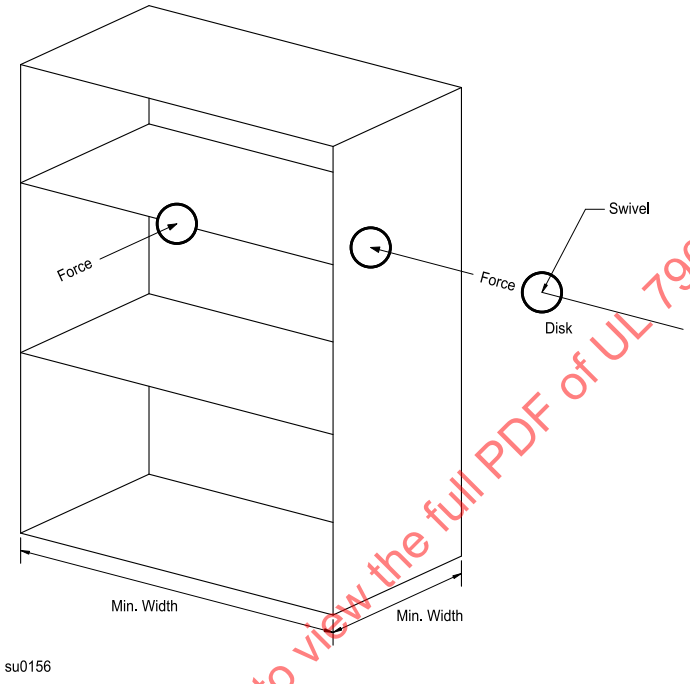
d) To back of the product at its right side;

e) To the left side of the product;

f) To the right side of the product.

Figure 32.5

Force stability test



Note: Disc diameter is eight inches.

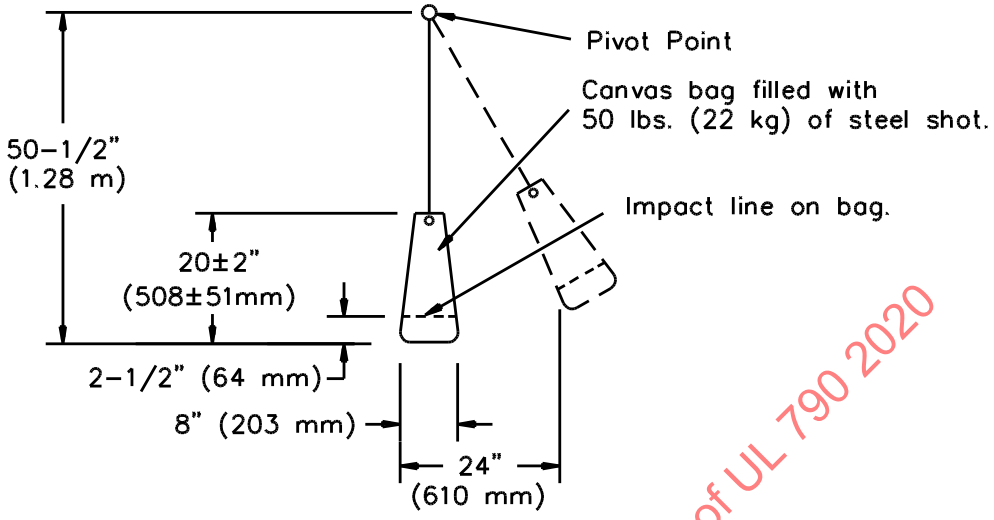
32.9 Impact stability test

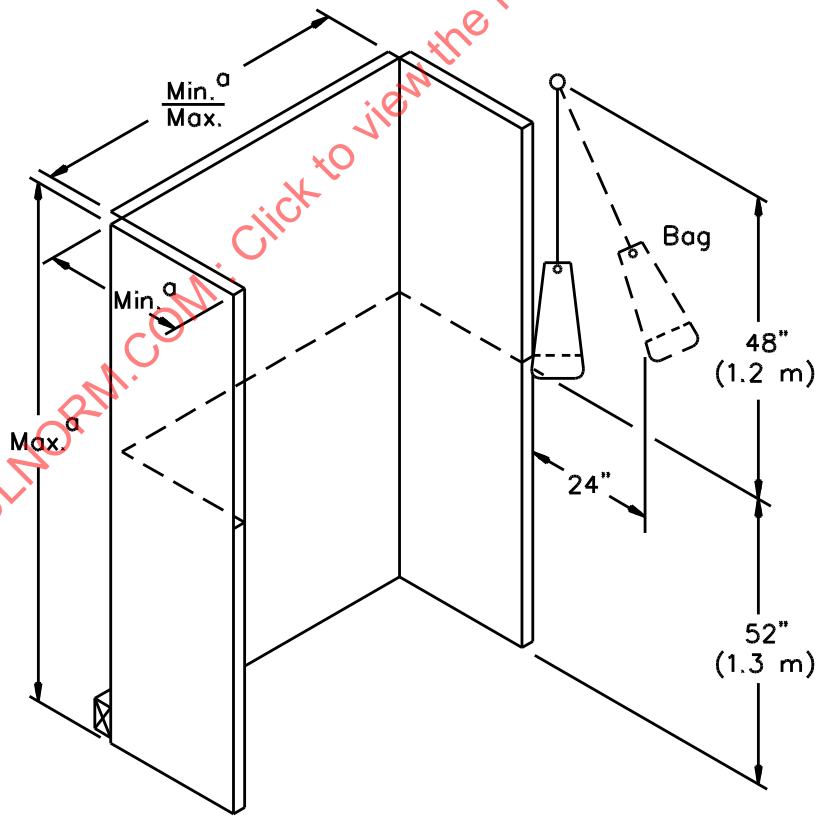
32.9.1 A floor supported display for commercial use shall be constructed such that there is no risk of fire, electric shock or injury to persons when subjected to the tests specified in 32.9.2. The display shall not overturn.

32.9.2 Each of the display assemblies is to be subjected to a single impact of a lead- or steel-shot-filled canvass bag having a diameter of 8.0 ±0.5 inches (203 ±13 mm) and a weight of 50 pounds (22 kg). The bag is to fall as a pendulum from a pivot point 48 inches (1.2 m) above the point of impact so as to traverse a horizontal distance of 24 inches (610 mm) and strike the display. The point of impact is to be at any location centered along a horizontal line 52 inches (1.3 m) above the floor or 4 inches (102 mm) below the top of the display, whichever is lower. See Figure 32.6 for details regarding the impact stability test.

Figure 32.6

Details for impact-stability test





[a] Maximum and minimum dimensions are those specified by the manufacturer.

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33 Structure Mounted or Secured Display Tests

33.1 General

33.1.1 The Cycling Test for Displays with Articulating Components, Section 37, shall be conducted prior to conducting the display securement tests.

33.2 Suspended display, securement test

33.2.1 A display secured to a vertical structure without additional support at the base (floor, shelf) or a display suspended from a horizontal structure (ceiling, rack) shall be secured to a structure in accordance with the installation instructions using the hardware provided or specified. See 83.10. A display system and its accessories shall be constructed so there is no cracking, or similar damage to the mounting bracket, securement means, supporting structure, display or any combination thereof to the point where the mounting system releases from the structure, the product collapses, creates a risk of fire, electric shock, or injury to persons when tested in accordance with 33.2.2 and 33.2.3.

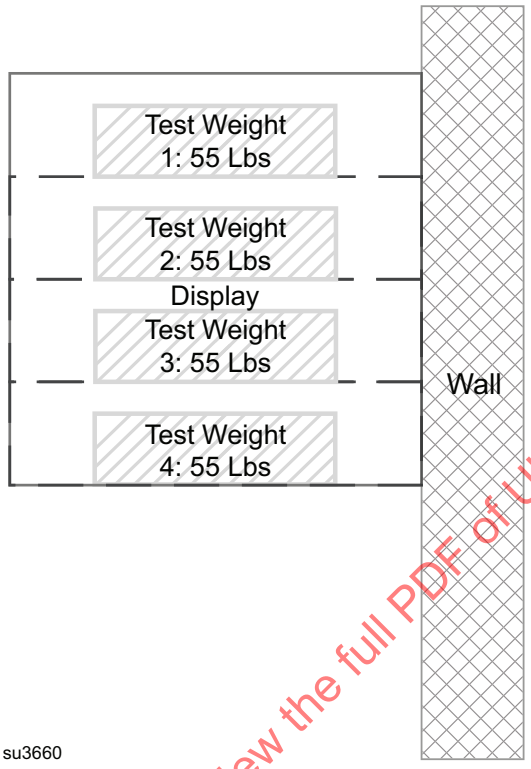
33.2.2 Common North American Structures, Section 36, defines typical building surfaces located in North America. The test shall be conducted using one or more surface type. The installation instructions shall specify the surfaces that were used for the test. Sufficient detail shall be provided in the instructions to specify the structures, hardware, fasteners and mounting system that were used to support the display.

Exception: None of the common structures in Section 36, Common North American Structures, have to be tested if the installation instructions define a different type of structure. That structure shall be used to conduct this test.

33.2.3 The test load shall be 4 times the weight of the display plus the rated load. The total test weight is to be gradually applied and maintained for 5 minutes; for example, display weighs 50 lbs (22.7 kg) and has a normal load of 20 lbs (9.1 kg). The test load to be added to the display is 4 times 50 lbs (22.7 kg) plus the 20 lbs (9.1 kg) equaling 220 lbs (100 kg). See Figure 33.1.

Figure 33.1

Suspended securement test example



33.3 Vertically secured – Base supported, securement test

33.3.1 A display system intended for attachment to a vertical structure while also resting on a horizontal structure (floor, shelf) shall be secured to the structure in accordance with the installation instructions using the hardware provided or specified. See 83.10. A display system and its accessories shall be constructed so there is no cracking or similar damage to the mounting bracket, securement means, supporting structure, display or any combination thereof to the point where the mounting system releases from the structure, the product collapses, creates a risk of fire, electric shock, or injury to persons when tested in accordance with these requirements.

33.3.2 The display shall be placed on a 2 degree plane that slopes away from the vertical support structure. The test shall be configured as follows:

a) Any adjustable leveling system shall be used to bring the display parallel to the vertical structure or as close to parallel to the vertical structure as the leveling means allows.

b) All appurtenances shall be adjusted to extend to their maximum position away from the vertical structure.

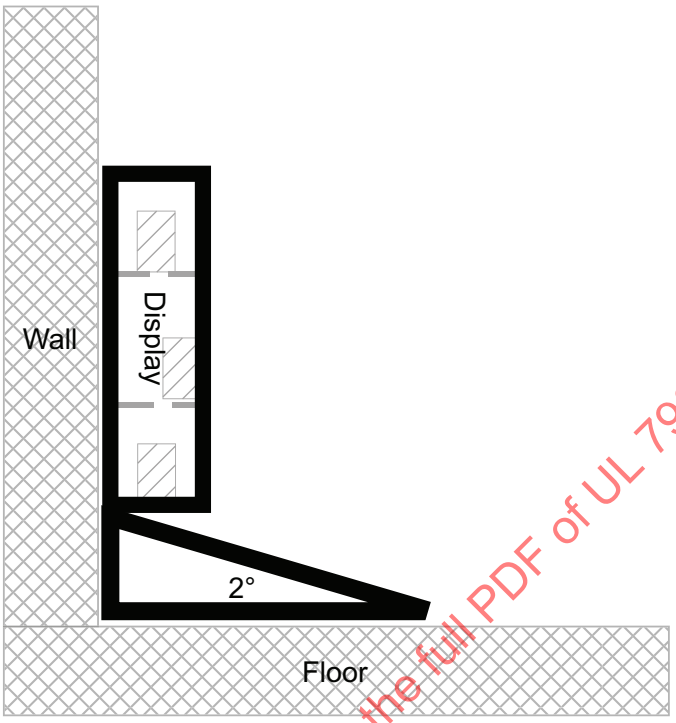
c) The display shall be loaded with the rated load.

d) The display shall be subjected to these forces for 5 minutes.

See Figure 33.2.

Figure 33.2

Vertically secured securement test



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33.4 Base secured – Base supported, securement test

33.4.1 A display system intended for attachment to a horizontal structure (example: floor or shelf) while also resting on the horizontal structure shall be secured to the structure in accordance with the installation instructions using the hardware provided or specified. See 83.10. A display system and its accessories shall be constructed so there is no cracking or similar damage to the mounting bracket, securement means, supporting structure, display or any combination thereof to the point where the mounting system releases from the structure, the product collapses, creates a risk of fire, electric shock, or injury to persons when tested in accordance with these requirements.

33.4.2 The display shall be placed on a 2 degree plane that slopes away from the vertical support structure. The test shall be configured as follows:

a) Any adjustable leveling system shall be used to bring the display parallel to the vertical structure or as close to parallel to the vertical structure as the leveling means allows.

b) All appurtenances shall be adjusted to extend to their maximum position away from the vertical structure.

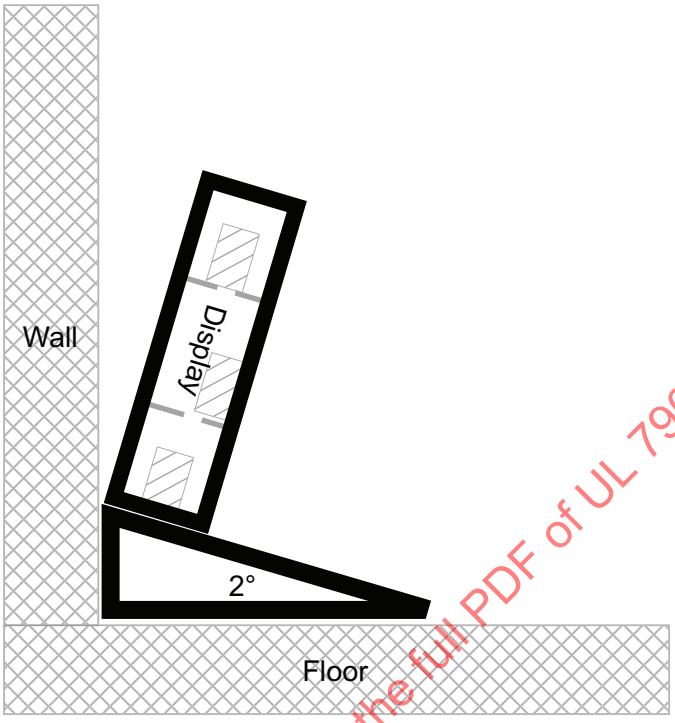
c) The display shall be loaded with the rated load.

d) The display shall be subjected to these forces for 5 minutes.

See Figure 33.3.

Figure 33.3

Base secured securement test



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34 Tests on Glass Sheets

34.1 Impact test

34.1.1 In accordance with Glass Components, 12.15, a glass surface shall be subjected to the impact test described in 34.1.2. The glass surface shall not crack or break to the extent that a piece of the glass surface is released or drops from its normal position.

34.1.2 A solid steel sphere, 2 inch (51 mm) in diameter and weighing 1.18 pounds (0.54 kg), is to fall through the distance required to result in an impact of 5 ft-lbf (6.8 J). The sample is to be supported as normally supported by the display.

34.2 Retention test

34.2.1 In accordance with Glass Components, 12.15, a glass surface shall be subjected to the retention test described in 34.2.2. The glass shall not become dislodged or displaced from its mounting means to the point where it completely separates from its mounting means.

34.2.2 The glass surface is to be mounted in the intended manner. A sand-filled bag having a 30.0 ±0.5 in (760 ±13 mm) circumference and a weight of 20 lb (9.1 kg) is to fall as a pendulum through the distance that produces an impact of 35 ft-lbf (18.4 J) on any point on the panel.

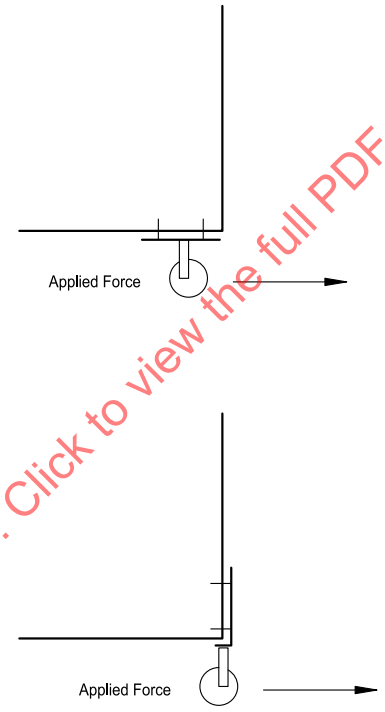
35 Wheel, Roller, or Caster Securement Test

35.1 A wheel, roller, or caster shall be capable of withstanding a pull equal to the normal rated load plus the weight of the display, divided by the number of wheels, rollers, or casters supporting the loaded weight of the display when applied as described in 35.2.

35.2 The force is to be applied by a weight or a steady pull for a period of 1 minute as shown in Figure 35.1 in any direction that represents the worst case based on how the wheel, caster or roller is attached. The force shall be applied at the axle center of the wheel, caster or roller. The force is to be applied with the specimen at room temperature and the display unloaded. The wheel, roller, or caster shall not pull free from its securing means and shall remain suitable for its intended use.

Figure 35.1

Caster test



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36 Common North American Structures

36.1 General

36.1.1 This section is provided to assist the user in selecting typical representative supporting surfaces. Tests are not required to be conducted utilizing these specific surfaces. The actual surfaces that the product is intended to be mounted to and the hardware to be used to accomplish the mounting or securement shall be tested and then specified in the installation instructions. For the purpose of these requirements ″standard″ materials are referenced to provide a basis of comparison of test results.

36.2 Insert type masonry anchors

36.2.1 Concrete anchors are to be installed in accordance with the anchor installation instructions. For performance tests in concrete the concrete area shall be at least two times the total intend mounting

surface area that the display mount will cover when installed. The concrete thickness shall be at least twice the depth of the anchor.

36.2.2 Whenever a standard concrete material is necessary it shall be mixed so that the 28 day compressive strength is from 2500 to 3000 psi (17.2 to 20.7 Mpa) or equivalent.

36.2.3 Whenever standard concrete block is needed it shall comply with the Standard Specification for Loadbearing Concrete Masonry Units, ASTM C90.

36.2.4 Whenever standard clay brick is needed it shall comply with the Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale), ASTM C62.

36.2.5 Following the installation of the test anchors in the substrate the display mounting system is to be secured to the anchors in accordance with the instructions specified in Section 31, Loading Test Requirements for Display, as appropriate.

36.3 Power driven masonry anchors/fasteners

36.3.1 Concrete powder-driven fasteners are to be driven into the concrete mounting samples to the full depth of the shank. Following the installation of test samples in the concrete, each assembly is to be secured and subjected to the required loading as specified in Sections 31 – 35, as appropriate, Structural Test Requirements for Displays.

36.3.2 Whenever standard concrete material is necessary, it shall be proportioned so that the 28 day compressive strength is from 2500 to 3000 psi (17.2 to 20.7 Mpa) or equivalent.

36.3.3 Samples of fasteners intended for use in steel are to be driven into steel having thickness(es) in which it is intended for use and having hardness values (Brinnell) of not less than 160 nor more than 240.

36.3.4 Each sample is to penetrate to the depth specified in the installation instructions.

36.4 Welding studs

36.4.1 Welding studs are to be attached to steel plates using the tools and methods specified in the installation instructions.

36.5 Wood studs

36.5.1 The display mounting system shall specify the minimum acceptable wall system to which the display mounting system is intended to be secured to. The minimum stud size [nominal 2-inch (50.8 mm) by 4-inch (102 mm), 2-inch (50.8 mm) by 6-inch (152 mm), etc.], the minimum and maximum stud spacing, the maximum specified wall covering thickness (Gypsum drywall, lath and plaster, etc.) shall be used for the test. Standard wood studs shall be graded in accordance with the American Softwood Lumber Standard No. PS 20 and shall be Grade No. 2.

36.5.2 For a typical 2-inch (50.8 mm) by 4-inch (102 mm) or 2-inch (50.8 mm) by 6-inch (152 mm) wood stud, the fastening means used to secure the mounting system to the wood studs shall be secured to the thin edge of the stud, the 1-1/2 inch (38 mm) width.

36.6 Steel studs

36.6.1 The minimum acceptable wall system to which the mounting system is intended to mount shall be specified. The minimum stud size [2-inch (50.8 mm) by 4-inch (102 mm), 2-inch (50.8 mm) by 6-inch (152

mm), etc.], the minimum stud metal thickness or gauge, the minimum and maximum stud spacing, the stud type and structural shape conforming to the North American Specification for the Design of Cold-Formed Steel Structural Members, the maximum wall covering thickness (Gypsum drywall, lath and plaster, etc.) shall be used for the test. Gypsum wallboard shall be standard 1/2-inch (12.7 mm) or less non fire rated secured to the studs with screws 12 inches (305 mm) on center.

36.6.2 For a typical 2-inch (50.8 mm) by 4-inch (102 mm) or 2-inch (50.8 mm) by 6-inch (152 mm) steel stud the fastening means used to secure the mounting system to the steel studs shall be secured to the thin edge of the stud, the 1-1/2 inch (38 mm) width.

37 Cycle Test for Displays with Articulating Components

37.1 A display with an articulating feature that when loaded exceeds 50 pounds (22.68 Kg) shall be constructed so there is no collapse, permanent damage, loosening of hinges or fasteners resulting in a risk of fire, electric shock, or injury to persons during or after the cycling test. The display shall be installed according to the instructions provided with the display. All movement tension adjustments shall be adjusted to provide the greatest resistance to movement recommended by the instructions provided.

37.2 The cycling test shall be conducted prior to conducting the display securement test.

37.3 An articulating display and its accessories shall be constructed so there is no undue wear to joints or reduction of spacings or damage to electrical insulation after the cycling test. Spacings shall comply with the requirements in Section 19, Spacings, after cycling and the display systems electrical system shall comply with the Dielectric Voltage Withstand Test, Section 54, after cycling.

Exception: Electrical systems supplied by a class 2 or LPS power source and posing no risk of injury from failure to operate are not required to comply with the dielectric voltage withstand test after cycling.

37.4 A manually or motor operated articulating display shall be subjected to 500 cycles of operation. Threaded fasteners and tension adjustments shall not be adjusted during the cycling test.

37.5 During the cycling test, an articulating display system shall be loaded to the rated load.

37.6 A cycle is considered to be one extreme position to the opposite extreme position and back to the original position.

37.7 A cycle for a display system with more than one axis of movement shall be cycled such that each axis is to be cycled either individually or in combination, whichever operation is allowed by the control and results in the 500 cycles being equally divided between all axes of adjustment. (Example: A manually-adjusted two-axis movement would have 250 cycles conducted on each axis). All axes may be tested at once if the testing apparatus is able to articulate each axis through its full range of motion.

38 Hydrostatic Pressure Test

38.1 When required by Section 23, Parts Subject to Pressure, three samples of each part or the system as an assembly subject to pressure are to be filled with any nonhazardous liquid, such as water, so as to exclude air, and are to be connected to a hydraulic pump. The pressure is to be raised gradually to the required test value, five times the maximum working pressure, and is to be held at that value for 1 minute, during which time the sample shall not burst. Leakage is acceptable provided the leakage does not create a risk of fire, shock or injury to persons.

39 Entrapment Force Measurement and Operator Attended Tests

39.1 A motorized or otherwise powered moving part as required by 12.3.4 shall be subjected to the force measurement tests described in 39.2 – 39.5. The force shall not exceed 40 pounds (177.9 N). There shall be no collapse or permanent damage to the display or mounting means (if provided) resulting in a risk of injury during or following the test.

39.2 The display shall be loaded with the rated load or unloaded if determined to be more severe.

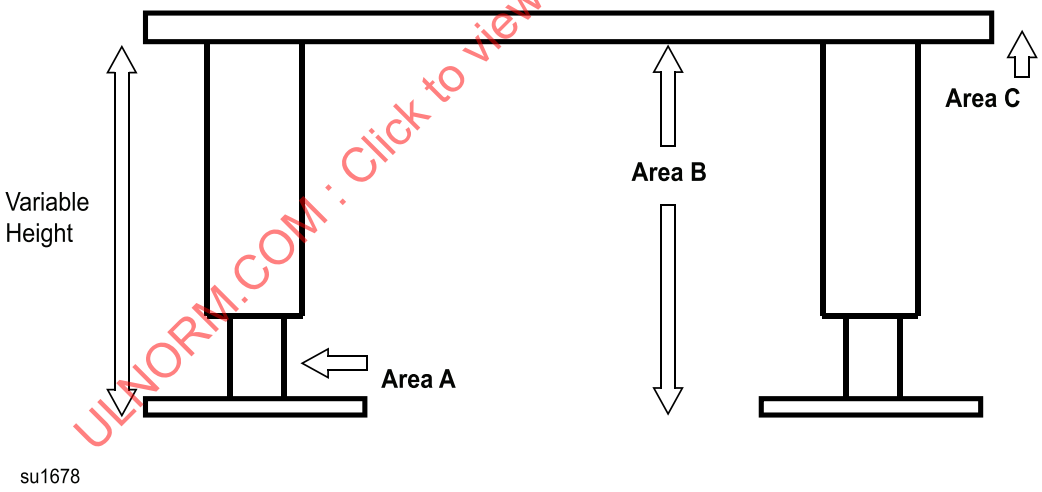
39.3 A display that has accessories that can be removed or added shall be subjected to the force measurement in any configuration determined to be most severe. Normally the largest size accessory is used for the investigation but consideration may be given to smaller sizes when a more severe result may occur.

39.4 The motorized or powered moving part of the display shall be operated at the maximum velocity allowed by the design of the display. The force measurement shall be repeated three times and the maximum force measured shall not exceed 40 pounds (177.9 N).

39.5 The force measurements shall be conducted in any location as required by 12.3.4. Figure 39.1 – Figure 39.4 are provided as typical examples of entrapment locations and shall be considered when conducting the force measurements.

Figure 39.1

Examples of entrapment areas



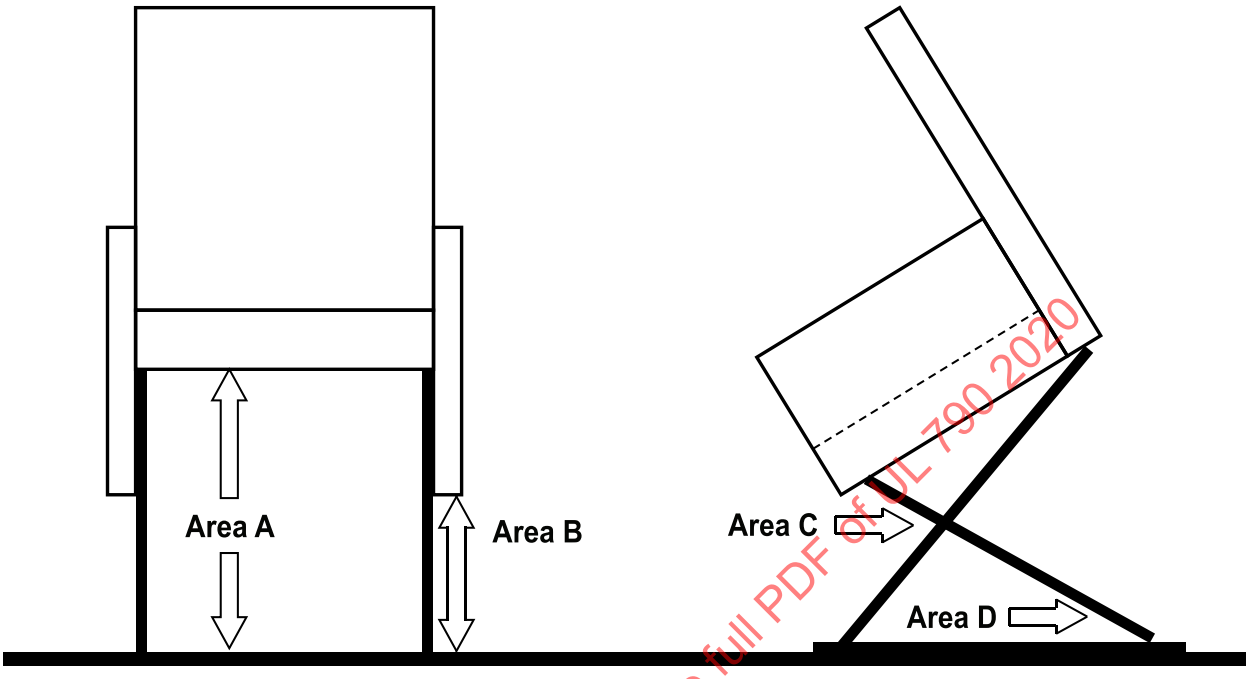
Area A – is considered to be an entrapment area because a head, hand, finger and other appendages can be pinched between the upper movable leg and lower fixed leg. Geometry and configuration can affect the entrapment concern.

Area B – is not considered to be an entrapment area because there is sufficient room between the table top and floor or between a chair seat and the table top. Instructions are also required to address entrapment.

Area C – The edge of the table could create an entrapment. Instructions address placement of the table in relation to other objects. The force limitation does not apply.

Figure 39.2

Examples of entrapment areas



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Area A – is considered to be an entrapment area because infants, children and animals could be within this area. Geometry and configuration can affect the entrapment concern.

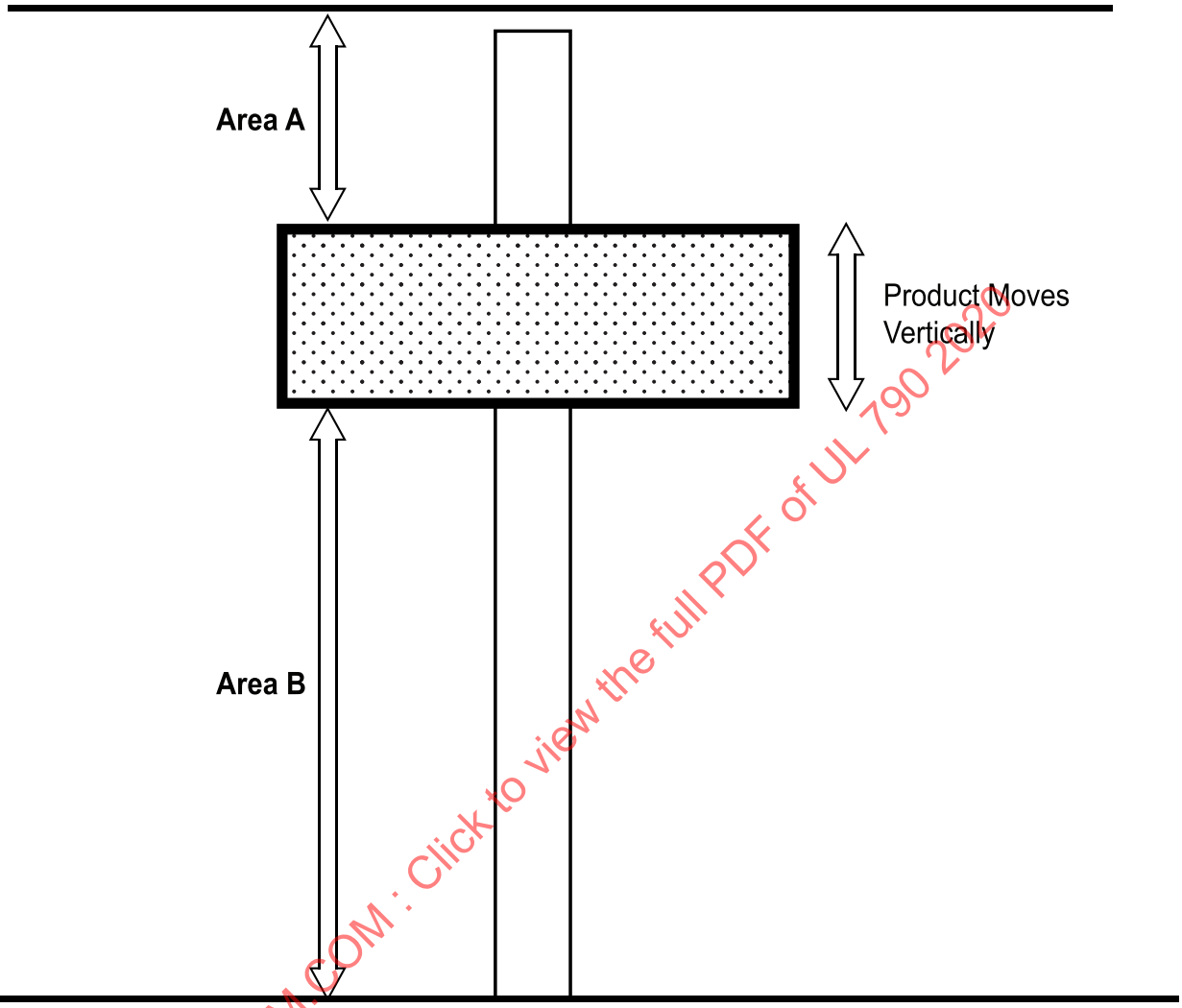
Area B – is considered to be an entrapment area because infants, children, animals and other appendages could be within this area. Geometry and configuration can affect the entrapment concern.

Area C – is considered to be an entrapment area because of the potential for a head, hand, finger or leg to become entrapped within the scissor mechanism.

Area D – is considered to be an entrapment area because of the potential for a head, hand, finger, leg and cords to become entrapped within the scissor mechanism.

Figure 39.3

Example of a typical entrapment location



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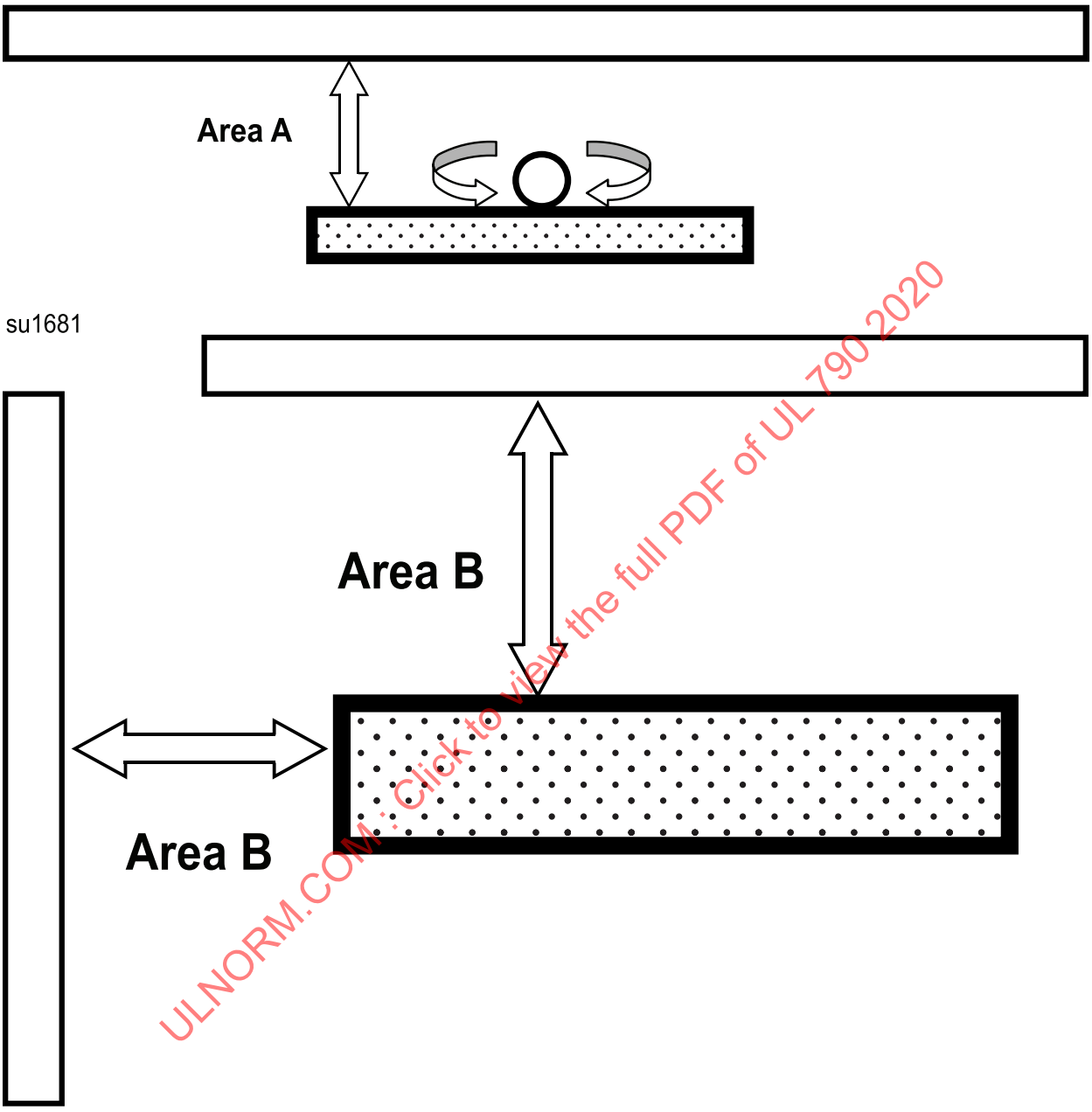
Area A – is considered to be an entrapment area when the top of the moving display is located below 84 inches (2133.6 mm) from the floor. Consideration must be given to displays that can be moved or placed on other displays that have fixed objects above them such as a shelf or top of a cabinet. Use and installation instructions can be utilized to determine recommended placement.

Area B – is considered to be an entrapment area because infants, children, animals and other appendages could be within this area. Geometry and configuration can affect the entrapment concern. A display that leaves 18 inches (457.2 mm) or more between the base or floor and poses no pinch concern would be considered not to be an entrapment hazard.

Figure 39.4

Example of a typical entrapment location



Area A – is considered to be an entrapment area when the display rotates about an axis and can entrap between the display and a fixed structure. Consideration must be given to displays that can be moved or placed on other displays that have fixed structures. Examples: a wall or back of a cabinet. Use and installation instructions can be utilized to determine recommended placement.

Area B – is considered to be an entrapment area when the display moves horizontally side to side or back to front in relation to a fixed structure. Consideration must be given to displays that can be moved or placed on other displays that have fixed objects behind them or to the side of them such as a wall or side or back of a cabinet. Use and installation instructions can be utilized to determine recommended placement.

40 Operator Attended Tests

40.1 A display that relies on a momentary contact switch to function shall be subject to the following conditions where applicable. The display is to carry the rated normal load during test and powered at rated voltage:

a) When a momentary contact switch is released the corresponding moving parts shall stop.

b) Upon power failure the display shall remain in the existing position.

c) Upon reinstatement of power the display shall not move until the operator activates the switch controlling movement.

d) A switch that controls the direction of travel shall be capable of being stopped and the direction of travel reversed at any point in the operation of the display.

41 Snap-Fit Cover Pull-Out Test

41.1 A snap-fit cover employed as part of a display electrical enclosure shall be subjected to the tests specified in 41.2 or 41.3. The cover shall not crack or dislodge from the means of support on the electrical enclosure. Any distortion of the cover resulting from the tests shall not restrict the normal removal and replacement of the cover.

41.2 The electrical enclosure is to be clamped in place and oriented so that the covered face of the electrical enclosure is parallel to the horizontal and directed down. A 25 pound (11.3 kg) weight is to be attached to any point on the edge or outside surface of the cover and gradually released until it hangs freely. The weight is then to hang for 1 minute.

41.3 For a snap-fit cover formed of polymeric material, the test specified in 41.2 is to be repeated on three additional samples of the cover after the samples have been conditioned as specified in Section 29, Conditioning of Products.

42 Tightening Torque Test

42.1 With respect to the Exception to 11.1.9, the tapped threads in a plate not less than 0.30 inch (7.6 mm) thick are able to be used when the threads do not strip after being subjected to the tightening torque specified in Table 42.1. A screw, either supplied or specified in the instructions, is to be tightened to the terminal at a torque, and with a wire in place, as specified in Table 42.1. There shall be two or more full threads in the metal. The metal is able to be extruded, when required, to provide the threads.

Table 42.1
Tightening torque for wire-binding screws

Size of terminal screw, No.	Wire sizes to be tested, AWG[a]	Tightening torque pound-inches (N·m)
8	14 (S) and 16 – 22 (ST)	16 (1.8)
10	10 – 14 (S) and 16 – 22 (ST)	20 (2.3)

[a] ST – stranded wire; S – solid wire.

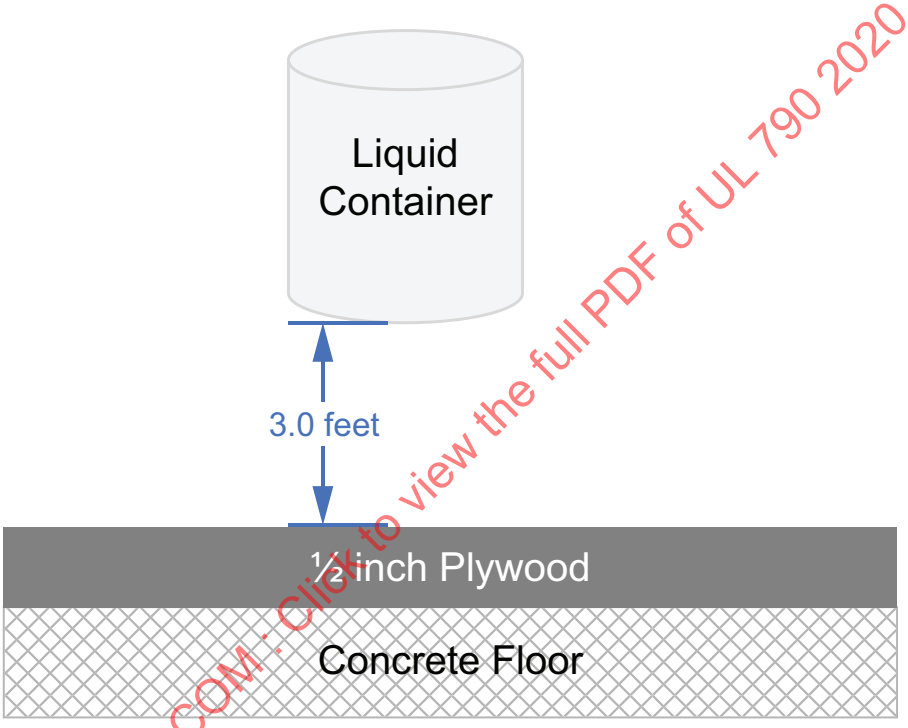
43 Portable Display with Liquid Drop Test

43.1 Three samples of a portable display provided with a factory filled and sealed liquid container shall be subjected to the drop test specified in 43.2 without leakage of the material within the vessel as determined by visual observation following the drop.

43.2 Three samples shall be dropped 3 feet (91.4 cm) onto a nominal 1/2 inch (12.7 mm) thick trade size knot free softwood or softwood plywood sheet directly supported by a concrete floor. See Figure 43.1.

Figure 43.1

Liquid drop test



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44 Tests on Mechanical Connectors

44.1 Mechanical connector test

44.1.1 Three complete samples of a nonmetallic unit-to-unit mechanical connector shall be conditioned as specified in 29.1, Conditioning of Polymeric Components. The connector shall not crack, shrink, melt, swell, warp, or otherwise be damaged to an extent that interferes with the intended use.

44.1.2 A connector of rubber-like material, such as neoprene, is to be placed in an air oven for 70 hours at 100 ±2°C (212 ±3.6°F).

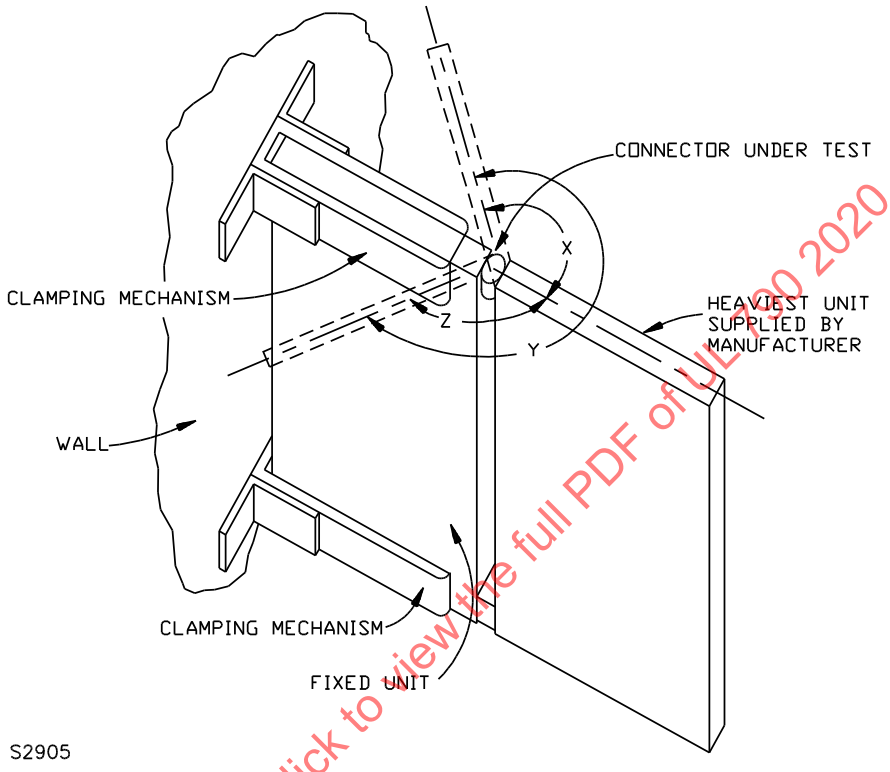
44.2 Flexing

44.2.1 A flexible unit-to-unit mechanical connector that allows the connected units to be moved without disassembly of the product shall be tested as specified in 44.2.2 and 44.2.3. The connector shall not be damaged to an extent that it presents a risk of injury to persons or that potentially interferes with the

intended use of the product. The connector shall continue to support the heaviest table at the end of the test. See Figure 44.1.

Figure 44.1

Flex test



44.2.2 Each of three samples of the connector is to be subjected to 50 cycles of flexing. The flexible connector is to be secured to two units, at least one of which is the heaviest unit provided. One unit is to be clamped in its normal upright position. The heaviest unit is to be pivoted along the axis of the hinge while standing on a smooth, hard surface with glides or feet, if provided, in place. Starting with the units making an angle of 180 degrees, the heaviest unit is to be moved through an angle X equal to 135 degrees unless the travel is mechanically limited to a lesser angle. The heaviest unit is then to be moved through an angle Y equal to 270 degrees in the opposite direction, unless the travel is mechanically limited to a lesser angle and then returned through an angle Z to the starting position. This is one complete cycle.

44.2.3 Following the test specified in 44.2.2, a connector formed of molded rubber or polymeric material is to be subjected to the appropriate conditioning as specified in 44.2.1 or 44.2.2. The connector is then to be subjected to 50 additional cycles of flexing using the procedure specified in 44.2.2.

ELECTRICAL TESTS

45 General

45.1 During any normal electrical test, no safety device shall operate, such as safety circuits, overcurrent, or over temperature protection.

45.2 Where cheesecloth is indicated as a risk of fire indicator, the cheesecloth shall be doubled layer and be bleached, running approximately 14 – 15 yd^2/lb (28 – 30 m^2/kg), and having what is known to the trade

as a ″count of 32 × 28″ – that is, for any inch square, 32 threads in one direction and 28 threads in the other direction (for any centimeter square 13 threads in one direction and 11 threads in the other direction).

46 Leakage Current Test

46.1 A cord-connected display rated for a nominal 250-volt or less single phase supply shall be tested in accordance with 46.2 – 46.9. Leakage current shall not be more than:

a) 0.5 MIU for a two-wire cord- and plug-connected portable display;

b) 0.5 MIU for a three-wire (including grounding conductor) cord- and plug-connected portable display; and

c) 0.75 MIU for a three-wire (including grounding conductor) cord- and plug-connected stationary or fixed display.

Exception No. 1: The leakage current of a display incorporating a sheath type heating element is to be monitored during heat-up and cool-down and shall not exceed 2.5 MIU during the first 5 minutes of energizing the display. At the end of this time, the leakage current shall be not more than the 0.5 MIU or 0.75 MIU limit, as applicable.

Exception No. 2: Displays provided with a single component, such as a power supply, that has already been subjected to the Leakage Current Test, Section 46, do not need to be tested again.

46.2 All accessible conductive parts are to be tested for leakage currents. Leakage currents from these parts are to be measured to the grounded supply conductor individually as well as collectively when simultaneously accessible, and from one part to another when simultaneously accessible. A part is determined to be accessible unless it is guarded by an enclosure that is intended for protection against the risk of electric shock as defined in Section 14, Accessibility of Uninsulated Live Parts and Film-Coated Wire. Conductive parts are determined to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that do not involve a risk of electric shock. When all accessible conductive parts are bonded together and connected to the grounding conductor of the power-supply cord, the leakage current is to be measured between the grounding conductor of the product and the grounded supply conductor.

46.3 When a conductive part other than metal is used for an enclosure or part of an enclosure, leakage current is to be measured using a metal foil with an area of 3.9 by 7.9 inches (10 by 20 cm) in contact with the surface. When the conductive surface has an area less than 3.9 by 7.9 inches (10 by 20 cm), the metal foil is to be the same size as the surface. The metal foil is to conform to the shape of the surface but is not to remain in place long enough to affect the temperature of the product.

46.4 A display employing water or other liquid is to be tested with a hard water solution of 0.5 grams of calcium sulphate ($CaSO_4$) per liter of distilled water (0.07 ounces $CaSO_4$ per gallon of distilled water).

Exception: The composition of the water solution is not specified when it is determined by engineering evaluation that the leakage current will not be affected.

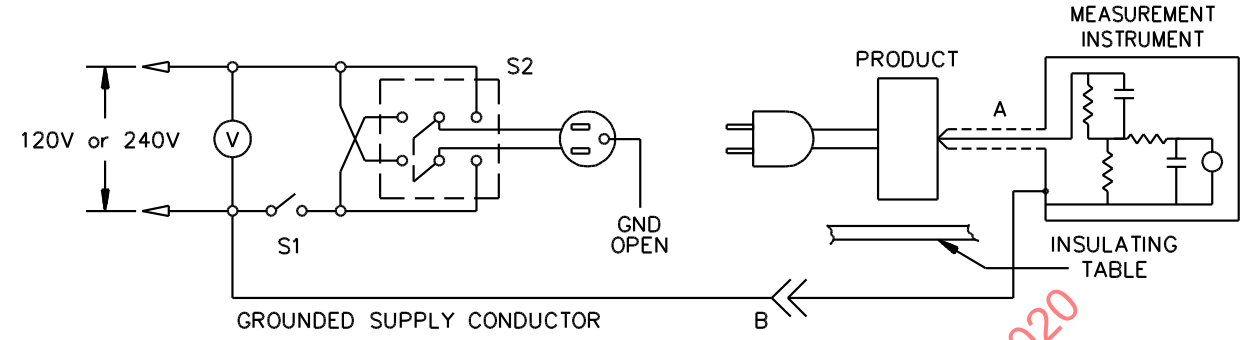
46.5 Typical measurement circuits for leakage current with the ground connection open are illustrated in Figure 46.1. The measurement instrument is defined in Figure 46.2. The meter that is used for a measurement is only required to indicate the same numerical value for a particular measurement as would the defined instrument; it is not required to have all the attributes of the defined instrument. Over the frequency range 20 Hz to 1 MHz with sinusoidal currents, the performance of the instrument is to be as follows:

a) The measured ratio V_1/I_1 with sinusoidal voltages is to be as close as feasible to the ratio V_1/I_1 calculated with the resistance and capacitance values of the measurement instrument shown in Figure 46.2.

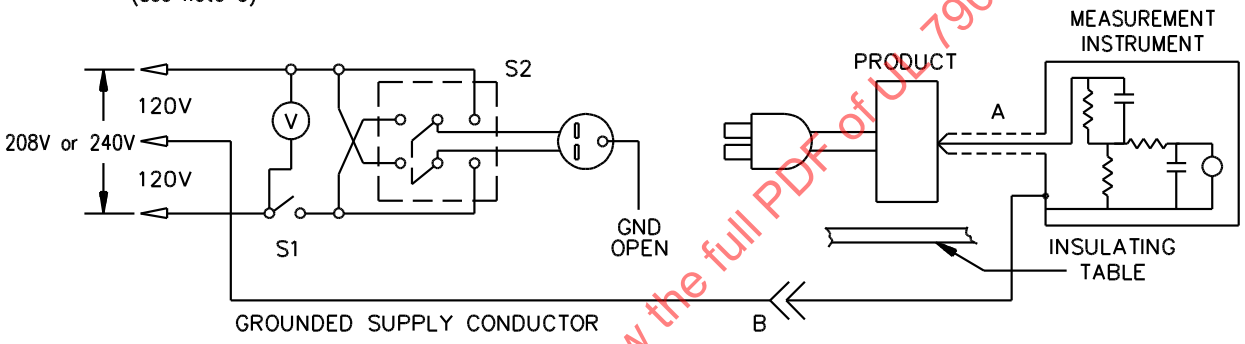
b) The measured ratio V_3/I_1 with sinusoidal voltages is to be as close as feasible to the ratio V_3/I_1 calculated with the resistance and capacitance values of the measurement instrument shown in Figure 46.2. V_3 is to be measured by the meter M in the measuring instrument. The reading of meter M in RMS volts can be converted to MIU by dividing the reading by 500 ohms and then multiplying the quotient by 1,000. The mathematic equivalent is to simply multiply the RMS voltage reading by 2.

Figure 46.1

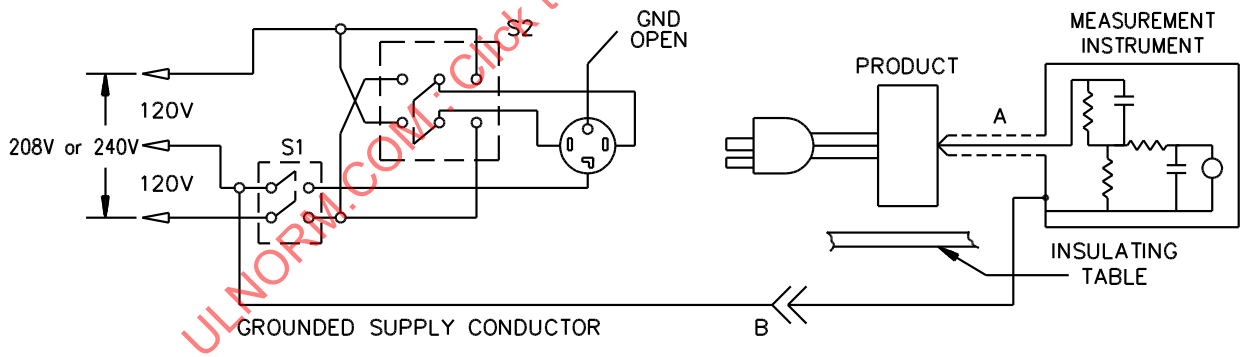
Equipment intended for connection to power supply



Equipment intended for connection to a 120–volt or an end–grounded 2–wire, 240–volt power supply (see note C)



Equipment intended for connection to a 2–wire grounded–neutral 208–volt or 240–volt power supply (see note C)



Equipment intended for connection to a 3–wire grounded–neutral 208–volt or 240–volt power supply

A – Probe with shielded lead.

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

C – Equipment intended for connection to a 2–wire 240–volt power supply is to be tested assuming that the product will be connected to an end–grounded supply (top circuit, above), unless the product is marked in accordance with paragraph 86.11 of UL 197, in which case it is to be tested for connection to a grounded–neutral supply (middle circuit, above).

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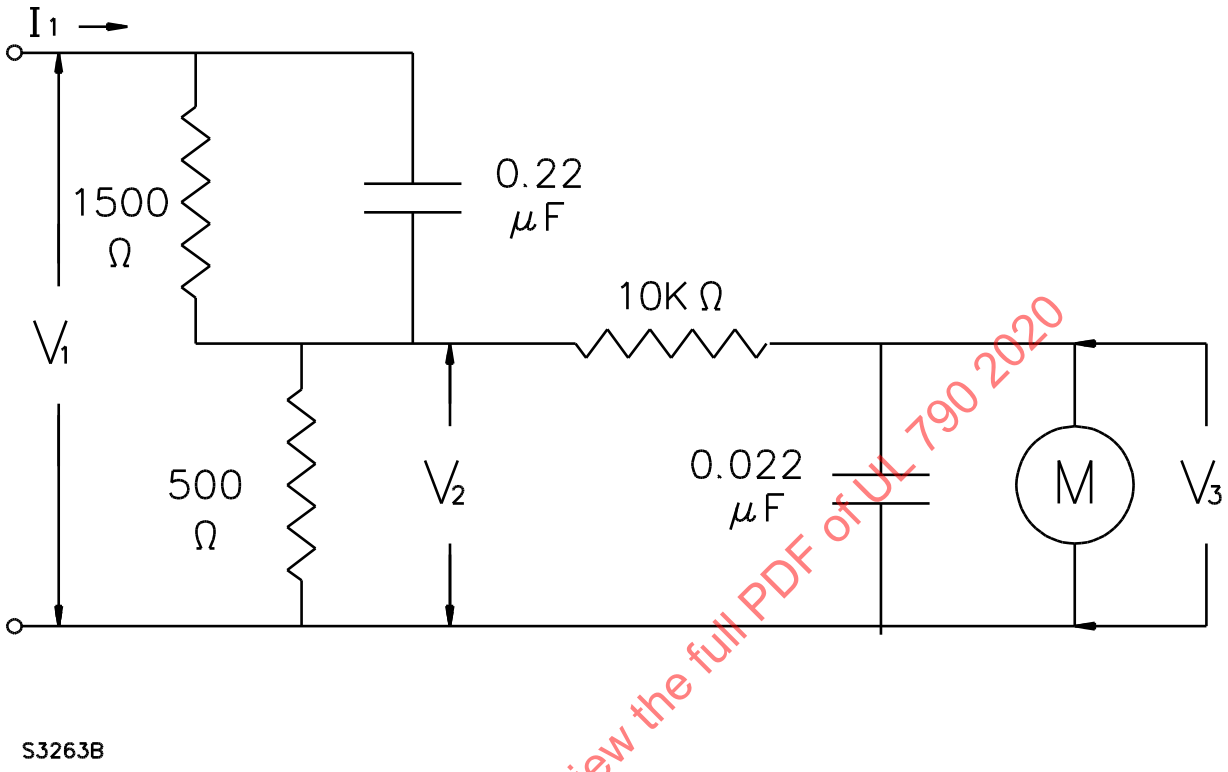
Figure 46.2

Measurement instrument for reaction (leakage) current



46.6 Unless the measurement instrument is being used to measure leakage current from one part of a display to another, it is to be connected between accessible parts and the grounding and supply conductor connected to ground (the grounded or grounding conductor) that has the least extraneous voltages introduced from other equipment operated on the same supply. For products rated 120 volts or 240 volts, with one supply conductor grounded, this is likely to be the grounded supply conductor.

46.7 Prior to the test specified in 46.8, a display utilizing one or more sheathed heating elements is to be conditioned for 24 hours in a chamber having a temperature of 30 ±5°C (86 ±9°F) and a relative humidity of 50 ±5 percent, followed by conditioning for 48 hours in a chamber having a temperature of 30 ±5°C (86 ±9°F), and a relative humidity of 90 ±5 percent. The test in 46.8 is to be conducted as soon as is practical after the conditioning, but in no case more than 24 hours after the display is removed from the conditioning chamber.

Exception No. 1: The entire display is not required to be conditioned if the sheathed heating elements are removed from the display and conditioned as stated. The elements are to be re-installed in the display before the test is conducted.

Exception No. 2: The conditioning is not required if all sheathed heating elements in the display comply with the requirements of the Resistance to Moisture Test in the Standard for Sheathed Heating Elements, UL 1030.

46.8 A sample of the display, conditioned as specified in 46.7, where required, is to be tested for leakage current starting with the as-received condition – the as-received condition being without prior energization, except as may occur as part of the production-line testing. The supply voltage is to be adjusted to rated voltage. The test sequence is to be as follows, with reference to the measurement circuit shown in Figure 46.1:

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

b) Switch S1 is then to be closed, energizing the display. Within 5 seconds, the leakage current is to be measured using both positions of switch S2 and with the display 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 – General, 49.1.

d) The leakage current is also to be monitored with switch S1 open while the display is at operating temperature and while cooling.

46.9 A sample is to be subjected to the entire leakage current test, as specified in 46.8, without interruption for other tests.

Exception: With the concurrence of those concerned, the leakage current test is not prohibited from being interrupted to conduct other nondestructive tests.

47 Starting Current Test

47.1 A motor-operated display shall start and operate normally on a circuit protected by an ordinary – not time-delay – fuse having a current rating corresponding to that of the branch-circuit power-supply to which the display is to be connected. As a result of the test the fuse shall not open or an overload protector provided as part of the display shall not trip.

Exception: The requirement for an ordinary fuse does not apply when:

a) The construction of the motor-operated display or the nature of its usage is such that it is used continually on the same branch circuit after installation;

b) The motor-operated display starts and operates as intended on a circuit protected by a time-delay fuse; or

c) The motor-operated display is marked in accordance with 77.3.

47.2 The motor-operated display is to be started three times at room temperature at the beginning of the test. Each start of the motor is to be made under conditions representing the beginning of intended operation and the motor is to be allowed to come to rest between successive starts.

48 Input Test

48.1 The current or wattage input to a display shall not be more than 110 percent of the rated value when the display is operated under the condition of maximum normal load and when connected to a supply circuit of maximum rated voltage and rated frequency. The current or wattage input to a display shall not be less than 85 percent of the rated value.

Exception No. 1: When the display is not provided with an installed electrical load (such as motor or luminaire), the input is determined as specified in Section 74, Electrical Ratings.

Exception No. 2: Displays that are not provided with any type of electrical load and only receptacles are not subjected to the Input Test, Section 48.

48.2 For a display having a single voltage rating, such as 115 volts, maximum rated voltage is determined to be that single value of voltage. When the rating is given in terms of a range of voltages, such as 110 – 120 volts, maximum rated voltage is determined to be the highest value of the range. If the range extends to other voltages levels then the test shall be performed at each of the voltage levels. For example, a display rated 100 – 240 Volts shall be tested at 120 V, 208 V, and 240 V.

48.3 Displays that operate from a power supply shall have the input to the load measured. The load current or wattage shall not exceed 110 percent of the rated value when the display is operated under the condition of maximum normal load and when connected to a supply circuit of maximum rated voltage.

49 Temperature Test

49.1 General

49.1.1 An electrified display shall be tested as described in 49.1.2 – 49.1.5. Temperatures shall not exceed the applicable values specified in Table 49.1.

Exception No. 1: When the display is only provided with an outlet assembly that complies with one of the following:

a) Standard for Relocatable Power Tap, UL 1363;

b) Standard for Furniture Power Distribution Unit, UL 962A; or

c) Outline of Investigation for Multioutlet Assembly, UL 111;

the temperature test is not required.

Exception No. 2: A display provided with a luminaire that complies with Section 3, Components, when installed and operated in accordance with its installation and operation instructions, has no other electrical load and no receptacle outlets is not required to be subjected to the temperature test.

Exception No. 3: When the display is not provided with an installed electrical load (such as motor or Luminaire), the temperature test is not required when the electrical system consists of receptacle assemblies installed and connected to a field wiring junction box or is cord and plug connected; and complies with the requirements as specified in the National Electrical Code, ANSI/NFPA 70 and the Canadian Electrical Code, C22.1-15.

49.1.2 The temperature limits specified in Table 49.1 are based on an ambient temperature of 25°C (77°F). The temperature test is able to be conducted at any ambient temperature 10 – 40°C (50 – 104°F) and corrected to an ambient of 25°C (77°F).

Table 49.1
Maximum temperature rises

Material and component parts	°C	(°F)
1. Capacitors:[b]		
Electrolytic[a]	65	(149)
Other types	90	(194)
2. Fuses		

Table 49.1 Continued on Next Page

Table 49.1 Continued

Material and component parts	°C	(°F)
A. Class G, J, L, T, and CC		
Tube	125	(257)
Ferrule or blade	100	(212)
B. Other[f]	90	(194)
3. Fiber employed as electrical insulation	90	(194)
4. At any point within a terminal box or wiring compartment of a permanently connected display in which power-supply conductors are to be connected, including such conductors themselves, unless the display is marked in accordance with 91.1.	60	(140)
5. A surface upon which a display is able to be fastened in place, and surfaces that are adjacent to the display when so fastened.	90	(194)
6. Surfaces that are adjacent to the cabinet light when it is mounted	90	(194)
7. Class 105(A)[c,h]		
Thermocouple method	90	(194)
Resistance method	100	(212)
8. Class 120(E)[c,h]		
Thermocouple method	100	(212)
Resistance method	110	(230)
9. Class 130(B)[c,h]		
Thermocouple method	110	(230)
Resistance method	120	(248)
10. Class 155(F)[c,h]		
Thermocouple method	135	(275)
Resistance method	145	(293)
11. Class 180(H)[c,h]		
Thermocouple method	150	(302)
Resistance method	160	(320)
12. Phenolic composition employed as electrical insulation or as part of the deterioration of which results in a risk of fire or electric shock[d]	150	(302)
13. Phenolic lampholder body[g]	150	(302)
14. Rubber- or thermoplastic-insulated wire and cord[d,e]	60	(140)
15. Sealing compound	65°C (149°F) less than melting point	
16. Varnished-cloth insulation	85	(185)
17. Wood and other combustible material	90	(194)
18. Lampholder screw shell	200	(392)
19. Current carrying parts		
A. Copper or copper alloy	200	(392)
B. Aluminum	200	(392)
C. Stainless steel, monel, nickel plated copper	250	(482)
20. Accessible parts		
A. External surfaces (other than lamps or lenses)[i]	90	(194)
B. Operating knobs, handles, and levers intended for momentary contact during adjustment only or areas that are able to be incidentally contacted.		

Table 49.1 Continued on Next Page

Table 49.1 Continued

Material and component parts	°C	(°F)
1. Wood	90	(194)
2. Plastic or rubber[j]	85	(185)
3. Glass, porcelain, or vitreous enameled material	75	(167)
4. Metal	50	(122)
C. Handles or surfaces intended to be grasped for lifting, carrying, or holding:		
1. Metallic	45	(113)
2. Nonmetallic	60	(140)
21. The maximum acceptable temperature rise on external surfaces of a display employing a heating pad in the area subject to user contact.	70	(158)

[a] The temperature rise on insulating material integral with the enclosure of an electrolytic capacitor that is physically integral with or attached to a motor shall not be more than 90°C (194°F).

[b] A capacitor that operates at a temperature rise of more than 90°C (194°F) is able to be judged on the basis of its marked temperature limit.

[c] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple are not prohibited to be higher by the following amount than the maximum specified when the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table.

Item	Additional temperature rises	
	°C	°F
7	15	(27)
8	15	(27)
9	20	(36)
10	15	(27)
11	15	(27)

[d] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and found usable at higher temperatures.

[e] Rubber-insulated conductors within a Class A-insulated motor, rubber-insulated motor leads, or a rubber-insulated flexible cord entering a motor are able to be subjected to a temperature rise of more than 60°C (140°F), when a braid is employed on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wires or cords.

[f] A fuse that has been investigated and found usable at a higher temperature is able to be used at that temperature.

[g] Does not apply when investigated and found to be usable at a higher temperature.

[h] A totally enclosed motor is able to have winding temperature 5°C (9°F) higher than those stated.

[i] Where lens is not also serving as a portion of the shade.

[j] Includes plastic with a metal plating not more than 0.005 inch (0.13 mm) thick; and metal with a plastic or vinyl covering not less than 0.005 inch thick.

49.1.3 When temperature readings are to be obtained by means of thermocouples, the thermocouples shall consist of wires not larger than 24 AWG (0.21 mm^2). When thermocouples are used in the determination of temperatures in connection with the heating of electrical devices, it is common to employ thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wire, and an instrument specifically designed for accurate determination of the attained temperature. Such equipment is to be used whenever reference temperature measurements are required.

49.1.4 To facilitate conducting the test on a totally enclosed – encapsulated – component of a display, thermocouples are to be attached to internal components prior to the addition of potting materials and are to be routed through holes made in the enclosure for this purpose.

49.1.5 A polymeric material used as a decorative trim or part shall be rated for the temperatures to which it is subjected during intended use, in that it shall not melt or deform in such a way as to interfere with the intended operation of the display.

49.1.6 A light is to be operated continuously at rated luminaire wattage until constant temperatures are attained. A motor-operated display is to be on and operating at maximum load during the temperature test. A temperature is determined to be constant when the test has been running for at least 3 hours, and three successive readings, taken at 30-minute intervals, are within 1.8°F (1°C) of one another and are not still rising. A motor operated display shall be operated as specified in 49.2.1 – 49.2.3.

49.1.7 A receptacle provided shall be loaded to its rating. Displays provided with a string of receptacles shall have the last receptacle loaded to the maximum load using a resistive load by means of a solid-blade attachment plug to the last receptacle and any other receptacle that attains higher temperatures as determined by their proximity to heat-producing components.

49.1.8 A display provided with overcurrent protection (OCP) rated greater than the display rating, shall be subjected to additional temperature test at the OCP rating with the OCP bypassed.

49.2 Motor-operated display

49.2.1 A thermal- or overload-protective device shall not open the circuit during the temperature test.

49.2.2 For a display that is not intended for continuous operation, the time of operation of the display is to be evaluated when conducting the temperature test.

49.2.3 For the Temperature Test, a mechanical load is to be placed on the display to simulate the intended use as follows:

a) The display shall be loaded with its rated load.

b) For a display that is not intended to operate continuously, the display shall be cycled until maximum temperatures are obtained in accordance with one of the following:

1) The minimum duty cycle sequence shall be nine complete cycles of its complete range of motion, without pause between cycles, except that a 5-minute period is to be interposed between the third and fourth cycle and between the sixth and seventh cycles. During the 5-minute interval the motor is to be running, with the display not operating, when allowed by the construction. Otherwise, the motor is to be de-energized. A temperature is determined to be maximum when the test has been running for at least 4 hours, and three successive readings, taken at 1-minute intervals, are within 1.8°F (1°C) of one another and are not still rising. When the speed of operation of the display is controllable, the test is to be performed at such speed that maximum heating results. A display that is capable of more than one mode of motion is to be tested in each mode for the nine complete cycles; or

2) When the operation instructions specify a different cycle and endurance sequence than ″1″ the operation sequence shall follow the sequence specified in the instructions. The operation instructions shall specify a duty cycle that is reasonable for the application of the product. Consideration shall be given to the specific function of the product.

50 Battery Operated Displays

50.1 General

50.1.1 Batteries shall not exceed the battery temperature limits and battery chargers and charging circuits shall not exceed their temperature limits.

50.1.2 Primary (Non rechargeable) battery powered displays shall be tested as specified in 50.2, Method I.

50.1.3 Secondary (rechargeable) battery powered displays shall be tested as specified first in 50.2, Method I, then followed by 50.3, Method II.

50.2 Method I

50.2.1 A battery powered display shall have new fully charged batteries installed. The display if powered from an external power source in addition to the battery shall be disconnected from the external power source. The display shall be operated as specified in the Temperature Test, Section 49, until the display will no longer perform the electrical or mechanical function(s) it is intended to perform.

50.2.2 A display that requires external power in addition to installed batteries shall have new fully charged batteries installed and the display shall be operated as specified in the Temperature Test, Section 49, until the temperatures stabilize or 4 hours minimum until the display will no longer perform the electrical or mechanical function(s) it is intended to perform.

50.3 Method II

50.3.1 Cells or batteries discharged to the rated capacity or as specified below are to be used for this test. The batteries are to be tested in an ambient temperature of 25 ±5°C (77 ±9°F):

a) If the display is to be tested using a lead-acid battery or batteries, each battery is to be discharged to 1.75 volts per cell – measured with the load connected.

b) If the display is to be tested with a typical 1.2 volts per cell nickel cadmium or nickel metal hydride battery, each battery is to be discharged to 0.9 volts per cell – measured with the load connected.

50.3.2 The display is to be energized and the batteries are to be allowed to fully charge with the display in a non-energy consuming or movement mode unless designed to be operable while the batteries are being charged.

50.4 Discharge test

50.4.1 The display shall be operated until all electrical storage products are fully charged.

50.4.2 The battery shall be removed and the time it takes for the circuit to fully discharge (no current flow in the circuit) shall not exceed 2 seconds. All accessible electrical circuits in the battery compartment shall be measured.

50.5 Battery installation test

50.5.1 Installing a battery in a display or a remote control shall not cause the display to operate in a manner that may cause personal injury.

50.5.2 A fully charged battery shall be installed in the display or remote control. The display shall not move in a manner that would cause personal injury. The test shall be repeated for each control setting on the display. Manually operated momentary contact switches are not to be activated while inserting the battery.

51 Strain Relief Test

51.1 Cords

51.1.1 The strain-relief means provided on an attached flexible cord, when tested in accordance with 51.1.2 shall be capable of withstanding for 1 minute, without displacement, a pull of 35 lbf (156 N) applied to the cord, with the connection within the display disconnected.

51.1.2 Strain relief that relies on polymeric material shall first be conditioned in accordance with 29.1, Conditioning of Polymeric Components. The cord conductors are to be severed within the display. A 35 pound (156 N, 15.9 Kg) force is to be applied to the cord and supported by the display so that the strain-relief means is stressed from any angle that the construction of the display permits. The strain relief is not in compliance if:

a) At the point of disconnection of the conductors, there is sufficient movement of the cord to indicate that stress on the connections have resulted; or

b) At the point of disconnection of the conductors movement exceeded 0.063 inches (1.6 mm).

51.2 Strain relief for internal conductors and connectors test

51.2.1 A pull force of 89 N (20 lb) shall be applied for 1 minute to each conductor in a direction perpendicular to the plane of the entrance to the conductor connection. If the conductors are bundled into a single monolithic cable the test may be conducted on the cable assembly instead of the individual conductors. There shall be no breaking of the conductor or loosening of the conductor connections.

52 Conductor Cycling Endurance Test

52.1 In accordance with 18.4, Conductors Subject to Flexing, a display in which the normal use of the display results in movement of conductors or other insulated electrically energized parts shall withstand an endurance test as described in 52.3 and 52.4. There shall be no electrical or mechanical malfunction of the display and, after the endurance test, the conductors subjected to the flexing and the display as a complete assembly shall comply with the requirements in Section 54, the Dielectric Voltage-Withstand Test. In addition to the general requirements specified in Section 54 shall be conducted between each individual conductor and any other conductor that was subjected to the Conductor Cycling Endurance Test, Section 52.

Exception: Conductors utilized in a LVLE circuit are not required to be subjected to the conductor cycling endurance test unless the circuit is relied upon for the safe operation of the display.

52.2 The display is to be energized during the test. The voltage supply circuit and the temperature conditions shall be in accordance with the normal Temperature Test – General, 49.1.

52.3 The endurance test required by 52.1 is to consist of 6000 cycles of operation. The conductors are to be flexed while energized from one extreme position to the opposite extreme position as allowed by the design of the display.

52.4 For the endurance test described in 52.3, any mechanical arrangement is to be employed to operate the movable member at a rate of between 10 – 30 cycles per minute or at rate allowed by the display construction.

53 Grounding-Impedance Test

53.1 The exposed non energized metal parts that may become energized and the ground contact of a receptacle outlet of the display shall be conductively connected to the ground pin of the attachment plug as determined by the grounding test in 53.2 – 53.4.

Exception: A ground path comprised of components evaluated for use as an assembly and suitable as a fault current path are not required to be tested.

53.2 Any resistance measuring device, such as an ohmmeter, is to be employed during testing.

53.3 When tested, the resistance between any point required to be grounded and the equipment grounding terminal in the case of a display intended for permanent electrical connection, or the point on the display where the grounding conductor of the cord is attached; shall not be more than 0.1 ohm. The resistance is to be determined by any convenient method as noted in 53.2, except that when unacceptable results are obtained, the measurement is to be taken in accordance with 53.4.

53.4 When a measurement is required by 53.3, an alternating current of at least 25 amperes from a power supply of not more than 6 volts is to be passed from the equipment grounding terminal or the point of attachment of the wiring system to the un-energized live part, and the resulting drop in potential is to be measured between these two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

54 Dielectric Voltage-Withstand Test

54.1 The insulation and spacings of a display shall withstand the test potential specified in Table 54.1 without breakdown. The test shall be performed immediately after the Temperature Test, Section 49.

Table 54.1
Dielectric voltage and time

Insulation type	Rated voltage	One minute (Vac)	One minute (Vdc)	1 Second (Vac)	1 Second (Vdc)
Single	42.4 ac peak or 60 dc or less	500	700	600	850
Double		1000	1400	1200	1700
Single	Above 42.4 ac peak or 60 dc	1000 + (2 × Rated Voltage)	1.414 × (1000 + (2 × Rated Voltage))	1200 + (2.4 × Rated Voltage)	1.414 x (1200 + (2.4 × Rated Voltage))
Double		2000 + (4 × Rated Voltage)	1.414 × (2000 + (4 × Rated Voltage))	2400 + (4.8 × Rated Voltage)	1.414 × (2400 + (4.8 × Rated Voltage))

54.2 Breakdown is usually indicated by the tripping of an overload protector in the test equipment; however, an abrupt decrease or retarded advance of the voltmeter reading also indicates insulation breakdown.

54.3 A 60-hertz sinusoidal (for AC) potential is to be applied between live parts conductively connected to the supply circuit and dead metal parts. The applied potential is to be as specified in Table 54.1. The supply source is to have capacity to maintain the potential specified, except in case of breakdown. The voltage is to be increased gradually from zero until the specified test potential is reached or until breakdown occurs.

Exception: Circuits operating at a voltage of 42.4 V ac peak or 60 V dc or less the test potential shall be 500 V ac or 700 V dc.

54.4 The test equipment is to include a transformer having a sinusoidal output for ac tests, a means of indicating the test potential, an audible or visual indicator of electrical breakdown, and either a manually reset device to restore the equipment after electrical breakdown or an automatic feature to reject any product that does not meet the requirement.

54.5 When the output of the test-equipment transformer is less than 500 volt-amperes, the equipment is to include the voltmeter in the output circuit to directly indicate the test potential.

54.6 When the output of the test-equipment transformer is 500 volt-amperes or more, the test potential is able to be indicated by a voltmeter in the primary circuit or in a tertiary-winding circuit, a selector switch marked to indicate the test potential, or in the case of equipment having a single test-potential output, a marking shall be visible while the equipment is in use to indicate the test potential. When a marking is used without an indicating voltmeter, the equipment shall include a positive means, such as an indicator lamp, to indicate that the manually reset switch has been reset following a dielectric breakdown.

54.7 Test equipment other than that specified in 54.4 – 54.6 is able to be used with the consent of those concerned.

54.8 For an upholstered display that employs a heating pad, the test potential specified in 54.3 is to be applied between interconnected current-carrying parts of each sample display in the area of the heating pad and sheets of metal foil on the sides or faces of the display. The display, with the foil on each side or face of the heating pad surface, is to be covered with felt mats as described in 54.9. A uniform pressure of 25 lb/ft^2 (122 kg/m^2) is to be applied to the felt mats so that the metal foil is held in close contact with the heating pad covering.

54.9 The felt mats specified in 54.8 are to be 1 inch (25 mm) thick and have an area sufficient to completely cover the area of the heating pad and to extend for not less than 2 inches (51 mm) all the way around the pad area.

55 Printed-Wiring Board Tests

55.1 Printed-Wiring Board (PWB) ground path test

55.1.1 Three samples of the PWB assembly with a ground path trace shall be subjected to the Ground Path Test currents as specified in Table 55.1. The enclosure of the PWB shall be mounted as intended and wrapped in cheesecloth. During and following the test, the following conditions shall not occur:

a) Emission of flame, molten metal, or glowing or flaming particles through any openings (preexisting or created as a result of the test) in the product;

b) Charring, glowing, or flaming of the supporting surface;

c) Ignition of the enclosure;

d) Creation of any openings in the enclosure that result in accessibility of live parts, when evaluated with the probe shown in Figure 14.1; and

e) There shall not be evidence of degradation or separation of a trace from the printed-wiring board.

Table 55.1
Ground path test currents

Grounding and bonding supply copper conductor size		Test current, A	
AWG or kcmil	(mm^2)	Time, s	Copper
14	(2.1)	4	300
12	(3.3)	4	470
10	(5.3)	4	750
8	(8.4)	4	1180
6	(13.3)	6	1530
4	(21.2)	6	2450

55.1.2 Following the test the resistance of each ground conductor trace is to be determined. This is determined by measuring the voltage drop when a current of 25 A, derived from a 60 Hz source with a no-load voltage not exceeding 6 V, is passed between the supply ground conductor or terminal and the load side of each outlet. The resistance shall not be more than 0.1 ohms.

55.2 Printed Circuit Board (PWB) Conductor Overcurrent Test

55.2.1 In accordance with Printed wiring boards, 3.10, three PWB circuit assemblies with supply conductor traces are to be subjected to the Printed Circuit Board Conductor Overcurrent Test. The assembly shall comply with the requirements in 55.2.4 and 55.2.5.

55.2.2 The display or smallest electrical enclosure containing the circuit under test shall be mounted as intended and wrapped in cheesecloth.

55.2.3 The overload current is to be 200 percent of the current rating of the maximum size branch circuit overload device to which the display is intended to be connected. The overcurrent test current is to be applied for 2 minutes.

55.2.4 During and following this test, the following conditions shall not occur:

a) Emission of flame, molten metal, or glowing or flaming particles through any openings (preexisting or created as a result of the test) in the product;

b) Charring, glowing, or flaming of the supporting surface;

c) Ignition of the enclosure;

d) Creation of any openings in the enclosure that result in accessibility of live parts, when evaluated with the probe shown in Figure 14.1; and

e) There shall not be evidence of degradation or separation of a trace from a printed-wiring board.

55.2.5 After the sample has cooled to room temperature the spacing's between traces or between the traces and other grounded non-energized metal parts shall comply with the requirements in Section 19, Spacings.

56 Motors Testing

56.1 General

56.1.1 Motors that use method 3.9.1 (c), (d), or (e) for protection shall comply with the following:

a) A motor that only operates when the user is present and when activated by the user with a momentary contact switch is not required to be subjected to the Running Overload Motor Test, 56.2.

b) A display where the motor operation is automatic or the motor can operate without the presence of the user shall comply with the Running Overload Motor Test, 56.2.

c) All motor operated displays shall comply with the Locked Rotor Test, 56.3, unless subjected to the locked rotor tests under one of the standards specified in 3.9.1.

56.1.2 Where the motor is protected by the limiting impedance of the motor windings or by the opening of an electrical component, other than over current protection, three samples of the motor under investigation shall be subjected to the test. Where the motor is protected by an overcurrent device or thermal protector only one sample will need to be tested.

56.2 Running overload motor test

56.2.1 The case of an enclosed motor or the windings of an open motor shall be thermocoupled with a minimum of three thermocouples. The case, windings or body of the motor shall then be wrapped in cheesecloth. The risk of fire indicator (cheesecloth) is to be double-layered. There shall be no ignition (charring or discoloration is acceptable) of the cheesecloth and the maximum temperature on [the case on an enclosed motor or a winding on an open motor] shall not exceed 150°C (302°F). The Dielectric Voltage-Withstand Test shall be conducted immediately following the running overload test while still heated. The test shall be conducted in accordance with Dielectric Voltage-Withstand Test, Section 54.

56.2.2 The Running Overload Test shall be carried out by operating the motor under normal load; and then increasing the load so that the current is increased to the point just below where the power supply or controller limits the current to the motor(s). Supply voltage shall be maintained at its original value.

56.2.3 In accordance with 3.5.6, if the display has a control that limits the operation time, the test duration of the overload test shall be conducted based on the controller limiting the operation of the device. Single component faults within the controller circuit shall be considered.

56.3 Locked rotor test

56.3.1 Three samples of the motor are used for this test. The motor is to be thermocoupled with a minimum of 4 thermocouples on the windings or case for a totally enclosed motor. The motor shall have cheesecloth loosely draped around the motor. The motor shall be mounted on a surface with the rotor locked. If the power supply or controller provided with the product is used to provide voltage, it shall have any overload protection defeated, including software unless it was evaluated in accordance with 3.9.1 (d) or (e) and 3.5.4, Protective Controls. The motor is to be operated at the voltage used in its application and with its rotor locked for 7 hours or until steady conditions are established. The Dielectric Voltage-Withstand Test, Section 54, shall be conducted immediately following the locked rotor test while still heated. The test shall be conducted in accordance with the Dielectric Voltage-Withstand Test, Section 54.

Exception: If a power supply is used with an evaluated foldback system, then the power supply does not need to be evaluated to 3.9.1 (d) or (e) and Conditioning of Products, Section 29.

56.3.2 There shall be no ignition (charring or discoloration is acceptable) of the cheesecloth and the maximum temperature on the case on an enclosed motor or a winding on an open motor shall not exceed 150°C (302°F). It shall comply with the Dielectric Voltage-Withstand Test, Section 54.

56.3.3 As an alternate to 56.3.1 for totally enclosed motors that have not been evaluated to 3.9.1, the motors shall be prepared as specified in 56.3.1, except a power source shall be used to provide sufficient

current without any protection circuit operating. The outside of the motor shall be draped with cheesecloth. If the motor is enclosed in a secondary metal enclosure, such as the leg of a table, the cheesecloth may be placed on the outside of the secondary enclosure and if the leg is open at one end, the cheesecloth shall be placed inside the leg in contact with the motor. If the test is performed with motor inside a secondary metal enclosure, such as a leg, temperatures shall be measured on the outside of the enclosure if the user may contact the surface.

56.3.4 There shall be no ignition (charring or discoloration is acceptable) of the cheesecloth or any indication of a fire, such as insulation on leads discolored or melted. The maximum temperature on the exposed enclosure (either the motor or secondary) shall not exceed 90°C (194°F).

57 Abnormal Tests

57.1 General

57.1.1 A product shall not present a risk of fire, electric shock, or injury to persons when operated under the abnormal conditions specified in 57.2 – 57.5. Compliance with the tests specified in this section is met when all of the following occurs:

a) There is no ignition or charring of the cheesecloth indicator (charring is deemed to have occurred when the structural integrity of the threads has been destroyed due to temperature);

b) The fuse from the enclosure to ground does not open;

c) Immediately following these tests, the product complies with:

1) The Dielectric Voltage-Withstand Test, Section 54, within 1 minute after completion of the abnormal test; or

2) The Leakage Current Test, Section 46, when the product is provided with a power supply cord and attachment plug; or

d) Immediately following these tests the product complies with the entrapment force limitations specified in Section 39, Entrapment Force Measurement and Operator Attended Tests.

e) The product complies with the enclosure and guarding requirements of 12.3, Mechanical Enclosures and Guards – Mechanical Considerations.

57.1.2 During the tests, cheesecloth, is to be draped loosely over the display or portion of the display under investigation.

57.1.3 The product is to be connected to a power supply and connected in series with a non-time-delay fuse of the maximum current rating of the branch circuit. Opening of the fuse before any condition of risk of fire or electrical shock results is considered as meeting the intent of the requirements. The enclosure, when metallic or employing dead-metal parts, shall be connected to ground either through a fuse rated to correspond to the input rating of the unit or 3 amperes, whichever is less. Only one abnormal condition is to be simulated at a time.

57.1.4 Abnormal operation tests are to be conducted until ultimate results are obtained, or for 7 continuous hours. Examples of ultimate results include the following:

a) Ignition of any portion of the display under investigation;

b) Electrical breakdown of an insulating system;

c) The display becomes permanently inoperable by:

1) Opening of one or more capacitors, diodes, resistors, semiconductor devices, printed-wiring board traces, motor, or similar part or component, when there is no indication of further change;

2) Opening of the intended branch-circuit overcurrent protective device; or

3) Opening of a non-user accessible, non-resettable protective device.

d) The operating temperatures of the display stabilize, and it is apparent that continued operation for the full 7 hours will not affect the test results.

e) Reset protector functions in accordance with 57.1.5; and

f) Any other condition that indicates continued operation will not affect the results of the test.

57.1.5 When an automatically reset protector functions during tests, the test is to be continued for a minimum of 7 hours or until ultimate results occur. When a M1 manual reset protector functions during a test, it is to be operated for 10 cycles using the minimum resetting time, at a rate not faster than 10 cycles of operation per minute. When an M2 manual reset protector functions during a test it is to be operated in the minimum time allowed by the construction of the display as specified in the use instructions to restore the operation of the display. The M2 protector shall be tripped for 10 cycles of operation or for a minimum of 7 hours or until ultimate results occur. The protector shall be operative upon completion of the test.

Exception: When the manual reset protector is a circuit breaker that complies with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489, it is to be operated for 3 cycles using the minimum resetting time at a rate not faster than 10 cycles of operation per minute.

57.1.6 A risk of fire or electric shock is determined to exist when any of the following occurs:

a) Flame or molten metal is emitted from the enclosure of the equipment as evidenced by ignition, glowing, or charring of the cheesecloth;

b) A breakdown results from the dielectric voltage-withstand test;

c) Live parts are made accessible;

d) The 3-amp non-time-delay ground fuse opens; or

e) A failure of the Leakage Current Test, Section 46.

57.1.7 During these tests, all fuses which are field-renewable by the user and are of an interchangeable type shall be replaced by a fuse of the same size and voltage rating using the highest available current rating for that size. Opening of the fuse before any condition of risk of fire or electrical shock results satisfies the requirement of the test.

Exception: Fuses need not be replaced when the product employs marking identifying the need for using the indicated fuse(s) located so that it is obvious as to which fuse or fuseholder(s) the marking applies and where readily visible during replacement of the fuse(s). A single marking is acceptable for a group of fuses. The marking shall comply with 75.21.

57.1.8 All abnormal conditions are to be continued until ultimate results are obtained, such as burnout or stabilization of temperatures.

57.2 Continuous operation

57.2.1 A user-operated control is to be adjusted to the position representing the most adverse operating condition.

57.2.2 A product that normally would only be operated for a limited time shall be capable of operating continuously in any condition of normal use possible without risk of fire, electric shock, or injury to persons.

57.3 Output or display interconnection field-wiring

57.3.1 Each output circuit of the product to which field wiring is intended to be connected is to be individually opened or shorted.

57.3.2 The test condition in 57.3.1 shall be applied one at a time. The abnormal condition shall be introduced while the equipment is operating in any condition of normal use.

57.4 Electronic components

57.4.1 All circuit components located in a control or safety circuit shall be examined using the equipment circuit diagrams and component specifications to determine those faults that can occur. The failure of any component in the input and output circuits, excluding secondary ground-fault protection circuits, that results in risk of fire or electric shock, shall be subjected to short-circuits and open-circuits of transistors, rectifiers, diodes, and capacitors, faults causing continuous dissipation in resistors designed for intermittent dissipation, and internal faults in integrated circuits causing excessive dissipation. The product shall then be operated during each of the fault conditions until constant temperature or burnout occurs. Only one short-circuit or open-circuit test is to be conducted at a time.

57.4.2 The components specified in 57.4.1 includes an electrolytic capacitor, a diode, a solid-state device, or any other component not previously investigated and determined to be rated for the application.

Exception: A previously investigated component determined to be reliable such as a rated electromagnetic and radio-frequency-interference capacitor, a resistor, a transformer, an inductor, or an optical isolator, is not required to be subjected to this test.

57.4.3 The faults referenced in 57.4.1 shall be applied one at a time. Short circuits shall be applied only between two terminals of a multi-terminal device at one time. Simulated circuits are also capable of being used for high-voltage circuit abnormal tests. But when the tests performed on simulated circuits indicate likely damage to other parts of the equipment to the extent that the safety of the equipment is capable of being affected, the tests shall be repeated in the equipment. The abnormal condition shall be introduced while the equipment is operating under intended conditions. This is to be accomplished by jumper leads and remote switches with consideration given to the effect these devices have on the test.

57.4.4 Component burnout shall not be used as the sole means of preventing a risk of fire or shock.

57.5 Cooling fans and blowers

57.5.1 The product shall be operated under the condition which produces the greatest power dissipation until constant temperature or burnout occurs with all cooling fans and blowers disabled.

57.5.2 The locked-rotor test is to be conducted on the product and operated with the rotor of each cooling fan and blower motor locked.

Exception: Where a means of limiting the current is inherent in or provided as part of the device, these features are to be given consideration when conducting the locked-rotor test. These features may be external to the fan or motor and include, but are not limited to, the following:

a) Non-resettable thermal elements that are integral with fan or motor windings;

b) Wire-wound, or other types of resistors that limit the load current;

c) Positive temperature coefficient (PTC) resistors;

d) Inherent limitation due to impedance of the fan or motor windings; and

e) Non-replaceable fusing elements soldered into the product.

57.6 Overlamping test

57.6.1 A display with a replaceable light source shall be operated with the highest wattage lamp that will physically fit for 7 hours. Cheesecloth shall be placed on any surfaces where the light will shine.

58 Lamp Drape Test

58.1 The display shall be operated continuously for 7 hours to determine that the ultimate result has been obtained. There shall be no:

a) Emission of flame or molten metal;

b) Combustion, glowing or flaming or disintegration of the material on which the unit is resting or of material placed on or near the unit;

c) Exposure of parts involving a risk of electric shock; or

d) Dielectric breakdown when subjected to Dielectric Voltage-Withstand Test, Section 54, while still heated following any of these tests.

58.2 An automatic temperature-regulating or -limiting control; or other protective device provided as part of the display is to be shunted out of the circuit during the test, unless the control has been shown by an investigation to be reliable and unable to be defeated by the user.

58.3 The cloth used in the abnormal drape test is to be cheesecloth. The cloth is to be loosely draped over each lamp being tested in order to serve as a flame indicator (presence of ash or burnt holes) not as a blanket to trap heat.

59 Spill Test

59.1 Procedure

59.1.1 With reference to 3.11.5, following the testing described in 59.1.2 – 59.1.4, the outlet assembly shall comply with Spill Test Dielectric Voltage-Withstand Test, 59.2.

59.1.2 A line voltage outlet and/or low voltage, such as a USB port, outlet is to be mounted as intended in the display. Suppressor elements, across-the-line or solid state connected components are to be disconnected, removed or bypassed prior to the test. All covers are to be opened. A cover that does not require a tool to remove is to be removed. Covers that tend to close themselves are to be allowed to fall to their natural resting position. When more than one convenience outlet is enclosed by a single self-closing cover, one standard 2-wire power-supply cord with a parallel blade attachment plug, NEMA 1-15P plug configuration, is to be mated with an outlet in order to hold the outlet cover open. The cord shall exit the

receptacle or cord connector assembly as allowed by the cover. The receptacle or cord connector assembly shall be un-energized and shall remain undisturbed throughout the test sequence. For receptacle or cord connector assemblies provided with non-metallic enclosures metal foil is to be wrapped around all of the accessible enclosure areas containing energized parts prior to spill test. Metal foil is not to be placed over a receptacle or cord connector face. The metal foil shall closely conform to the shape of the enclosure.

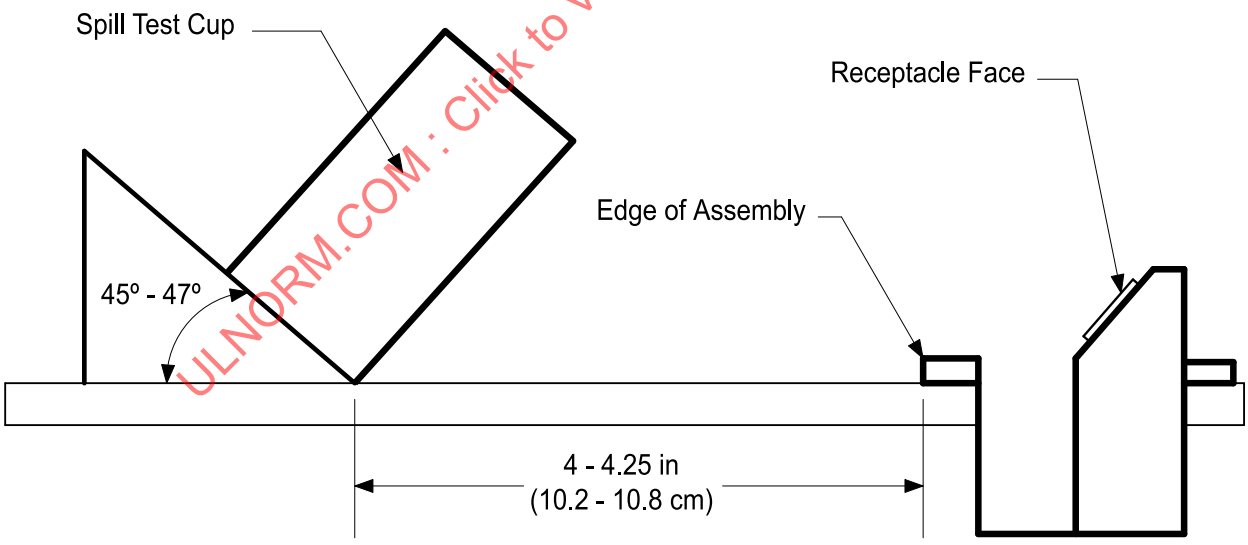
59.1.3 A cord connector shall be manually manipulated to any position allowed by the construction of the display and released so that it returns to its at rest position for the Spill Test.

59.1.4 An acrylic cylinder 3 ±1/16 inches (76.2 ±1.6 mm) inside diameter by 4 ±1/16 inches (101.6 ±1.6 mm) overall height with 1/8 inch ±1/16 inch (3.2 ±1.6 mm) thick base and cylinder wall is to be filled with 8 ±0.25 fluid ounces (237 ±7.4 ml) of saline solution, consisting of 8 ±0.1 g of plain food grade Iodized table salt per 1 ±0.1 L of distilled water at ambient room temperature.

59.1.5 The test cup, as described in 59.1.4, is to be placed on a 45 – 47 degree incline plane from the horizontal surface. The incline plane is to be large enough to support the entire base of the cup. The leading edge of the test cup base is to be positioned on the test surface 4 to 4.25 inches (10.2 to 10.8 cm) in from the edge of the unit. See Figure 59.1 and Figure 59.2. The test cup is to be placed so that the rim of the cup, when tipped over, is aligned with the receptacle or cord connector face. See Figure 59.3. If a plug is inserted, the cup is to be aligned with a receptacle or cord connector without the inserted plug. The cup is then to be manually tilted toward the receptacle or cord connector under test and allowed to fall by gravity toward the receptacle or cord connector.

Figure 59.1

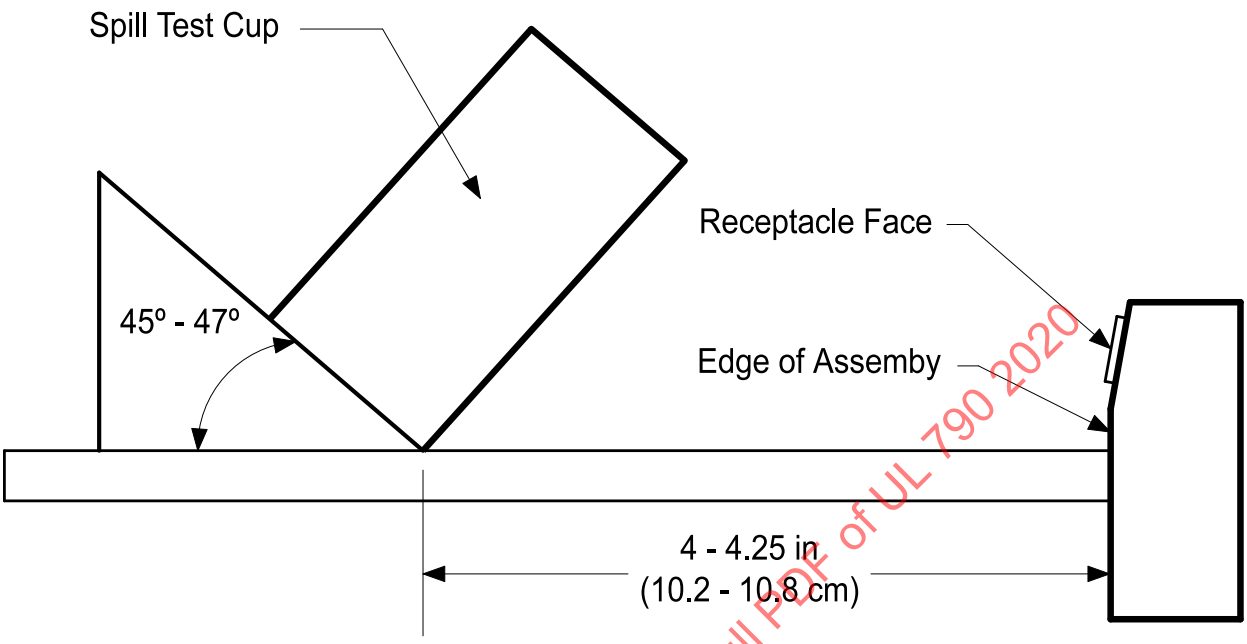
Side view of spill test fixture to test sample (drawing not to scale)



su0274

Figure 59.2

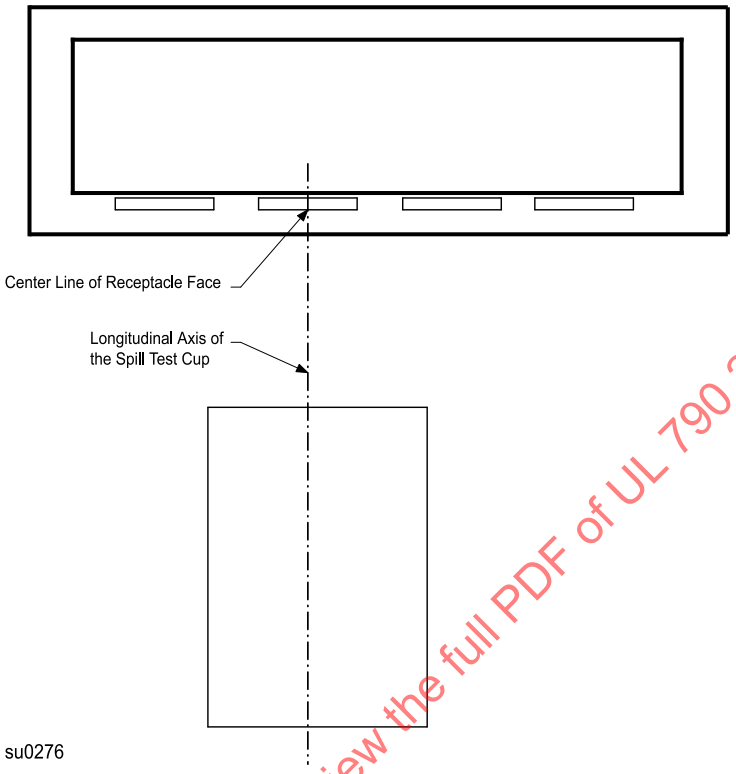
Side view of spill test fixture to test sample (drawing not to scale)



su0275

Figure 59.3

Top view of spill test cup to receptacle face



59.2 Spill test dielectric voltage-withstand test

59.2.1 A receptacle or cord connector assembly shall be undisturbed following the spill test and shall withstand an applied potential as specified in Table 54.1.

59.2.2 For receptacle or cord connector assemblies provided with metallic enclosures, the potential shall be applied one minute after the spill test cup is released. The potential shall be applied between any live part conductively connected to the supply circuit and any dead metal part and the enclosure.

59.2.3 For receptacle or cord connector assemblies provided with non-metallic enclosures the potential shall be applied one minute after the test cup is released between any energized part conductively connected to the supply circuit and any non-energized metal part or metal foil applied to the enclosure without disturbing the product.

60 Flooding Test

60.1 A display that is provided with a water reservoir or is intended to have water added (such as vegetation planter) shall be subjected to the addition of water such that the water spills out the reservoir or over the side of the display. Water shall be added at a volume and rate as described in 60.4 and 60.5. There shall be no wetting of uninsulated live parts and the display shall comply with the dielectric voltage withstand test immediately following the addition of the water.

60.2 Each configuration of a display is to be assembled in accordance with the instruction manual. The glides, feet, casters, and similar parts are to be adjusted to present the most likely accumulation of water. Drain holes are to be plugged or left open whichever is most likely to cause flooding or wetting of electrical component parts.

60.3 Before the flooding test is conducted, an enclosure containing an opening for supply connections is to be fitted with the intended supply connection means. All wired display sections, fittings, and similar components are to be assembled as intended. A gasket or bushing shall, after conditioning for 168 hours in a circulating air oven at a temperature 20°C (36°F) above the temperature measured on the gasket or bushing during the temperature test, have a tensile strength of not less than 60 percent and an elongation of not less than 75 percent of the values determined before conditioning.

Exception: Neoprene rubber is acceptable for 60°C (140°F) and silicone rubber is acceptable for 105°C (221°F) without being subjected to the conditioning.

60.4 A water reservoir that would typically be filled from another container by hand shall be filled at a rate of 1 gallon (3.79 L) per minute and shall be subjected to twice the reservoir volume. Other fill material such as soil shall be disregarded in determining the reservoir volume.

60.5 A water reservoir that would typically be filled from a pressurized source such as a garden hose shall be filled at a rate of 5 gallons (18.95 L) per minute and shall be subjected to 5 times the reservoir volume. Other fill material such as soil shall be disregarded in determining the reservoir volume.

61 Upholstered Displays with Heating Pads

61.1 Resistance to moisture test

61.1.1 A display that employs a heating pad with an upholstered covering in the area of the heating pad shall be tested as described in 61.2.1. As a result of the test, the leakage current for a display shall not exceed 0.5 MIU at 120 V, and the covering shall not lose its moisture-resistant properties.

61.1.2 To determine whether a display complies with the requirements in 61.1.1, a display of such as a chair or massage table, is to have a 1 inch (25-mm) thick felt mat placed against that portion of the display containing the heating pad. The sample is then to be continuously operated at its maximum operating temperature. After operation for 300 hours, the surface of the covering is to be manipulated back and forth several times as allowed by the construction of the display to flex the material throughout the entire surface. Following the manipulation, the display is to be tested for leakage current in accordance with the Leakage Current Test, Section 46.

61.1.3 The sample or the area of the sample containing the heating pad is then to be placed in a horizontal plane, with the edges of the display turned up at right angles for approximately 1 inch (25 mm) to form a shallow tray. If the edges of the display cannot be turned up, supplementary sides may be attached to or formed on the display to hold the solution. The side or face that was in contact with the felt mat during the 300-hour test is to be the upper or inside surface of the tray. A solution of approximately 8 g of NaCl per 1000 ml of water is to be introduced into the tray to a minimum depth of 1/4-inch (6 mm), and the leakage current between the electrolyte and the display is then to be measured. The solution is to be allowed to remain on the covering for 3 hours, and if there is no measurable leakage current, the test may be discontinued, but, if any leakage current is measured, the test is to be continued until ultimate results are obtained, but not longer than 7 hours.

61.2 Thermostat test

61.2.1 General

61.2.1.1 A thermostat employed in a heating pad shall comply with 61.2.2 – 61.2.5.

61.2.2 Original calibration

61.2.2.1 The cutoff temperature of each of six thermostats that are identical to the thermostats employed in the heating pad is to be measured by any method whereby the temperature can be closely regulated and accurately measured.

61.2.3 Overload

61.2.3.1 When tested as described in 61.2.3.2, there shall be no electrical or mechanical breakdown or undue pitting or burning of the contacts in any of the six calibrated thermostats.

61.2.3.2 The thermostats are to be operated automatically at rated voltage for 100 cycles at a rate of not more than 6 cycles per minute, making and breaking twice the maximum current that the thermostat normally carries in the pad. An alternating-current supply circuit is to be used if the pad is rated for use on only alternating current. A direct-current supply circuit is to be used if the pad is rated for use on only direct current or for use on both direct current and alternating current.

61.2.4 Endurance

61.2.4.1 There shall be no electrical or mechanical breakdown or undue pitting or burning of the contacts in any of the six thermostats that performed acceptably in the overload test described in 61.2.3 as the result of their additional automatic operation at rated voltage for at least 100,000 cycles at a rate of not more than 30 cycles per minute making and breaking the maximum current that the thermostat normally carries in the pad.

61.2.4.2 This test is intended to represent at least 1000 hours of service under conditions that produce the fastest operation of a thermostat in the pad. The test is to be continued beyond 100,000 cycles if necessary to represent 1000 hours of service.

61.2.5 Recalibration

61.2.5.1 After the six thermostats that were subjected to the endurance test described in 61.2.4 have been kept at a temperature of 0°C (32°F) for 1 hour and then at a temperature of 125°C (257°F) for an additional hour, the cutoff temperature of each of the six thermostats shall not be more than 5°C (9°F) higher than the original cutoff temperature determined in accordance with 61.2.2.

61.3 Flexing and twisting test

61.3.1 Flexing

61.3.1.1 A display employing a heating pad that may be subjected to flexing or twisting, or both, shall be tested as described in 61.3.1.3 – 61.3.2.4. Following the test:

a) The display shall comply with the requirements in the:

1) Leakage Current Test, Section 46;

2) Strain Relief Test, Section 51 and Strain Relief for Internal Conductors and Connectors Test, 51.2;

3) Dielectric Voltage-Withstand Test, Section 54; and

4) Resistance to Moisture Test, 61.1; and

b) There shall be no:

1) Loosening of the cord or conductors from the display or heating pad;

2) Breakage of the covering material or of the seams of the covering material;

3) Breakage or loosening of any wiring connection;

4) Appreciable shifting of the position of the heating pad within the display; or

5) Breakage of a conductor of the heating element or other interruption of the electrical circuit through the heating pad or display.

61.3.1.2 Each of three complete samples of the heating pad assembly is to be flexed 8000 cycles under the conditions described in 61.3.1.3 – 61.3.2.4.

61.3.1.3 The apparatus for conducting the flexing test is to consist of a power-driven testing machine, a pair of wide clamps for gripping the edges of each sample, and a number of weights, each large enough to exert 1 pound of force (4.45 N) when suspended from a clamp.

61.3.1.4 The machine is to draw each sample back and forth by means of a clamp over the 1/2-inch (13-mm) radius edge of a smooth horizontal metal bed at a rate of approximately 15 cycles per minute. The stroke of the machine is to be adjustable to accommodate a heating pad assembly of various dimensions, so that the greatest possible area of the heating pad is subjected to the flexing.

61.3.1.5 The clamps are to be in pairs that are long enough to accommodate edges of different dimensions, and may be of any construction that securely grips the edges of the heating pad assembly. One clamp is to be provided with hooks for the suspension of the weights. The clamps are to be applied to opposite edges of each sample, which is then to be adjusted in the machine with the weighted clamp hanging over the rounded edge of the bed. A weight exerting a force of 1 pound (4.45 N) is to be used for each 6 inches (152 mm) or fraction thereof of the edge of the display in the clamp.

61.3.1.6 Each sample is to be connected by means of its flexible cord and plug to a supply circuit. After 2000 cycles of continuous operation the machine is to be stopped, the pad turned 90 degrees so that the bending is at right angles to that previously made, and operation resumed. After the second 2000 cycles of operation the machine is to be stopped, the pad turned over, and operation resumed. After the third 2000 cycles of operation the machine is to be stopped, the pad turned again through 90 degrees, and the operation continued for a fourth 2000-cycle period.

61.3.2 Twisting

61.3.2.1 Each of three complete samples of a heating pad assembly shall be subjected to a 6000-cycle twisting test as described in 61.3.2.2 – 61.3.2.4 while connected to a supply circuit, with the heating pad switch in the high position. At the completion of the test, the display shall comply with the requirements in 61.3.1.1.

61.3.2.2 The apparatus for conducting the twisting test is to consist of a power-driven twisting machine and a pair of wide clamps for gripping the edges of each sample.

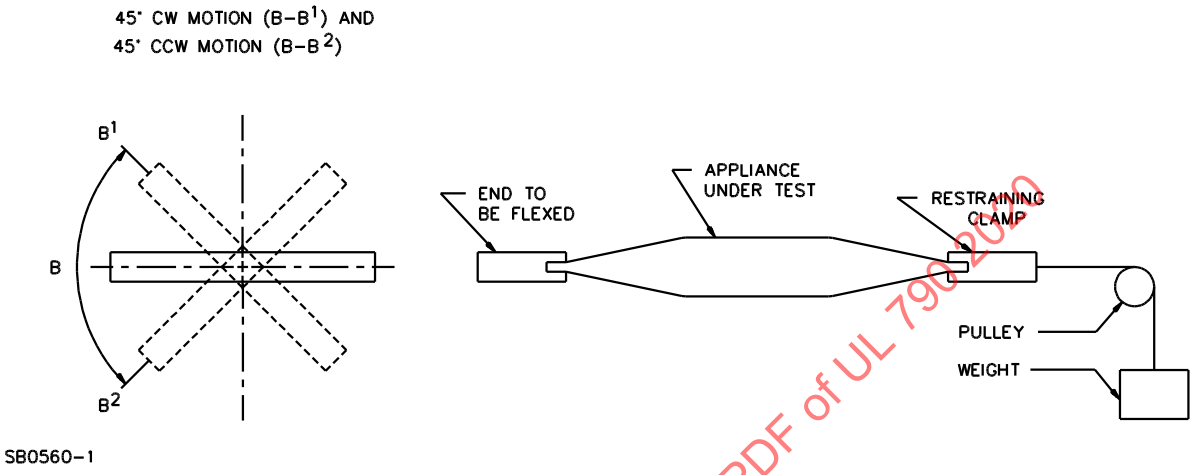
61.3.2.3 One end of the sample is to be rigidly clamped in a horizontal plane along its width. This end is to be prevented from twisting. The heating pad assembly is to be kept in tension by a pull of 5 pounds (22 N) that is placed on this end. The other end of the heating pad assembly is to be clamped in the twisting machine along its width.

61.3.2.4 The machine, with the sample clamped in place, is to twist back and forth through a 90 degree arc. The test is to be conducted at approximately 15 cycles per minute, a cycle being considered as the movement from the horizontal clockwise through 45 degrees of arc, counterclockwise through 90 degrees

of arc to a position 45 degrees below the horizontal, and back to the horizontal. A faster twisting rate may be used with the concurrence of those concerned. See Figure 61.1.

Figure 61.1

Twisting-test apparatus



62 Magnetic Field Test

62.1 A display that is intended to produce magnetic fields external to the display shall be subjected to the applicable tests described in this section. The display shall not exceed a threshold limit (ceiling) for static magnetic fields of 0.2 mT (5 Gauss) at a distance of 1 foot (30.48 cm) from the display. The display may exceed 0.2 mT (5 Gauss) at a distance less than 1 foot (30.48 cm) from the display if marked in accordance with 75.20.

62.2 The temperature test and magnetic field strength test shall be conducted with object(s) intended to be subjected to the displays magnetic field, without the object (s), and with other objects which could produce a visible action on the object or display. Objects may be manipulated by hand only if by doing so creates a visible effect on the object or display.

62.3 A display shall be placed in its intended position in accordance with the installation and operation instructions. The display shall be operated at rated voltage. Any doors, covers or other components which are removable or operable without the use of tools shall be removed or operated to determine the maximum magnetic field strength.

62.4 The magnetic field shall be measured at 1.0 inch (25.4 mm) intervals up to 1 foot (30.48 cm).

63 Circuit Power / Voltage Limit Measurement Tests

63.1 15 W power limit test

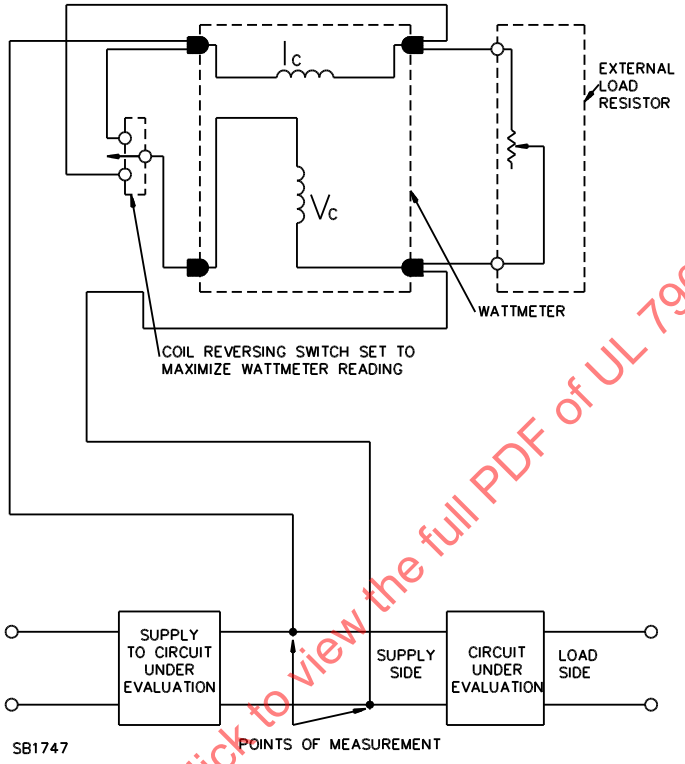
63.1.1 This test shall be used to determine if the power available to a circuit under any loading condition, including short circuit, measured after one minute of operation exceeds a defined limit (15 watts).

63.1.2 The point in the circuit under evaluation is to be connected to the measurement circuit as shown in Figure 63.1. While the circuit is operating with the anticipated normal load, the external adjustable load resistor is reduced gradually to the point where 15 W is being dissipated. The load shall be re-adjusted as

needed to maintain 15 W for one minute. If 15 W cannot be attained and maintained for one minute under any load condition, the test shall be discontinued.

Figure 63.1

15 Watt measurement circuit



63.1.3 For a circuit without a designated current limiting device, a circuit component that opens in less than 1 minute at any power delivery level less than 15 W and that precludes delivery of 15 W for more than one minute is considered to effectively limit the circuit output to less than 15 W, if the test can be repeated two additional times on new samples with comparable results.

63.1.4 For a circuit with a designated current limiting device, a closed shorting switch is to be connected across the current limiting device and the adjustable resistance is then to be reduced to result in a power dissipation of exactly 15 W as indicated by the meter. The switch across the current limiting device is then to be opened and the time required for the device to open is to be recorded. A current limiting device that opens the circuit in less than 1 minute is considered to effectively limit the circuit output to less than 15 W.

63.1.5 If the test is disrupted by the failure of other circuit components (i.e. capacitor, diode, coil winding, foil trace, etc.) then that test shall be repeated two additional times, with new samples, under the same test condition. Test disruption by opening of the same, or a different, component during these repeated tests is acceptable.

63.1.6 If the supply to the circuit under evaluation consists of other than a single resistor, the test described in this section shall be repeated under any single component fault conditions within the supply circuit likely to result in greater output power availability. The fault condition shall first be applied, and then the variable resistance load shall be adjusted as needed. A new sample shall be used for each component fault.

Exception: Components whose reliability against failure has been deemed acceptable by a separate investigation shall not be faulted. Examples of such components: optical isolators evaluated to the Standard for Optical Isolators, UL 1577; capacitors evaluated to the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14; etc.

63.1.7 If there is any indication of component overheating during any of the tests (i. e., odor, smoke, discoloration, glowing, cracking, melting, or changes in circuit current through the fault), the test condition shall be repeated as part of the Abnormal Electronic Component Test, 57.4.

63.2 Determination of low-voltage, limited-energy circuit status

63.2.1 When evaluated in accordance with 63.2.2 – 63.2.4, a circuit is be considered low-voltage, limited-energy when, one minute after operation, its supply source does not exceed:

a) 8 amperes for a voltage up to 42.4 V peak ac or 30 V dc; or

b) 150/V amps for a voltage between 30 – 60 V dc.

63.2.2 The input to the source under evaluation shall be connected as intended in the end product. The output to the circuit under evaluation shall be connected to a variable resistance load. If the source under evaluation has multiple outputs, all other outputs shall be open-circuited. The output voltage to the circuit under evaluation shall first be measured under open circuit conditions. The variable resistance load on the output under test shall then be adjusted from open circuit to short circuit until an available current of 8 amperes can be obtained and sustained for one minute of operation. If 8 amperes cannot be sustained for one minute under any condition of load, the test shall be discontinued.

63.2.3 When a secondary fuse or similar device is used to limit the output current to the circuit under evaluation, it shall be rated as indicated in Table 63.1. Any value may be used for a primary fuse; however, the maximum available output current levels shall be maintained. A fuse replacement marking (voltage and current rating) shall be provided adjacent to any fuse relied upon to limit the output current level, in accordance with 75.21.

Table 63.1
Output limiting secondary fuse

Open circuit potential, Vpeak or DC	Maximum fuse rating, amps	Open circuit potential, Vpeak or DC	Maximum fuse rating, amps
0 – 20	5.0		
> 20 – 60	100/ Vpeak or DC		

63.2.4 When a fixed impedance or regulating network is used to limit the voltage and/or current, it shall limit the voltage and current accordingly under any single component fault condition.

64 Environmental Conditioning

64.1 Humidity exposure

64.1.1 A unit intended for use in damp or wet locations 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) to be followed by the Dielectric Voltage Withstand Test, Section 73.

64.2 Water shield impact conditioning

64.2.1 A sample of the water shield shall be mounted on the luminaire for impact conditioning. The sample shall be subjected to a 3 ft·lb (4.1 J) impact from the steel sphere of 64.2.3 from a vertical distance of 30.5 in (775 mm) on any surface of the water shield that is exposed and that can be subjected to an impact during its intended use.

64.2.2 The horizontal or top surface of the water shield shall be subjected to an impact from the steel sphere. Other surfaces of the water shield shall be subjected to an impact from the steel sphere suspended by a cord.

64.2.3 The impact specified in 64.2.1 is to be produced by dropping a solid steel sphere, 2 inch (51 mm) in diameter and weighing 1.18 pounds (0.54 kg), from the height of 36 inches (914 mm).

65 General – Test Conditions

65.1 Before a rain or sprinkler test is conducted, an enclosure containing an opening for supply connections is to be fitted with the intended supply connection means. All wired display sections, fittings, and similar components are to be assembled as intended.

65.2 The rain or sprinkler test is to be conducted in the operating sequence shown in Table 65.1.

Table 65.1
Rain or sprinkler test operating sequence

Duration in hours	Display	Water
1.0	On	Off
0.5	Off	On
2.0	On	On
0.5	Off	On

66 General – Test Results

66.1 Test results are satisfactory if, after the impact conditioning (if applicable) and the rain or sprinkler tests, no water has entered the display.

Exception: Water may enter if the water does not cause wetting of any lampholder, wiring, or other electrical parts that are not inherently waterproof and if the display is provided with a drain hole as required in 12.11.2.2.

67 Sprinkler Test

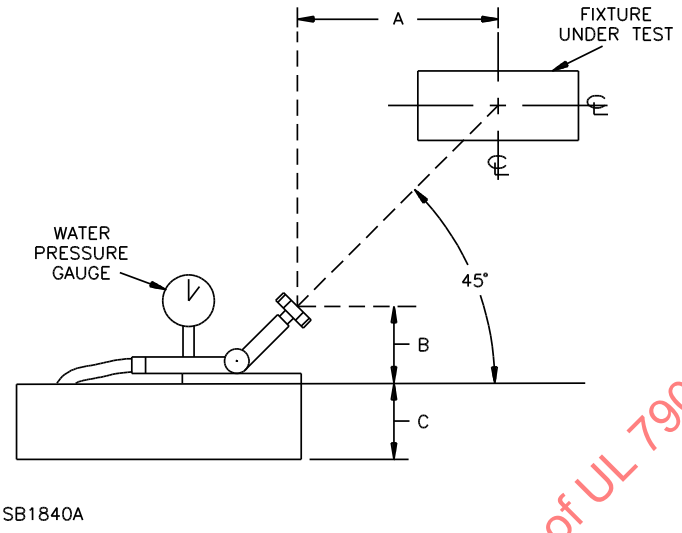
67.1 A display required to be subjected to a sprinkler test shall comply with the requirements in 67.2 and 67.3.

67.2 A display is to be turned about its vertical axis to each of four positions 90 degrees from each other, each for 30 minutes during the 2-hour portion of the test described in 65.2, with adjustable parts arranged for maximum vulnerability to the water spray.

67.3 The display is to be positioned, as shown in Figure 67.1 in front of a standard water spray head of the type shown in Figure 67.2, to which the water pressure is maintained at a gage pressure of 20 pounds per square inch (137.9 kPa).

Figure 67.1

Representative sprinkler test setup



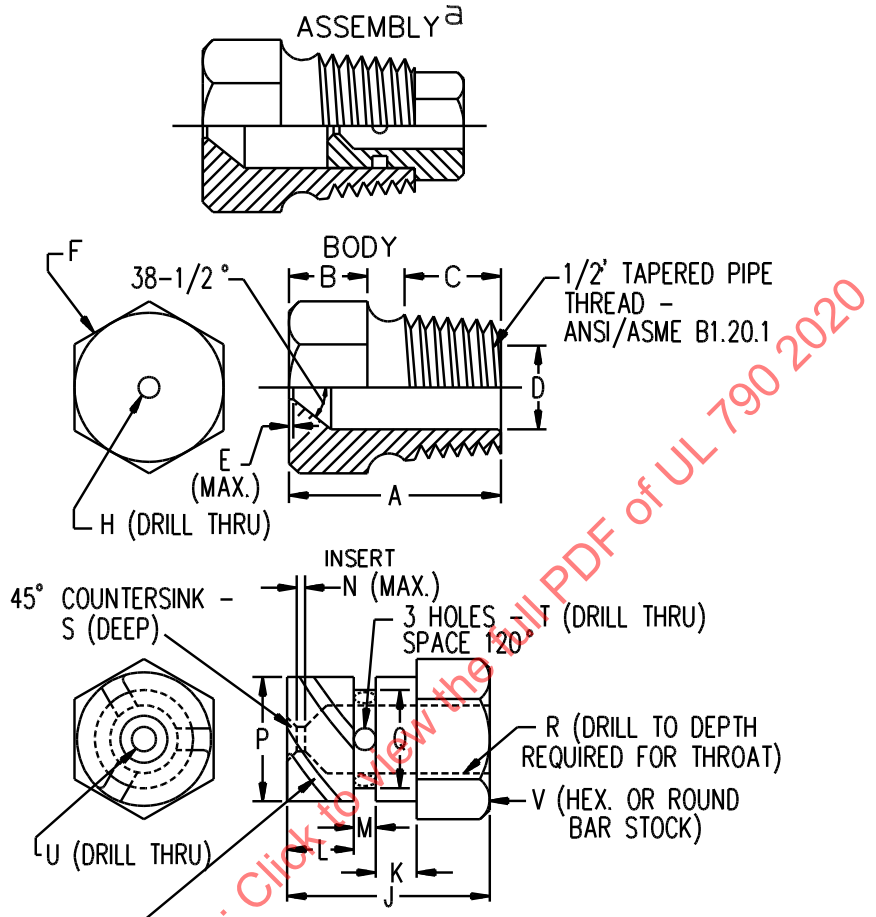
A – 36 inches (914 mm).

B – 3 – 6 inches (76.2 – 152 mm).

C – Height necessary for the display to be mounted as intended with the dimensional center of the display on a line projected from the center line of the nozzle head.

Figure 67.2

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.

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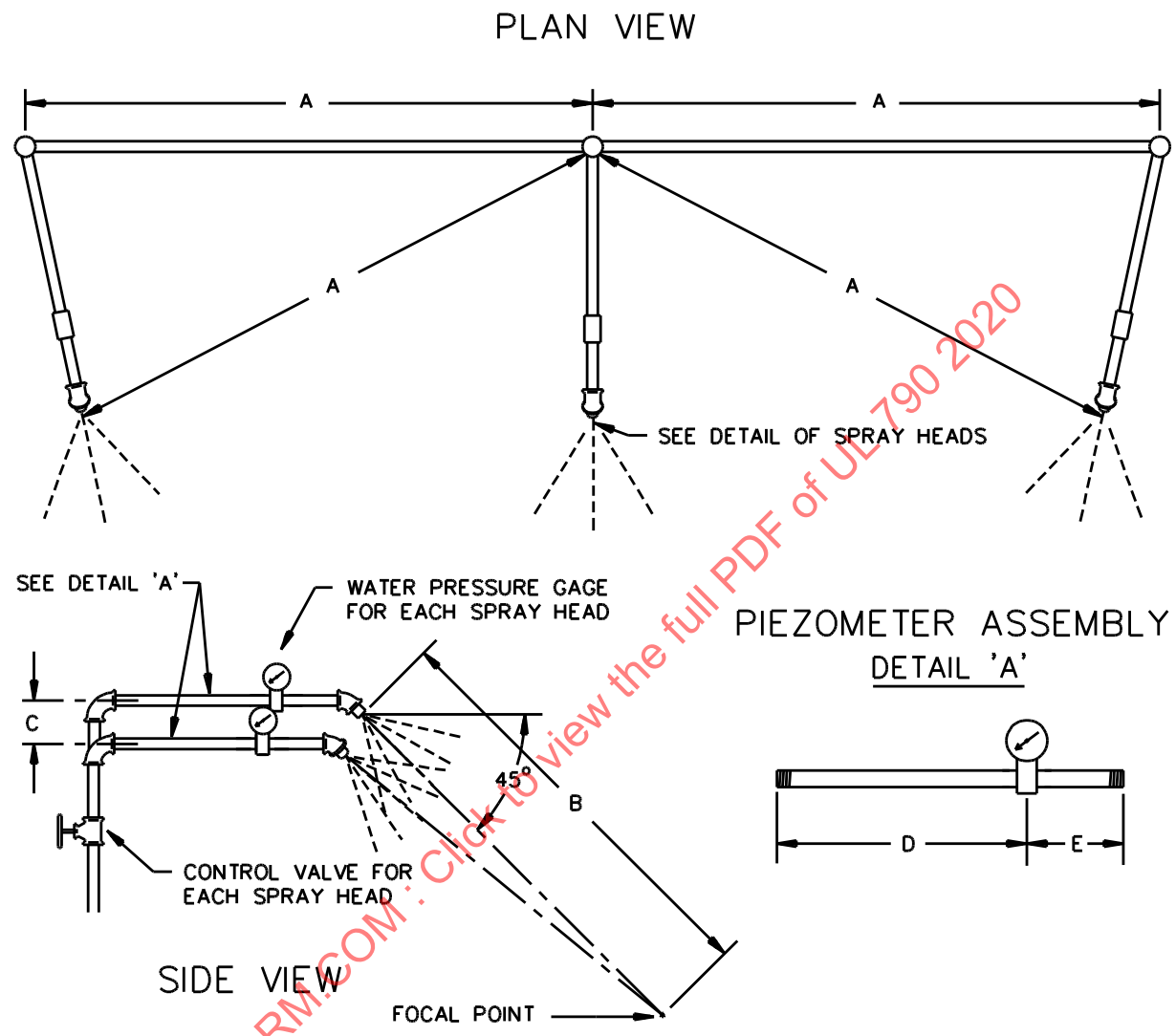
68 Rain Test

68.1 A display required to be subjected to a rain test shall comply with the requirements in 68.2 and 68.3.

68.2 The rain test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 68.1. Spray heads are to be constructed in accordance with the details shown in Figure 67.2. The display is to be set up as in a normal installation with conduit – without pipe compound – if so intended. The enclosure is to be positioned in the focal area of the spray heads so that the greatest quantity of water potentially will enter the enclosure. The water pressure is to be maintained at 5 pounds per square inch (34.5 kPa) at each spray head.

Figure 68.1

Rain test apparatus



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

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68.3 A gasketed display shall be tested after the temperature test (if required elsewhere in this standard) or after operation for 1/2-hour, followed by removal and replacement of rings, frames, lamps or other replaceable part serving to compress the gasket.

69 Thermal Conditioning

69.1 A polymeric material, not including wood, used as a water shield that is subjected to an operating temperature in excess of 65° C (149° F) as determined by the temperature test shall retain its original dimensions and shape after exposure for 1000 hours to a temperature in accordance with Table 69.1. The lamp used for the temperature test shall be as intended and marked on the display, or, if the display is not provided with a lamp replacement marking, the largest lamp wattage and size that will physically fit in the display. Exposure time is able to be reduced by one-half for each increase in oven temperature of 10°C (18°F). If the sample is too large for the test oven, the sample is able to be cut to fit.

Exception No. 1: A polymeric water shield that also serves as an enclosure, as required in 12.1.1, and complies with the requirements in 12.9, Electrical Enclosures of Polymeric Material, is not required to be tested.

Exception No. 2: A material that possesses a mechanical temperature index, with impact, as a result of long term aging, of at least the temperature to which it is subjected, is not required to be tested.

Table 69.1
1000-hour Exposure Temperature

ormal temperature on polymeric diffuser or lens material				Oven Test Temperature	
Higher than		Not higher than			
°F	°C	°F	°C	°F	°C
65	(149)	75	(167)	85	(185)
75	(167)	86	(185)	95	(203)
85	(185)	95	(203)	105	(221)

69.2 A gasket or bushing employed to comply with the requirements for wet locations shall, after conditioning for 168 hours in a circulating air oven at a temperature 20°C (36°F) above the temperature measured on the gasket or bushing during the temperature test, have a tensile strength of not less than 60 percent and an elongation of not less than 75 percent of the values determined before conditioning.

Exception: Neoprene rubber is acceptable for 60°C (140°F) and silicone rubber is acceptable for 105°C (221°F) without being subjected to the test.

70 Gasket Adhesion Test

70.1 A gasket assembly secured by an adhesive shall be subjected to the gasket adhesion test.

70.2 Three gasket assemblies shall be used to determine the average initial force required to remove the gasket from its mounting surface. The force shall be applied to the edge of the gasket in a plane perpendicular to the surface on which the gasket is mounted.

70.3 Six additional gasket assemblies shall be conditioned for 168 hours in a circulating air oven at 20°C (36°F) above the maximum gasket or bushing temperature as determined by the normal Temperature Test – General, 49.1.

70.4 The force required to remove the gaskets from the mounting surface shall be measured within 30 minutes after the conditioning for three of the samples. The force required to remove the gaskets from the mounting surface of the three remaining samples shall be measured 24 hours after the conditioning.

70.5 After conditioning, the average force necessary to remove the gaskets from the mounting surface shall be not less than 60 percent of the initial average value measured before conditioning.

MANUFACTURING AND PRODUCTION TESTS

71 Grounding-Continuity Test

71.1 Each cord-connected display shall be tested, as a routine production-line test, to determine that grounding continuity exists between the grounding pin of the attachment plug and the electrical enclosure or other dead metal parts. When the electrical enclosure is complete, the electrical enclosure is not required to be attached to a display.

71.2 Any appropriate indicating device – an ohmmeter, battery- and buzzer-combination, or similar equipment – is able to be used to determine compliance with 71.1.

72 Polarity

72.1 Each display shall be checked as a routine production-line test to verify that there is electrical continuity between the grounded supply-circuit conductor of the attachment plug – wide blade of a 2-wire type – and the part of the product that is intended to be connected to the grounded supply-circuit conductor of the attachment plug (for example, screw shell of an incandescent lampholder). The continuity shall be determined either visually or through the use of an electrical test. Equivalently, continuity is able to be verified between the ungrounded supply-circuit conductor of the attachment plug and the part of the product that is intended to be connected to the ungrounded conductor (for example, the center contact of an incandescent lampholder).

73 Dielectric voltage-withstand test

73.1 Each line-voltage display shall withstand without electrical breakdown, as a routine production-line test, the application of a 40 – 70 hertz potential as specified in Table 73.1, between:

a) The supply wiring and dead metal parts that become energized;

b) Supply wiring of opposite polarity when separate grounded supply conductors are employed; and

c) The ungrounded supply conductors of opposite polarity when the same grounded supply conductor is employed for both circuits.

Table 73.1
Dielectric withstand voltage

Insulation type	One minute (V ac)	One minute (V dc)	1 Second (V ac)	1 Second (V dc)
Single	1000 + (2 × Rated Voltage)	1.414 × (1000 + (2 × Rated Voltage)	1200 + (2.4 x Rated Voltage)	1.414 × (1200 + (2.4 × Rated Voltage))
Double	2000 + (4 × Rated Voltage)	1.414 × (2000 + (4 × Rated Voltage))	2400 + (4.8 × Rated Voltage)	1.414 × (2400 + (4.8 × Rated Voltage))

73.2 The test is to be conducted with the display fully assembled. It is not intended that the product be unwired, modified, or disassembled for the test.

Exception: A furnishing employing solid-state components (such as load connected, across-the-line components or transient voltage surge suppressors) that are able to sustain damage from the dielectric potential are able to be tested before the components are electrically connected or a DC voltage may be used.

73.3 The test equipment is to include a transformer having a sinusoidal output if AC, a means of indicating the test potential, an audible or visual indicator of electrical breakdown, and either a manually reset device to restore the equipment after electrical breakdown or an automatic feature to reject any product that does not meet the requirement.

73.4 When the output of the test-equipment transformer is less than 500 volt-amperes, the equipment is to include the voltmeter in the output circuit to directly indicate the test potential.

73.5 When the output of the test-equipment transformer is 500 volt-amperes or more, the test potential is able to be indicated by a voltmeter in the primary circuit or in a tertiary-winding circuit, a selector switch marked to indicate the test potential, or in the case of equipment having a single test-potential output, a marking shall be visible while the equipment is in use to indicate the test potential. When marking is used without an indicating voltmeter, the equipment shall include a positive means, such as an indicator lamp, to indicate that the manually reset switch has been reset following a dielectric breakdown.

73.6 Test equipment other than that specified in 73.3 – 73.5 is able to be used when it is determined to accomplish the intended factory control.

74 Electrical Ratings

74.1 A display shall be rated with its electrical ratings, including input voltage, frequency or ″AC″, ″DC″, and current or watts.

74.2 The maximum ampere rating shall be calculated by adding the ratings of each load and device on each circuit. The following are applicable:

a) The calculated load of each line-voltage incandescent lampholder by dividing the marked wattage rating by 120 volts or rated voltage;

b) The ampere rating of each ballast, transformer, power supply or driver; and

c) The ampere rating of any other electrical load, such as a motor, or similar part.

d) On a cord and plug connected display provided with an ANSI/NEMA 5-15P plug and provided with 15 ampere receptacles, the maximum rating per cord and plug connection for the display shall be 12 amperes, 1440 VA for utilization equipment and 15 amperes for distribution devices. If the display is provided with an ANSI/NEMA 5-20P cord and plug connection and 15 or 20 ampere receptacles the maximum rating per cord and plug for the display shall be 16 amperes, 1920 VA for utilization equipment and 20 amperes for distribution devices.

e) For a permanently connected display, loads shall be calculated as follows:

1) For any load provided with the display or as an accessory for the display the electrical rating of the load; and

2) For unoccupied 120V 15A or 20A receptacles 180VA per outlet or 180VA for duplex or triplex outlets.