



UL 863

Underwriters Laboratories Inc. Standard for Safety

Time-Indicating and -Recording Appliances

ULNORM.COM : Click to view the full PDF of UL 863 2009



ULNORM.COM : Click to view the full PDF of UL 863 2009

UL Standard for Safety for Time-Indicating and -Recording Appliances, UL 863

Eighth Edition, Dated November 16, 2007

SUMMARY OF TOPICS

These revisions to UL 863 are being issued to address universal upkeep of UL Standards for Safety. These revisions are considered to be non-substantive and not subject to UL's STP process.

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

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical photocopying, recording, or otherwise without prior permission of UL.

UL provides this Standard "as is" without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will UL be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if UL or an authorized UL representative has been advised of the possibility of such damage. In no event shall UL's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

Users of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgment (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

No Text on This Page

ULNORM.COM : Click to view the full PDF of UL 863 2009

NOVEMBER 16, 2007

(Title Page Reprinted: November 3, 2009)

1

UL 863

Standard for Time-Indicating and -Recording Appliances

First Edition – October, 1941

Second Edition – May, 1968

Third Edition – October, 1970

Fourth Edition – July, 1975

Fifth Edition – March, 1982

Sixth Edition – April, 1993

Seventh Edition – July, 1997

Eighth Edition

November 16, 2007

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 <http://csds.ul.com>.

UL's Standards for Safety are copyrighted by UL. Neither a printed nor electronic copy of a Standard should be altered in any way. All of UL's Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of UL.

COPYRIGHT © 2009 UNDERWRITERS LABORATORIES INC.

No Text on This Page

ULNORM.COM : Click to view the full PDF of UL 863 2009

CONTENTS

INTRODUCTION

1 Scope	5
2 General	5
2.1 Components	5
2.2 Units of measurement	6
2.3 Undated references	6

CONSTRUCTION

3 General	6
4 Frame and Enclosure	6
4.1 General	6
4.2 Doors and covers	8
5 Protection Against Corrosion	8
6 Mechanical Assembly	9
7 Supply Connections – Cord-Connected Appliances	9
7.1 Cords and plugs	9
7.2 Grounding	13
7.3 Strain relief	13
7.4 Bushings	14
8 Supply Connections – Permanently-Connected Appliances	15
8.1 General	15
8.2 Terminal boxes	15
8.3 Field-wiring terminals and leads	15
8.4 Provisions for grounding	16
9 External Interconnections	18
9.1 Cord-connected appliances	18
9.2 Permanently-connected appliances	18
10 Live Parts	18
11 Internal Wiring	18
12 Coil Windings	19
13 Separation of Circuits	20
14 Spacings	21
15 Outdoor-Use Appliances	23
15.1 General	23
15.2 Rainproof enclosures	23
15.3 Lampholders	24

PERFORMANCE

16 Current Input Test	24
17 Normal Temperature Test	25
18 Overload Test	29
19 Endurance Test	29
20 Burnout Test	30
21 Dielectric Voltage-Withstand Test	30
22 Crossover Lead Dielectric Voltage-Withstand Test	31
22.1 General	31
22.2 Potential test	31

22.3 Potential test repeated	31
23 Strain Relief Test	31
24 Test for Resistance to Rain	32
25 Gasket Aging Test	35

MANUFACTURING AND PRODUCTION TESTS

26 Production-Line Dielectric Voltage-Withstand Test	37
27 Production-Line Grounding Continuity Test	38

RATINGS

28 General	39
------------------	----

MARKINGS

29 General	39
30 Supply Wiring	40
31 Ratings	40
32 Informational	40
33 Cautionary	41

APPENDIX A

Standards for Components.....	A1
-------------------------------	----

ULNORM.COM : Click to view the full PDF of UL 863 2009

INTRODUCTION

1 Scope

1.1 These requirements cover electrically-operated clocks that form parts of a master clock system, secondary, cost, pay-roll, and other clocks intended primarily for industrial installations; and also time stamps, job-card recorders, timers, and similar time-indicating and -recording appliances. These appliances are intended for use on circuits of 300 volts or less in accordance with the National Electrical Code.

1.2 These requirements do not cover clocks intended primarily for household installations nor do they cover illuminated clocks designed to serve as portable electrical lamps or for other illuminating purposes.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

2.1.2 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.

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

2.1.4 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.

2.2 Units of measurement

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

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

2.3 Undated references

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

CONSTRUCTION

3 General

3.1 Throughout these requirements the term "thermoplastic" is used to designate a synthetic compound, the basic constituent of which is polyvinyl chloride or a copolymer of vinyl chloride and vinyl acetate.

4 Frame and Enclosure

4.1 General

4.1.1 An appliance shall be formed and assembled so that it has the strength and rigidity 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.

4.1.2 An edge, projection, or corner of an enclosure, opening, frame, guard, knob, handle, or similar part of an appliance shall be smooth and rounded and not sufficiently sharp to cause a cut type injury when contacted during normal use or user maintenance.

4.1.3 An electrical part of an appliance shall be located or enclosed so that persons will not unintentionally contact a live part, unless the voltage on the part is 30 volts or less or the available current measured through a 1500-ohm, noninductive resistor is 5 milliamperes or less.

4.1.4 Unless the appliance is marked in accordance with 33.1, a device such as a lampholder, fuseholder, circuit breaker, or a replaceable tape shall be designed and installed so that persons servicing the lamps, fuses, circuit breakers, or other devices will not unintentionally contact any uninsulated live part other than a screw shell or the clips of a fuseholder.

4.1.5 The enclosure of an appliance shall be complete. No dependence shall be placed on adjacent walls or equipment to complete an enclosure.

Exception: An elapsed time indicator may have an incomplete enclosure if the indicator has provision for panel mounting so that uninsulated live parts and internal wiring are completely enclosed after installation.

4.1.6 The enclosure of a stationary appliance shall be provided with means for support. Mounting holes shall be located or guarded so that nails or similar hangers will not come in contact with any bare, covered, or insulated live part.

4.1.7 For unreinforced, flat surfaces in general, cast metal shall be not less than 1/8 inch (3.2 mm) thick.

Exception No. 1: Malleable iron may be not less than 3/32 inch (2.4 mm) thick, and die-cast metal may be not less than 5/64 inch (2.0 mm) thick.

Exception No. 2: For a curved, ribbed, or otherwise reinforced surface, or if the shape and/or size of the surface is such that equivalent mechanical strength is provided, cast metal in general may be not less than 3/32 inch, malleable iron may be not less than 1/16 inch (1.6 mm), and die-cast metal may be not less than 3/64 inch (1.2 mm) thick.

4.1.8 If threads for the connection of metal conduit are tapped all the way through a hole in a box wall, or if an equivalent construction is used, there shall be not fewer than 3-1/2 and not more than 5 threads in the metal, and the construction of the device shall be such that a suitable conduit bushing can be properly attached. If threads for the connection of conduit are not tapped all the way through a hole in the box, wall, conduit hub, or the like, there shall be no fewer than 5 full threads in the metal, and there shall be a smooth, well-rounded inlet for the conductors that shall:

- a) Afford protection to the conductors equivalent to that provided by a standard conduit bushing and
- b) Have an internal diameter approximately the same as that of the corresponding trade size of rigid metal conduit.

4.1.9 An enclosure of sheet metal is to be judged with regard to its size, shape, thickness of metal, and its suitability for the particular application, considering the intended use of the complete appliance. The use of sheet steel having a thickness of less than 0.026 inch (0.66 mm) if uncoated or 0.029 inch (0.74 mm) if galvanized or of nonferrous sheet metal having an average thickness of less than 0.036 inch (0.91 mm) is not recommended.

Exception: Sheet metal thinner than that described may be used for relatively small areas or for surfaces that are covered or otherwise reinforced.

4.1.10 Among the factors taken into consideration when judging a nonmetallic enclosure or an enclosure of magnesium are:

- a) Mechanical strength,
- b) Resistance to impact,
- c) Moisture-absorptive properties,
- d) Combustibility, and
- e) Resistance to distortion at temperatures to which the material may be subjected under conditions of normal or abnormal usage.

4.1.11 If a flush plate facilitating mounting of a clock on an outlet box is provided as an integral part of the clock or is packaged or otherwise provided with the clock, the plate shall be made of one of the materials indicated in Table 4.1, and shall be at least as thick as indicated in that table.

Table 4.1
Thickness of flush plates

Acceptable material	Minimum acceptable thickness at any point of plate,	
	inch	(mm)
Ferrous metal	0.030	0.76
Nonferrous metal	0.040	1.02
Noncombustible electrical insulating material	0.100	2.54

4.2 Doors and covers

4.2.1 A door or cover that is accessible from outside the enclosure shall be hinged if it gives access to any kind of overload protective device that is required to be enclosed.

Exception: A cover, panel, door, or other part of the enclosure that, by its function, obviously must be in place if the appliance is to operate properly, need not be permanently attached.

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

5 Protection Against Corrosion

5.1 An iron or steel part shall be protected against corrosion by enameling, galvanizing plating, or other equivalent means, if the failure of such a part would be likely to result in the risk of fire, electric shock, or injury to persons.

Exception No. 1: If the oxidation of iron or steel from exposure of the metal to air and moisture is not likely to be appreciable (thickness of metal and the temperature also being factors), the surfaces of sheet steel and cast-iron parts within an enclosure need not be protected against corrosion.

Exception No. 2: The requirement in 5.1 does not apply to bearings or laminations or to minor parts of iron or steel (such as washers, screws, and the like).

6 Mechanical Assembly

6.1 An appliance shall be assembled so as not to be affected adversely by the vibration of normal operation.

6.2 A switch, fuseholder, lampholder, receptacle, plug connector, or other component that is handled by the user shall be mounted securely, and shall be prevented from turning.

Exception No. 1: The requirement that a switch be prevented from turning may be waived for a switch that is normally operated by mechanical means rather than by direct contact by persons if all three of the following conditions are met:

- a) The switch is a plunger or other type that does not tend to rotate when operated. A toggle switch is considered subject to forces that tend to turn the switch during normal operation.*
- b) The means of mounting makes it unlikely that operation can loosen the switch.*
- c) The spacings cannot be reduced below the minimum acceptable values if the switch does rotate.*

Exception No. 2: A lampholder of a type in which the lamp cannot be replaced (such as a neon pilot or indicator light in which the lamp is sealed in by a nonremovable jewel) need not be prevented from turning if rotation cannot reduce spacings below the minimum acceptable values.

6.3 The means for preventing the turning specified in 6.2 shall consist of more than friction between surfaces – for example, a lock washer, properly applied, is acceptable as a means to prevent turning of a small stem-mounted switch or other device having a single-hole mounting means.

7 Supply Connections – Cord-Connected Appliances

7.1 Cords and plugs

7.1.1 A cord-connected appliance shall be provided with a length of flexible cord and an attachment plug for connection to the branch-circuit supply.

7.1.2 A job-card recorder, elapsed-time indicator, or a time stamp shall be provided with a cord not less than 6.0 feet (1.8 meters) long, having a grounding conductor and a grounding-type attachment plug. The grounding conductor in a flexible cord shall be green with or without one or more yellow stripes, and shall be conductively connected to all exposed dead metal parts and to all dead metal parts inside the enclosure that are exposed to contact during any servicing operation (including maintenance and repair) and that are likely to become energized.

7.1.3 The attachment plug of the power supply cord of an appliance provided with a 15- or 20-ampere general-use convenience receptacle shall be of the 3-wire grounding type. The attachment plug of the power supply cord of all other appliances shall be polarized.

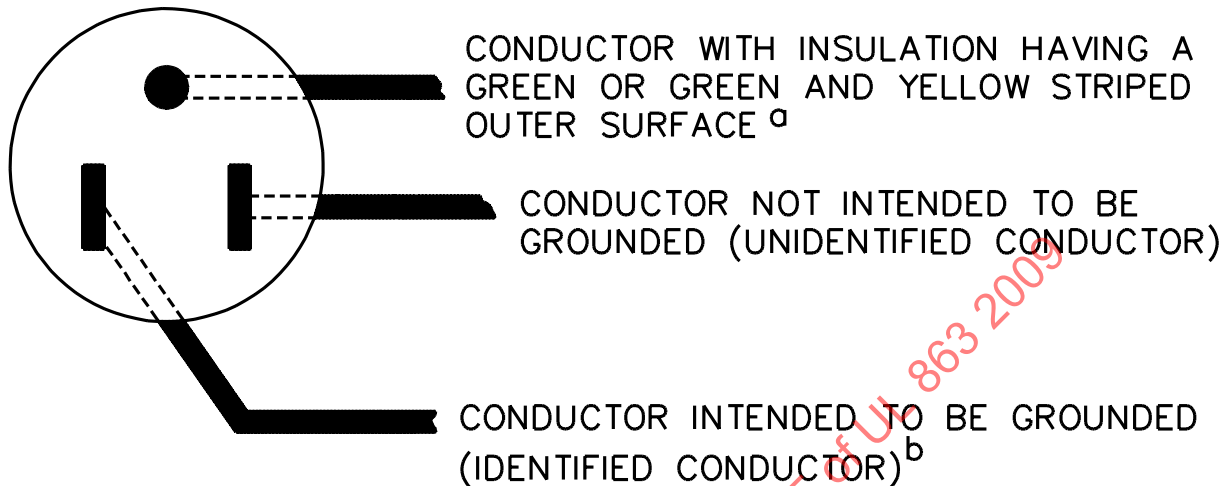
7.1.4 A 3-wire grounding-type attachment plug or a 2-wire polarized attachment plug shall be provided. The attachment plug connections shall comply with Figure 7.1, and the polarity identification of the flexible cord shall comply with Table 7.1.

Table 7.1
Polarity identification of flexible cords

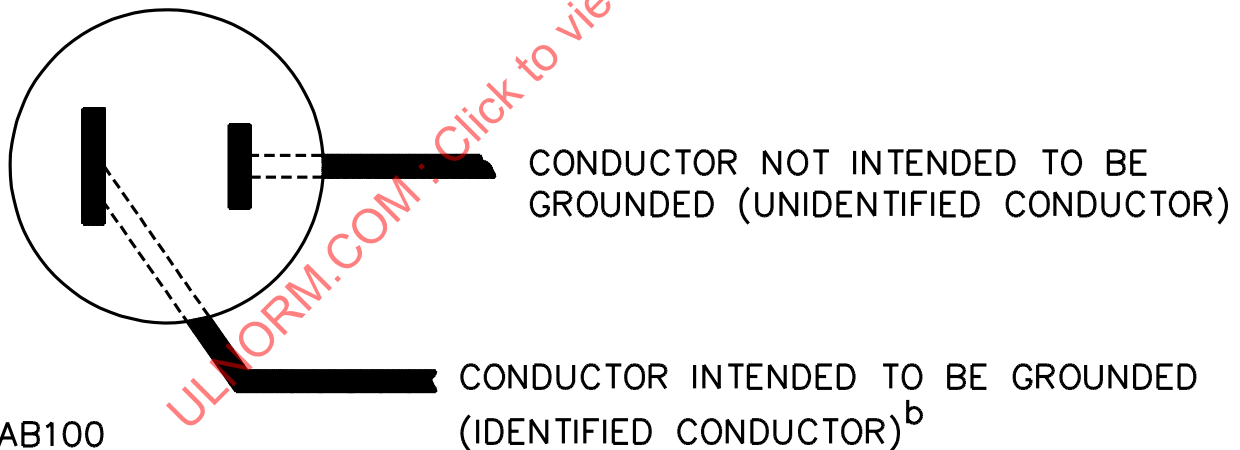
Method of investigation	Acceptable combinations	
	Wire intended to be grounded ^a	All other wires ^a
Color of braids on individual conductors	A Solid white or gray – without tracer	Solid color other than white or gray – without tracer
	B Color other than white or gray – with tracer in braid	Solid color other than white or gray – without tracer
Color of insulation on individual conductors	C ^b Solid white or gray	Solid color other than white or gray
	C1 ^c Light blue	Solid color other than light blue, white, or gray
Color of separators	D ^d White or gray	Color other than white or gray
Other means	E ^e Tin or other white metal on all strands of the conductor	No tin or other white metal on the strands of the conductor
	F ^d A stripe, ridge, or groove on the exterior surface of the cord	
^a A wire finished to show a green color with or without one or more yellow stripes or tracers is to be used as an equipment grounding conductor. See 7.2.1 and Figure 7.1. ^b Only for cords – other than Types SP-1, SP-2, and SPT-1 – having no braid on any individual conductor. ^c For jacketed cord. ^d Only for Types SP-1, SP-2, SPT-1, and SPT-2 cords. ^e Only for Types SPT-1 and SPT-2 cords.		

Figure 7.1
Connection to attachment plug

CONNECTIONS OF CORD CONDUCTORS TO GROUNDING – TYPE
ATTACHMENT PLUG (FACE OF PLUG REPRESENTED)



CONNECTIONS OF CORD CONDUCTORS TO POLARIZED
ATTACHMENT PLUG (FACE OF PLUG REPRESENTED)



AB100

^a In the above illustration, the blade to which the green conductor is connected may have a U-shaped or a circular cross section.

^b Signifies a conductor identified in accordance with Table 7.1.

7.1.5 The circuit conductors in the flexible cord shall be connected to the plug and to the wiring in the appliance so that the following devices used in the primary circuit are connected to the ungrounded side of the line:

- a) The center contact of an Edison-base lampholder.
- b) A fuseholder.
- c) Any other single-pole, overcurrent-protective device other than an automatic control without a marked off position.
- d) A manually-operated, line-connected, single-pole switch.

7.1.6 The screw shell of a plug fuseholder and the accessible contact of an extractor fuseholder shall be connected toward the load.

7.1.7 A flexible cord shall be as indicated in Table 7.2, or shall be of a type at least as serviceable for the particular application. It shall be rated for use at a voltage no lower than the rated voltage of the appliance and shall have an ampacity as given for the type in the National Electrical Code, ANSI/NFPA 70-1996, no lower than the current rating of the appliance.

Table 7.2
Acceptable cords

Type of appliance		Acceptable types of cord
1.	Floor-mounted appliances and others not included in items 2 and 3	S, SO, SOO, ST, STO, STOO, SJ, SJO, SJOO, SJT, SJTO, SJTOO
2.	Appliances intended for use on desks, counters, tables, and similar furniture in an office	SV, SVO, SVOO, SVT, SVTO, SVTOO, SP-2, SPE-2, SPT-2
3.	Wall clocks rated for 125 volts or less	SP-1, SPT-1

7.1.8 The attachment plug for connection to the branch-circuit supply shall have an American National Standard configuration of pins and American National Standard ratings. It shall be of a type rated for use:

- a) With a current no lower than the rated current of the appliance and
- b) At a voltage equal to the rated voltage of the appliance.

If the appliance can be adapted for use on two or more different supply voltages by field alteration of internal connections, the attachment plug provided with the appliance shall be rated for the voltage for which the appliance is connected when it is shipped from the factory.

7.1.9 An appliance designed for connection to a remote-control or similar circuit instead of to a convenience power-supply outlet receptacle may employ a plug that has been investigated and determined to be in compliance with the intent of these requirements.

7.1.10 The flexible cord may be permanently attached to the appliance or may be in the form of a separable cord set with means for connection to the appliance.

7.1.11 If an appliance incorporates a removable cord set, the arrangement shall not expose any live part under any normal conditions.

7.2 Grounding

7.2.1 An equipment grounding conductor of a flexible cord shall be:

- a) Finished to show a green color with or without one or more yellow stripes.
- b) Conductively connected to:
 - 1) All exposed dead metal parts that are likely to become energized and
 - 2) All dead metal parts within the enclosure that are exposed to contact during any user servicing and that are likely to become energized.

The grounding conductor shall be connected by means of a screw or other means not likely to be removed during any servicing operation not involving the power supply cord. Solder alone shall not be used for securing this conductor.

- c) Connected to the fixed grounding member of an attachment plug of the grounding type.

7.2.2 Sheet-metal screws shall not be used to connect grounding conductors to enclosures.

7.3 Strain relief

7.3.1 A power-supply cord shall be provided with a means to resist transmittal of tension from the cord to terminals, splices, or wiring within the appliance.

7.3.2 A metal strain-relief clamp or band (without auxiliary protection) is acceptable with a Type SV, SVE, SVO, SVOO, SJ, SJE, SJO, SJOO, S, SE, SO, SOO, SJT, SJTO, SJTOO, ST, STO, or STOO cord. A metal strain-relief clamp or band is acceptable with Type SP-2 or SPE-2 rubber-insulated cord and with Type SPT-2, SVT, SVTO, or SVTOO cord only if auxiliary, nonconducting, mechanical protection is provided over the cord.

7.3.3 Means shall be provided to reduce the risk of the flexible cord being pushed into the appliance through the cord-entry hole if such displacement can result in damage to the cord or exposure of the cord to a temperature higher than that for which the cord is rated, or can reduce spacings (such as to a metal strain-relief attachment) below the minimum acceptable values.

7.3.4 If a knot in a flexible cord serves as strain relief, the surfaces that the knot can touch shall be free of sharp edges, projections, and the like, that could damage the cord.

7.4 Bushings

7.4.1 At the point at which a supply cord passes through an opening in a wall, barrier, or the overall enclosure, there shall be a bushing or the equivalent that shall be substantial, secured in place, and that has a smooth, well-rounded surface against which the cord can bear. If a cord other than Type S, SE, SO, SOO, ST, STO, STOO, SJ, SJO, SJOO, SJE, SJT, SJTO, SJTOO, SV, SVE, SVD, SVOO, SVT, SVTO, or SVTOO is used and the wall or barrier is of metal, an insulating bushing shall be provided.

7.4.2 If the cord hole is in porcelain, phenolic composition or similar nonconducting material, a smooth, well-rounded surface is considered equivalent to a bushing.

7.4.3 Ceramic materials and some molded compositions are acceptable generally for insulating bushings, but a bushing of wood or hot-molded shellac-and-tar composition is not acceptable.

7.4.4 Vulcanized fiber may be used if the bushing is not less than 1/16 inch (1.6 mm) thick, with a minus tolerance of 1/64 inch (0.4 mm) to allow for manufacturing variations, and is formed and secured in place to avoid being adversely affected by conditions of ordinary moisture.

7.4.5 A separate soft-rubber, neoprene, or polyvinyl-chloride bushing of good quality may be used on a supply cord at the point at which the cord enters the frame of a motor or the enclosure of a capacitor that is physically attached to a motor if:

- a) The bushing is not less than 1/16 inch (1.6 mm) thick, with a minus tolerance of 1/64 inch (0.4 mm) and
- b) The bushing is located where it cannot be exposed to oil, grease, oil vapor, or other substances that have a deleterious effect on the compound used.

7.4.6 A bushing of any of the materials specified in 7.4.5 is acceptable on a supply cord anywhere in an appliance if it is used in conjunction with a type of cord for which an insulating bushing is not required. The edges of the hole in which such a bushing is so used shall be free from burrs, fins, and other conditions capable of damaging the bushing.

7.4.7 A bushing of the same material as and molded integrally with the supply cord is acceptable on a Type SP-2 or heavier cord if the built-up section is not less than 1/16 inch (1.6 mm) thick at the point at which the cord passes through the enclosure.

7.4.8 An insulated metal grommet may be used in place of an insulating bushing if the insulating material is not thinner than 1/32 inch (0.8 mm), and completely fills the space between the grommet and the metal in which the grommet is mounted.

8 Supply Connections – Permanently-Connected Appliances

8.1 General

8.1.1 An appliance intended for permanent connection to the branch-circuit supply shall have provision for permanent connection to the branch-circuit supply.

8.1.2 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than 0.032 inch (0.81 mm) if uncoated steel, not less than 0.034 inch (0.86 mm) if galvanized steel, and not less than 0.045 inch (1.14 mm) if nonferrous.

8.2 Terminal boxes

8.2.1 The location of a terminal box or compartment in which branch-circuit connections to a permanently wired appliance are to be made shall ensure that these connections can be readily inspected without disturbing the wiring after the appliance is installed as intended.

8.2.2 A terminal compartment intended for connection to a supply raceway shall be attached to the appliance in a manner that prevents the compartment from turning with regard to the appliance.

8.2.3 Wiring space or other compartments intended to enclose wires shall be free of any sharp edge, burr, fin, moving part or the like that can damage the conductor insulation.

8.3 Field-wiring terminals and leads

8.3.1 A permanently-connected appliance shall be provided with field-wiring terminals for the connection of conductors having an ampacity appropriate for the appliance, or the appliance shall be provided with suitable leads for this connection.

8.3.2 A lead provided for a splice connection shall be of suitable 18 AWG (0.82 mm²) or larger fixture wire or the equivalent.

8.3.3 The free length of a lead inside an outlet box or a field-wiring compartment shall be 6 inches (152 mm) or more.

8.3.4 Field-wiring terminals shall be suitable for copper supply conductors or for either aluminum or copper supply conductors in accordance with the marking required by 30.1.

8.3.5 A field-wiring terminal shall be prevented from turning.

8.3.6 A wire-binding screw shall thread into metal.

8.3.7 A setscrew type of terminal for binding a conductor shall be made the object of an investigation to determine whether it is in compliance with the intent of these requirements.

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

Exception: A wire-binding screw may be used only at a wiring terminal intended to accommodate a 10 AWG (5.3 mm²) or smaller conductor if upturned lugs, cupped washers, or their equivalent are provided to hold the wire in position.

8.3.9 An upturned lug or cupped washer shall be capable of retaining a 10 AWG (5.3 mm²) supply conductor under the head of the screw or washer.

8.3.10 Terminal parts shall ensure reliable connections even under hard use. The parts to which wiring connections are made may consist of clamps or binding screws with terminal plates having upturned lugs or their equivalent to hold the wires in position. If a wire-binding screw is used at a wiring terminal, the screw shall not be smaller than No. 8 (4.2 mm diameter).

Exception: A No. 6 (3.5 mm diameter) screw may be used for a terminal to which 14 AWG (2.1 mm²) wire would normally be connected.

8.3.11 It should be noted that 14 AWG (2.1 mm²) is the smallest conductor acceptable for branch-circuit wiring and thus is the smallest conductor that is to be anticipated at a terminal for connection of a branch-circuit conductor.

8.3.12 A terminal plate for a field-wiring wire-binding screw shall be of 0.050-inch (1.27-mm) or thicker metal.

Exception: A plate as thin as 0.030 inch (0.76 mm) is acceptable if tightening the wire-binding screws with a torque of 20 inch pounds (2.26 N·m) does not strip the threads from the terminal plate. There shall be two or more full threads in the metal, which may be extruded if necessary to provide the threads.

8.3.13 The screw shell of a fuseholder for a plug fuse and the accessible contact of an extractor fuseholder shall be connected toward the load.

8.4 Provisions for grounding

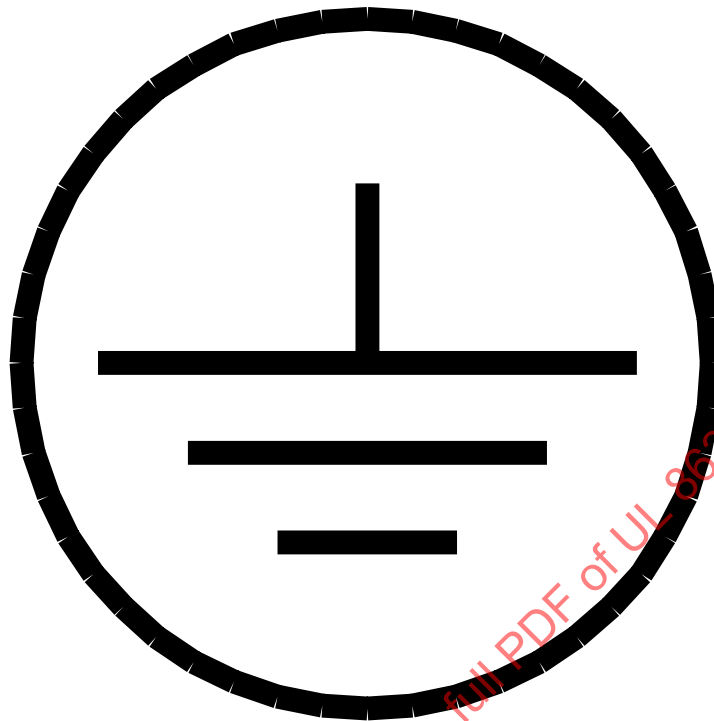
8.4.1 All exposed dead-metal parts of a permanently-connected appliance that are likely to become energized shall be conductively connected to the point at which armored cable, conduit, or the like is to be connected. A permanently connected wall clock rated for more than 50 volts shall have provision for grounding exposed dead metal parts.

8.4.2 A terminal screw or the equivalent intended for the connection of a field-installed equipment grounding conductor shall have a green-colored head that is hexagonal-shaped. The head may or may not be slotted.

8.4.3 When the terminal for the equipment grounding conductor is readily removable, the area adjacent to the terminal shall be marked with:

- a) The word "green" or "ground",
- b) The letters "G" or "GR",
- c) The grounding symbol shown in Figure 8.1, or
- d) A distinctive green color.

Figure 8.1
Grounding symbol



8.4.4 Sheet-metal screws shall not be used to connect grounding conductors to enclosures.

8.4.5 A plug having provision for grounding is acceptable as an alternate to the terminal screw construction in the following types of appliance:

- a) A clock (such as an impulse clock) that is provided with a special plug requiring the installation of a corresponding special receptacle at an installation.
- b) A clock (such as a flush-mounting type) requiring the installation of a special back box at an installation.
- c) An electronic-type secondary clock.

8.4.6 A permanently-connected appliance rated at 125 or 125/250 volts (3-wire) or less and employing a lampholder of the Edison-screw-shell type, or a single-pole switch or overcurrent protective device other than an automatic control without a marked "off" position, shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit. The identified terminal or lead shall be the one that is electrically connected to screw shells of lampholders and to which are connected to switches or overcurrent protective devices of the single-pole type other than automatic controls without a marked "off" position.

8.4.7 A field-wiring terminal intended for the connection of a grounded supply conductor shall be identified by means of a coating of metal that is substantially white in color and shall be easily distinguishable from the other terminals, or proper identification of the terminal for the connection of the grounded conductor shall be clearly shown in some other manner, such as on an attached wiring diagram. If wire leads are provided instead of terminals, the identified lead shall have a white or gray color and shall be easily distinguishable from the other leads.

8.4.8 An insulated equipment grounding conductor shall be green with or without one or more yellow stripes, and no other lead shall be so identified.

9 External Interconnections

9.1 Cord-connected appliances

9.1.1 External interconnections on cord-connected appliances shall be by cord and attachment plug. The interconnections shall also comply with the requirements in Supply Connections – Cord-Connected Appliances, Section 7.

9.2 Permanently-connected appliances

9.2.1 External interconnections on permanently-connected appliances shall comply with the requirements in 8.1.1 – 8.3.13.

10 Live Parts

10.1 A current-carrying part shall be of silver, copper, a copper-base alloy, or equivalent metal.

10.2 An uninsulated live part shall be secured to the surface on which it is mounted. Supporting insulating material shall be secured in place to prevent the part from turning or shifting in position if turning or shifting would reduce spacings below the minimum acceptable values indicated in 13.1 – 13.6 and 14.1 – 14.5.

10.3 Friction between surfaces is not acceptable as a means of preventing shifting or turning of live parts, but a suitable lock-washer properly applied may be acceptable.

11 Internal Wiring

11.1 The internal wiring of an appliance shall:

- a) Consist of insulated conductors having the mechanical strength and ampacity for the service and
- b) Be protected against mechanical injury.

11.2 Wire having thermoplastic insulation at least 1/64 inch (0.4 mm) thick or equivalent insulation is acceptable without supplementary insulation.

Exception: Supplementary insulation shall be provided when:

- a) The wire may be damaged or handled during installation or routine maintenance of the appliance.*
- b) The wire is subjected to vibration (as in a time stamp or similar appliance) while it is in contact with a rough surface such as that of a casting.*

c) The insulation may be subject to flow because the wire is formed over the edge of metal or through a hole punched in sheet metal.

11.3 Supplementary insulating tubing having a wall thickness not less than 1/64 inch (0.4 mm), may be acceptable for protection against the conditions indicated in (a), (b), and (c) of the Exception to 11.2.

11.4 Wires within an enclosure compartment, raceway, or the like shall be located or protected to prevent contact with any sharp edge, burr, fin, moving part, or the like that can damage the conductor insulation. A hole in a sheet-metal wall through which insulated wires pass shall be provided with a bushing if the wall is 0.042 inch (1.1 mm) or less thick. A hole in a wall thicker than 0.042 inch shall have a smooth, well-rounded edge.

11.5 Each joint and connection shall be mechanically secure and shall provide adequate and reliable electrical contact without strain on connections and terminals.

11.6 If stranded internal wiring is connected to a wire-binding screw or stud terminal, it shall be connected so that loose strands do not result.

11.7 Compliance with the requirement in 11.6 can be accomplished by:

- a) Use of pressure terminal connectors, soldering lugs, or crimped eyelets;
- b) Soldering all strands of the wire together;
- c) Tightly twisting all strands together; or
- d) Equivalent means.

11.8 A splice shall be provided with insulation equivalent to that on the wires involved if permanence of adequate spacing between the splice and uninsulated metal parts is not ensured.

12 Coil Windings

12.1 The insulation of a coil winding shall resist the absorption of moisture.

12.2 Enameled wire requires no additional treatment to prevent moisture absorption.

13 Separation of Circuits

13.1 An insulated conductor shall not touch any other insulated conductor operating at a higher potential unless both conductors are suitable for use at the higher potential. This includes the conductors in terminal compartments and boxes as well as internal wiring, but does not include field wiring applications.

13.2 Conductors that operate at different potentials but are not insulated for the highest potential among them as indicated in 13.1 shall be permanently separated from one another by barriers, routing, or clamping.

13.3 Any of the insulated conductors specified in 13.1 and 13.2 may touch any insulated live part operating at a potential higher than the potential at which the conductor itself operates if the conductor is insulated for the higher potential and the part it touches is not sharp or otherwise capable of damaging the insulated conductor.

13.4 A field-installation conductor of any circuit shall be separated by a barrier:

- a) From field installation and factory installed conductors connected to any other circuit.

Exception: If the conductors of both circuits are or will be insulated for the maximum voltage in either circuit, the requirement for separation may be waived.

- b) From an uninsulated live part of any other circuit in the appliance, and from any uninsulated live part whose short-circuiting results in unsafe operation of the appliance.

Exception No. 1: A construction in which field installed conductors might touch wiring terminals is acceptable if standard building or fixture wires or equivalent conductors are or will be installed.

Exception No. 2: A construction in which a field installed conductor that does or can have less insulation than is required on the types of wire specified in Exception No. 1 which contacts a low voltage wiring terminal, is acceptable if short circuiting such a terminal does not result in unsafe operation of the appliance.

13.5 In many appliances, a solid (unpierced) barrier permanently secured in place is used to achieve compliance with 13.4(a). However, in appliances to which field connections for some applications are different from the connections for other applications, a removable solid barrier may be used or a permanent barrier in which there are holes for the passage of conductors may be used. Instructions for use of a removable or pierced barrier are to be a permanent part of the appliance. In any case, instead of a barrier, a wiring diagram may be provided on or with the appliance if:

- a) Provision is made for routing all conductors,
- b) Such routing is clearly and completely shown by the diagram, and
- c) Complete wiring instructions accompany the diagram.

13.6 Separation of some field-installation conductors from others and from uninsulated live parts connected to different circuits is accomplished by arranging the location of openings in the enclosure for the various conductors (with regard to the terminals or other uninsulated live parts) so that there is no risk of intermingling between the conductors or parts of different circuits. When no more openings are provided in the enclosure than are required for proper wiring of the appliance, and each opening is opposite a set of terminals, it is to be assumed in determining compliance with 13.4 that conductors entering the enclosure through any such opening are connected only to the terminals opposite that opening. When more openings are provided in the enclosure than are required for proper wiring of the appliance, it is to be assumed in determining compliance with 13.4 that conductors enter the enclosure through openings not opposite the terminals to which they are intended to be connected, and touch insulated conductors and uninsulated live parts of circuits other than their own; in which case, the requirements in 13.1 and 13.3 are to be considered when determining acceptability.

13.7 In determining if an appliance complies with the requirements of 13.4, the appliance is to be wired in the manner in which it would be wired in the field – that is, a reasonable amount of slack is to be left in each conductor within the enclosure, and no more than average care is to be used in stowing the slack in the compartment.

14 Spacings

14.1 The spacings in an appliance shall not be less than those indicated in Table 14.1. These values apply to the spacings between any uninsulated live part and:

- a) An uninsulated live part of opposite polarity, either grounded or ungrounded.
- b) A wall or cover of a metal enclosure, including attached metal pieces and fittings for rigid metal conduit or for armored cable.
- c) An uninsulated grounded dead metal part other than the enclosure.
- d) An exposed dead metal part that is isolated or insulated.

Greater spacings may be required if the enclosure (because of its size, shape, or the material used) is not sufficiently rigid to ensure maintenance of the minimum spacings.

Exception No. 1: The spacings specified in Table 14.1 as the minimum acceptable do not apply to snap switches and other components for which the spacings that apply are specified in the requirements for the particular component.

Exception No. 2: Spacings are not specified for:

- a) A circuit involving a potential of no more than 30 volts and supplied by a primary battery, by a standard Class 2 transformer (maximum 30 volts rms and 42.4 volts peak), or by a suitable combination of transformer and fixed impedance having output characteristics in compliance with what is required for a Class 2 transformer or*
- b) A circuit in which the current is limited by series impedance or the equivalent to the levels specified for a Class 2 transformer.*

Table 14.1
Spacings

Potential involved in volts	Parts involved	Smallest acceptable through-air and over-surface spacings,	
		inch	(mm)
0 – 50	Wiring terminals	1/8 ^a	3.2 ^a
	Commutator or collector rings of a motor	3/64	1.2
	Elsewhere in appliance	3/64	1.2
51 – 125	Wiring terminals	1/4 ^a	6.4 ^a
		1/8 ^{a,b}	3.2 ^{a,b}
	Commutator or collector rings of a motor	1/16	1.6
	Elsewhere in appliance	3/32 ^c	2.4 ^c
126 – 250	Wiring terminals	1/4 ^a	6.4 ^a
	Commutator or collector rings of a motor	1/16	1.6
	Elsewhere in appliance	3/32	2.4
251 – 300	Wiring terminals	1/4 ^a	6.4 ^a
	Commutator or collector rings of a motor	3/32	2.4
	Elsewhere in appliance	3/32	2.4

^a Spacings at wiring terminals are to be measured while a conductor is connected to each terminal as in actual service. The conductor is to be of a size having an ampacity no less than the current rating of the appliance. The conductor is not to be smaller than 14 AWG (2.1 mm²) if of copper and is not to be smaller than 12 AWG (3.3 mm²) if of aluminum.

^b The 1/8-inch (3.2-mm) spacing is a through-air spacing acceptable only if the terminals are either recessed insulating material or separated by an insulating barrier to the extent that loose strands of conductors attached to one terminal are unlikely to contact ground or an adjacent terminal or conductor.

^c For a motor rated 1/3 horsepower (249 W output) or less, these spacings may be no less than 1/16 inch (1.6 mm).

14.2 The spacing between bare current-carrying parts of a low-potential (0 – 50 volts) circuit and a circuit operating at more than 50 volts shall not be less than that required for the circuit of the higher potential.

14.3 The spacing between bare current-carrying parts of circuits in which the energy is limited in accordance with Exception No. 2 to 14.1 and circuits in which the energy is not limited shall not be less than that required for the potential of the circuit in which the energy is not limited.

14.4 If insulation is provided in lieu of spacings between a magnetic coil winding and other uninsulated live parts or grounded dead metal parts, the type of insulation may differ from that required by 14.5 – 14.7. Crossover lead insulation and insulation under coil terminals secured to the coil winding need not comply with 14.5 – 14.7, if, for insulation thicknesses less than 0.013 inch (0.33 mm), there is no indication of breakdown as a result of the tests described in the Burnout Test, Section 20.

14.5 An insulating barrier or liner used as the sole separation between uninsulated live parts and grounded dead metal parts (including the enclosure), or between uninsulated live parts of opposite polarity, shall be of material of a type that is acceptable for the mounting of uninsulated live parts, and shall be not less than 0.028 inch (0.71 mm) thick.

Exception: Fiber not less than 0.028 inch thick may be used as the sole separation between the enclosure and an uninsulated metal part electrically connected to a grounded circuit conductor.

14.6 An insulating barrier or liner used in conjunction with an air space in place of the required spacing through air shall be not less than 0.028 inch (0.71 mm) thick. If the barrier or liner is of fiber, the air space shall be not less than 1/32 inch (0.8 mm), and if the barrier or liner is of other material not acceptable for the support of uninsulated live parts, the air space provided shall be such that, upon investigation, it is found to fulfill the intent of the requirement.

Exception: A barrier or liner used in addition to no less than one half the required spacing through air may be less than 0.028 inch but not less than 0.013 inch (0.33 mm) thick when the barrier or liner is:

- a) Of material of a type that is acceptable for the mounting of uninsulated live parts,*
- b) Of such strength to withstand exposure to mechanical damage,*
- c) Secured in place, and*
- d) Located so that it will not be affected adversely by operation of the equipment in service.*

14.7 Insulating material having a thickness less than that specified in 14.4 – 14.6 may be used if, upon investigation, it is found to be acceptable for the particular application.

15 Outdoor-Use Appliances

15.1 General

15.1.1 An appliance intended for outdoor use shall comply with the requirements in this section, as well as the other applicable requirements of this standard.

15.1.2 An outdoor use appliance shall be designed and constructed to protect against the weather.

15.2 Rainproof enclosures

15.2.1 A live part (other than the screw shell of a lampholder) and all wiring shall be enclosed by metal or other material that is resistant to combustion.

15.2.2 Plain glass may be used as a part of the enclosure if its breakage or removal does not afford access to uninsulated current-carrying parts.

15.2.3 An enclosure housing a live part that is not acceptable for exposure to the weather shall be constructed to exclude a beating rain as judged by applying the requirements of 15.2.4. The enclosure shall be provided with external means for mounting, or with internal means for mounting that are designed to prevent water from entering the enclosure. A hinge or other attachment shall be resistant to corrosion.

15.2.4 To determine compliance with the requirement in 15.2.3, a complete appliance with supply conduit connections assembled without pipe thread compounds is to be subjected to the rain test described in the Test for Resistance to Rain, Section 24.

15.2.5 Sheet steel shall be not less than 0.023 inch (0.58 mm) thick if zinc-coated and shall be not less than 0.020 inch (0.51 mm) thick if uncoated.

15.2.6 Sheet copper, brass, or aluminum shall be not less than 0.025 inch (0.64 mm) thick.

15.2.7 A joint or edge of sheet metal shall be fastened by welds, rivets, bolts, screws, or equivalent acceptable means.

15.2.8 A sheet steel or other iron or steel part that is depended upon for the protection and support of wiring and live parts shall be protected against corrosion by galvanizing, electroplating, or the equivalent.

15.2.9 Painting alone is not acceptable for protecting sheet metal against corrosion. Copper, stainless steel, and other materials having inherent resistance to atmospheric corrosion need not be additionally protected.

15.2.10 Vitreous enamel may be used as the sole protective coating for 0.031-inch (0.79-mm) or thicker sheet steel.

15.2.11 A hole for conduit shall be threaded unless it is located wholly below the lowest terminal lug or other live part within the enclosure when the enclosure is mounted in the position intended. Provision shall be made for drainage of the enclosure.

15.2.12 A gasket that is depended upon for protection against rain is to be subjected to the Gasket Aging Test, Section 25.

15.3 Lampholders

15.3.1 A lampholder shall be of the unswitched type and shall have a body of porcelain or molded composition. A lampholder employing fiber or similar absorptive material shall not be used.

15.3.2 A lampholder having an aluminum screw shell shall not be used.

PERFORMANCE

16 Current Input Test

16.1 The current input to an appliance must not exceed the rating marked on the appliance by more than 10 percent when the appliance is operated as in normal use at maximum normal load as described in 17.2 while connected to a supply circuit of the rated voltage and frequency of the appliance.

Exception: A clock rated at 20 watts or less may have an input of not more than 25 percent above its marked rating.

16.2 Rated voltage is to be taken as:

- a) 120 volts if the marked rating is within the range of 110 – 120 volts and
- b) 240 volts if the marked rating is within the range of 220 – 240 volts.

17 Normal Temperature Test

17.1 An appliance, when tested under the conditions of maximum normal load described in 17.2 shall not attain a temperature at any point sufficiently high to constitute a risk of fire, damage to any material used in the appliance, or greater rises in temperature above 25°C (77°F) than as indicated for specific points in Table 17.1.

Table 17.1
Maximum acceptable temperature rises

Materials and components		°C	(°F)
1.	Varnished-cloth insulation	60	108
2.	Fuses	65	117
3.	Fiber used as electrical insulation	65	117
4.	Wood and other similar material	65	117
5.	Any point on or within a terminal box on a stationary appliance	65	117
6.	A surface upon which a cord-connected or permanently-wired appliance might be mounted in service, and surfaces that might be adjacent to the appliance when it is mounted	65	117
7.	Class A insulation systems on coil windings of DC and universal motors:		
	a) In open motors:		
	Thermocouple method	65 ^a	117 ^a
	Resistance method	75 ^a	135 ^a
	b) In totally enclosed motors:		
	Thermocouple method	70 ^a	126 ^a
	Resistance method	80 ^a	144 ^a
8.	Class A insulation systems on coil windings of AC motors (not including universal motors) having a frame diameter ^b of 7 inches or less:		
	a) In open motors:		
	Thermocouple or resistance method	75 ^a	135 ^a
	b) In totally enclosed motors:		
	Thermocouple or resistance method	80 ^a	144 ^a
9.	Class 105 insulation systems on windings of relays, solenoids, magnets, and the like:		
	Thermocouple method	65 ^a	117 ^a
	Resistance method	75 ^a	135 ^a
10.	Class B insulation systems on coil windings of DC and universal motors:		
	a) In an open motor:		
	Thermocouple method	85 ^a	153 ^a
	Resistance method	95 ^a	171 ^a
	b) In totally enclosed motors:		
	Thermocouple method	90 ^a	162 ^a
	Resistance method	100 ^a	180 ^a
11.	Class B insulation systems on coil windings of AC motors (not including universal motors) having a frame diameter ^b of 7 inches or less:		
	a) In open motors:		
	Thermocouple or resistance method	95 ^a	171 ^a
	b) In totally enclosed motors:		
	Thermocouple or resistance method	100 ^a	180 ^a
12.	Class 130 insulation systems on windings of relays, solenoids, magnets, and the like:		
	Thermocouple method	85 ^a	153 ^a
	Resistance method	95 ^a	171 ^a

Table 17.1 Continued on Next Page

Table 17.1 Continued

Materials and components		°C	(°F)
13.	Phenolic composition used as electrical insulation or as a part whose failure would result in a hazardous condition	125 ^c	225 ^c
14.	Rubber- or thermoplastic-insulated wires and cords	35 ^{d,e}	63 ^{d,e}
15.	On the surface of a capacitor casing:		
	Electrolytic	40 ^e	72 ^e
	Other types	65 ^f	117 ^f
16.	Transformers with Class 105 insulation systems:		
	Thermocouple method	65 ^a	117 ^a
	Resistance method	75 ^a	135 ^a
17.	Transformers with Class 130 insulation systems:		
	Thermocouple method	85 ^a	153 ^a
	Resistance method	95 ^a	171 ^a

^a See 17.3, 17.8, and 17.9.

^b The frame diameter is the diameter measured in the plane of the laminations, of the circle circumscribing the stator frame, excluding lugs, boxes, and the like used solely for motor mounting, assembly, or construction.

^c The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and determined to have heat-resistant properties.

^d Rubber-insulated conductors within a Class A insulated motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor can be subjected to a temperature rise of more than 35°C (63°F) if a braid is used on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wire or cords.

^e For an electrolytic capacitor that is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure shall be no higher than 65°C (117°F).

^f A capacitor on whose casing the measured temperature rises further above the ambient than indicated in the table is acceptable at the temperature limit marked on the capacitor.

17.2 In testing an appliance, maximum normal load is considered to be the load that approximates as closely as possible the most severe conditions of normal use. It is not a deliberate overload, but is intended to simulate conditions of actual use that may be more severe than the maximum load conditions recommended by the manufacturer of the appliance.

17.3 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 means of a thermocouple may be 15°C (27°F) more than the maximum indicated in notes 7 and 10 of Table 17.1, and 5°C (9°F) more than the maximum indicated in note 8 of Table 17.1, when the temperature rise of the coil, as measured by the resistance method, is no more than specified in Table 17.1.

17.4 All values in Table 17.1 are based on an assumed ambient (room) temperature of 25°C (77°F), but a test may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F). However, if the operation of an automatic thermal control during the test limits the temperature under observation, no observed temperature higher than 25°C (77°F) plus the specified maximum rise is acceptable.

17.5 A short length of rubber- or thermoplastic-insulated flexible cord exposed to a temperature higher than 60°C (140°F) (such as at terminals) is acceptable if supplementary heat-resistant insulation is used on the individual conductors of the cord to safeguard deterioration of the conductor insulation. The dielectric withstand properties and temperature rating of the supplementary insulation shall be in accordance with the electrical and thermal environment in which the material is used.

17.6 For the normal temperature test, the voltage of the test circuit is to be 120 volts if the appliance is rated between 110 and 120 volts, or 240 volts if the appliance is rated between 220 and 240 volts. For any other voltage rating, the appliance is to be tested at its marked voltage rating. An appliance that is rated for use at more than one voltage or for a range of voltages and contains a tapped transformer or other means of being adapted to different supply voltages is to be tested at the most unfavorable combination of supply voltage and internal adjustment.

Exception: An appliance may be tested while connected in accordance with the manufacturer's instructions when all three of the following conditions are met:

- a) A clear, permanent marking is provided adjacent to the cord or supply compartment to warn the user that internal adjustments must be made when the appliance is installed or moved.*
- b) Detailed instructions clearly showing the adjustments that must be made for various voltages are permanently attached to the appliance. These instructions may be on the outside or on the inside of the overall enclosure where visible at the point at which adjustments for supply voltages must be made.*
- c) The means provided for adjusting for different voltages comply with the requirements for wiring terminals in 8.3.1 – 8.3.13.*

17.7 If an appliance obviously is not intended for continuous operation, the normal temperature test may be modified to take into consideration the probable occasional or periodic short-time operation of the appliance.

17.8 Thermal equilibrium is to be considered to exist only if successive readings indicate no change when taken at the conclusion of each of three consecutive equal intervals of time, the duration of each interval being whichever of the following is longer:

- a) 5 minutes or
- b) 10 percent of the total test time elapsed previous to the start of the first interval.

17.9 For the thermocouple-measured temperature of a coil in a 7-inch-diameter (178-mm) or smaller-frame alternating-current motor other than a universal motor (note 8 in Table 17.1), the thermocouple is to be applied to the magnet wire, or it is to be separated from that wire by no more than the insulation on the conductor itself. For the thermocouple-measured temperature of a coil of any other motor, the thermocouple is to be mounted as described above, or it may be separated from the conductor by no more than the insulation on the conductor itself and the normal coil wrap. Ordinarily, temperatures are to be measured by means of thermocouples.

Exception: Motor-coil temperatures may be determined by the resistance method if the coil is inaccessible for mounting thermocouples.

17.10 When thermocouples are used in determining temperatures in electrical equipment, it is standard practice to use thermocouples consisting of 30 AWG (0.05 mm²) iron and constantan wire and a potentiometer type instrument; and such equipment is to be used whenever referee temperature measurements by thermocouples are necessary.

17.11 The thermocouples and related instruments are to be accurate and calibrated in accordance with good laboratory practice. The thermocouple wire is to conform to the requirements for special thermocouples as specified in the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

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

17.13 Rubber and other material subject to deterioration is to be removed from feet and other supports of the appliance if absence of the material might result in the appliance attaining higher temperatures.

17.14 The thermocouple method consists of the determination of temperature by the application of thermocouples to the hottest accessible parts.

17.15 The resistance method consists of the determination of the temperature of a copper winding by comparing the resistance of the winding at the beginning of the test with its resistance at the end of the test, also taking into consideration ambient (room) temperature at the beginning and end of the test period according to the following formula:

$$\Delta t = \frac{R}{r} (234.5 + t_1) - (234.5 + t_2)$$

in which:

R is the resistance of the winding in ohms at the end of the test,

r is the resistance in ohms at the beginning of the test,

234.5 is the constant for copper,

*t*₁ is the room temperature in degrees C at the beginning of the test, and

*t*₂ is the room temperature in degrees C at the end of the test.

17.16 Because it is generally necessary to de-energize the winding before measuring *R*, the value of *R* at shutdown may be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values and the time may be plotted and extrapolated to give the value of *R* at shutdown.

18 Overload Test

18.1 The switching contacts of an appliance, when tested under overload conditions as described in 18.2 – 18.4 shall be capable of performing successfully for 50 cycles of operation at the rate representing normal service, but not slower than 6 cycles per minute. There shall be neither electrical nor mechanical failure of the switching mechanism nor undue burning, pitting, or welding of the contacts. The enclosure, if of metal, and any other exposed, noncurrent-carrying metal parts shall be grounded through a 3-ampere, nondelay-type fuse. The test load shall be representative of the load (inductive or noninductive) that the contacts are intended to control.

18.2 The contacts of a master clock, push button, or similar device that is supplied with and controls the normal load – that is, contacts that are not intended to be connected to a separate load in the field – shall be tested at 110 percent of the voltage measured at the contacts when the appliance is operated at the voltage indicated in 17.6 for the normal temperature test.

18.3 The contacts of a component or part such as a relay, or the minute-impulse contacts of a master clock to which a load is intended to be connected in the field shall be tested at maximum rated voltage and at 150 percent of rated current.

18.4 The contacts of an appliance that are used to control a motor shall be tested while the rotor of the motor is stalled.

19 Endurance Test

19.1 An appliance or device having switching contacts whose failure can result in a hazardous condition shall be capable of withstanding a continuous-operation test under the conditions described in 19.2 and 19.3. There shall be neither electrical nor mechanical failure of the appliance or device, nor undue burning, pitting, or welding of the contacts.

19.2 The test shall involve the necessary number of cycles of make and break with the contacts carrying their maximum normal load (inductive or noninductive) at rated voltage to represent at least 1000 hours of service. In the case of an appliance intended for continuous duty, a test representing more than 1000 hours is usually necessary.

19.3 An electrically operated time stamp or similar appliance shall be subjected to not less than 100,000 cycles of continuous operation without any hazardous electrical or mechanical failure.

20 Burnout Test

20.1 If the condition of continuous energization can result from the mechanical failure of any component or components, the electro-magnet coils of an appliance of periodic short-time operation (such as those of a minute-impulse-type secondary clock, master clock, relay, motor) and the electro-magnet coil of an appliance of occasional short-time operation (such as a time stamp) shall be capable of withstanding continuous energization at maximum rated voltage without emission of flame or molten metal from the enclosure and without otherwise increasing the risk of fire.

20.2 In determining compliance of an appliance with the requirement in 20.1, a coil is to be connected to the supply circuit and operation continued until constant temperatures are attained or until burnout occurs. During the test, exposed dead metal parts of the appliance are to be connected to ground through a 3-ampere nondelay fuse. The supply circuit is to be protected by fuses rated at not less than 150 percent of the appliance rating.

Exception: The next lower fuse rating may be used if the value is not a standard ampere rating, but in no case is the protection to be less than 20 amperes.

21 Dielectric Voltage-Withstand Test

21.1 An appliance shall be subjected for 1 minute to the application of a 60 hertz, essentially sinusoidal potential between:

- a) All live parts and the enclosure,
- b) All live parts and exposed dead metal parts, and
- c) Live parts of circuits operating at different potentials or at different frequencies.

In (c), the test potential shall be the value determined by the higher voltage of the different circuits. The test potential shall be 500 volts for circuits operated at 50 volts or less and 1000 volts for circuits operated at more than 50 volts. The results are acceptable if there is no dielectric breakdown.

21.2 To determine if an appliance complies with the requirements in 21.1 the appliance is to be stressed by means of a 500 volt-ampere or larger capacity testing transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test level is reached and is to be held at that level for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by the voltmeter.

22 Crossover Lead Dielectric Voltage-Withstand Test

22.1 General

22.1.1 To determine compliance with 14.4, a coil as described in 14.4 is to undergo the tests described in this section.

22.2 Potential test

22.2.1 Three separate samples are to be subjected to the test described in 22.2.2 after constant temperatures have been reached as the result of operation under the conditions specified in the Normal Temperature Test, Section 17. While heated from the normal temperature test, the coil terminals are to be connected to an alternating current potential of twice the rated voltage at any appropriate frequency for 7200 electrical cycles, or for 60 seconds, whichever is less.

22.2.2 The test voltage specified in 22.2.1 is to be obtained by applying one quarter or less of the full value and increasing to the full value in not more than 15 seconds. After being held for the time specified, the voltage is to be reduced within 5 seconds to one quarter or less of the maximum value, and the circuit is to be opened.

22.3 Potential test repeated

22.3.1 While heated, following operation at 110 percent of its rated voltage, the samples subjected to the test described in 22.2.1 and 22.2.2 are to be subjected to a repeated potential test at 65 percent of the potential applied in accordance with 22.2.1.

22.3.2 If the temperature that a coil winding reaches in the tests described in 22.2.1 and 22.2.2 is known, an oven that can be set at the required temperature may be used to condition the sample to that temperature before conducting the test.

23 Strain Relief Test

23.1 The strain-relief means provided on the flexible cord shall be subjected for 1 minute to a pull of 35-pounds force (155.7 N) applied to the cord while the connections within the appliance are disconnected.

23.2 The test force is to be exerted on the cord and supported by the appliance to stress the strain-relief means from any angle that the construction of the appliance permits. The means of affording strain is acceptable if, at the point of disconnection of the conductors, there is no movement of the cord indicating that stress would have resulted on the connections.

24 Test for Resistance to Rain

24.1 Appliances intended for outdoor use shall be subjected to the rain test described in 24.2 – 24.8. Following the test, the appliance shall have an insulation resistance of not less than 50,000 ohms measured between live parts and dead metal parts and shall withstand a repeated dielectric withstand test as described in the Dielectric Voltage-Withstand Test, Section 21. The appliance shall also comply with 24.8.

24.2 The test is to be conducted under intended conditions of operation most likely to cause entrance of water into or onto the electrical components. It may be necessary to operate the appliance under various modes of operation or to de-energize the appliance if more adverse conditions could result. In any case, each exposure to the simulated rain is to be for 1 hour. If more than one exposure is required, the appliance is to be reconditioned as necessary so that the results of each test will not be affected by prior exposures.

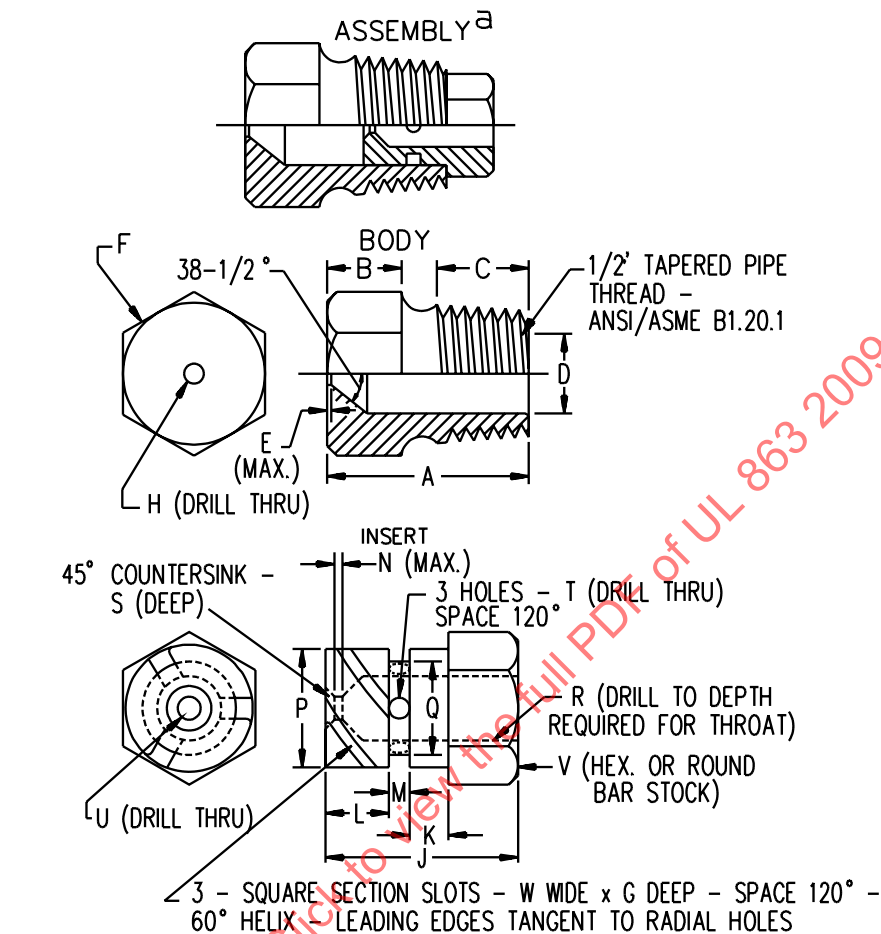
24.3 Following the water spray exposure, units intended to be permanently installed are not to be moved prior to the test described in 24.4.

24.4 Field wiring connections to the appliance are to be made to represent the intended method of field wiring. Normally, openings at which conduit is to be terminated will be sealed, but openings for the entry of a conductor or conductors of a low voltage circuit shall not be sealed.

24.5 The Dielectric Voltage-Withstand Test, Section 21, is to be repeated after exposure to simulated rain, and the insulation resistance is to be measured following each exposure.

24.6 The rain test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 24.1. Spray heads are to be constructed in accordance with the details shown in Figure 24.2. The water pressure for all tests is to be maintained at 5 pounds per square inch (34.4 kPa) at each spray head. The spray is to be directed towards the top and side of the appliance, which is to be centrally located within the spray pattern. The top of the appliance is to be at least 3 feet (0.91 m) below the plane of the lower spray head outlet.

Figure 24.1
Rain test spray head



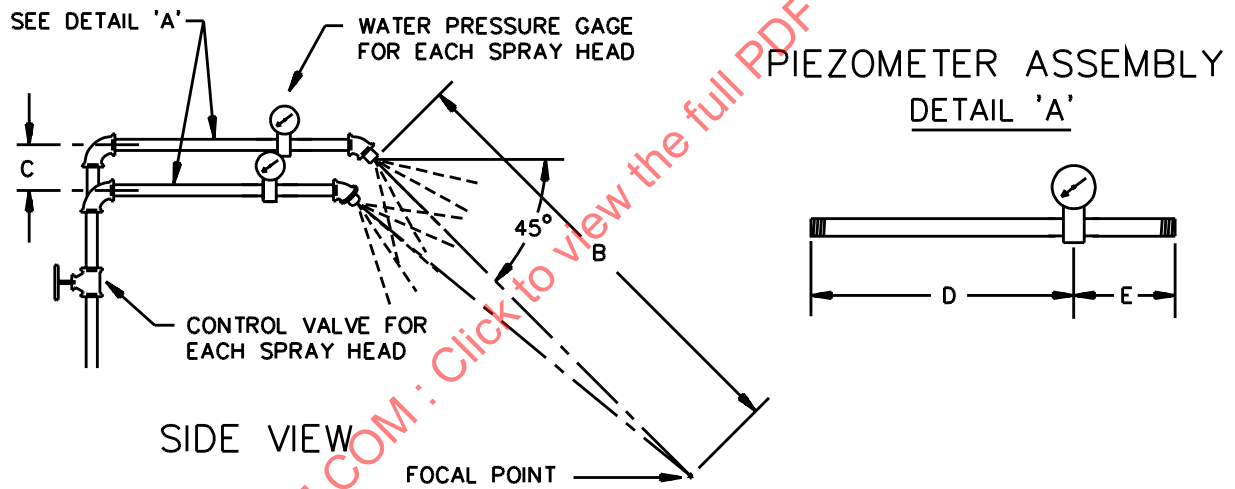
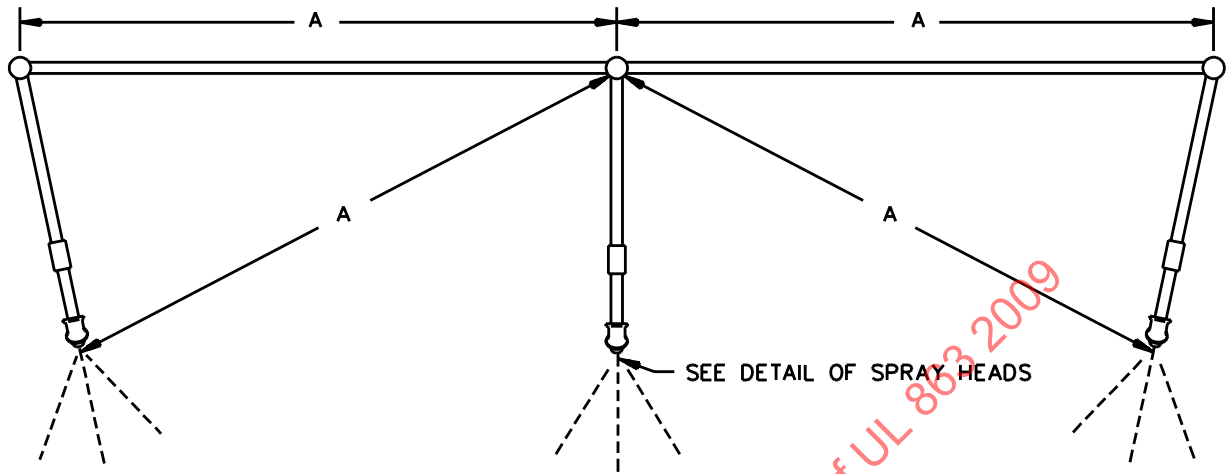
Item	inch	mm	Item	inch	mm
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0		.576	14.63
D	.578	14.68	Q	.453	11.51
	.580	14.73		.454	11.53
E	1/64	0.40	R	1/4	6.35
F	c	c	S	1/32	0.80
G	.06	1.52	T	(No. 35) ^b	2.80
H	(No. 9) ^b	5.0	U	(No. 40) ^b	2.50
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06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

Figure 24.2
Rain test spray head piping
PLAN VIEW



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

RT101E