UL 1429

STANDARD FOR SAFETY

Pullout Switches

UL Standard for Safety for Pullout Switches, UL 1429

Fourth Edition, Dated April 18, 2000

SUMMARY OF TOPICS

This revision of ANSI/UL 1429 dated December 4, 2020 includes the following changes:

Barriers to address inadvertent contact on line side of service disconnect; Section 18A, Table 49.1 and 49.5.7.

Editorial updates; 9.2, 11.2.1, 11.2.2, 17.2, 20.5, 26.3, and 37.2.

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.

These new and revised requirements are substantially in accordance with Proposal (s) on this subject dated August 28, 2020.

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UL 1429

Standard for Pullout Switches

First Edition – December, 1985
Second Edition – October, 1988
Third Edition – October, 1994

Fourth Edition

April 18, 2000

This ANSI/UL Standard for Safety consists of the Fourth edition including revisions through December 4, 2020.

The most recent designation of ANSI/UL 1429 as an American National Standard (ANSI) occurred on December 4, 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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INTRODUCTION

1 Scope

1.1 These requirements cover non-enclosed and enclosed pullout switches of the detachable type.

1.2 These requirements cover pullout switches rated 600 V or less, 400 A or less, with or without horsepower ratings, and with or without high-available fault current ratings.

1.3 These requirements cover pullout switches mounted in complete enclosure. Such an enclosure may contain meter sockets or neutral assemblies or both.

1.4 These requirements also cover enclosed pullout switches intended for use as service equipment.

1.5 These requirements cover non-enclosed pullout switches for use as mains and branches in panelboards, switchboards, and the like.

1.6 This standard does not cover hinged pullout switches. Such switches are covered in the Standard for Enclosed and Dead-Front Switches, UL 98.

1.7 These requirements do not cover enclosed pullout switches containing more than one independent switch which are covered by the Standard for Panelboards, UL 67.

1.8 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 Components

2.1 Except as indicated in 2.2, 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.

2.2 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.

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

2.4 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 Units of Measurement

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

4 References

4.1 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

5 General

5.1 A pullout switch shall employ materials throughout that are acceptable for the particular use.

5.2 All parts of a pullout switch shall be assembled in place when the switch is shipped from the factory, except as noted in 5.3.

5.3 A pullout switch may have provision for factory or field-installed accessories, such as neutral assemblies, provided that:

a) The pullout switch is for use with or without such assemblies,

b) Each accessory is acceptable for the intended use,

c) Each accessory can be installed without the disassembly of factory-assembled parts and without the use of a special tool unless such a tool and instructions for its use are furnished with each accessory,

d) A barrier that is necessary because spacings would otherwise be less than required, or for any other reason, is securely attached at the factory to either the switch or to the accessory to be installed,

e) The accessory is an essentially complete unit and does not require detailed assembly in the field. An arrangement that requires cutting, splicing of existing wires, or resoldering of connections is not acceptable, and

f) The accessory and switch are marked in accordance with 49.6.1.

5.4 With reference to 5.3, screws for mounting the neutral assembly must be furnished with that assembly but need not be assembled in place.

5.5 A Class CTL pullout switch shall have a size or configuration that, in conjunction with the physical means provided in a Class CTL panelboard, prevents the installation of more switch poles than that number for which the assembly is designed and rated.

5.6 Live parts of the fuse, including the fuse ferrules, shall not be relied upon to perform the switching function of a pullout switch.

6 Enclosure

6.1 General

6.1.1 An overall enclosure shall comply with the Standard for Enclosures for Electrical Equipment, UL 50, except for modifications and additional requirements as specially described in this Standard.

6.1.2 The entire enclosure of a switch intended for surface mounting and the box proper of a switch intended for flush mounting may be formed of sheet steel not less than 0.042 inch (1.07 mm) thick, excluding any coating thickness, if:

a) The length does not exceed 18 inches (457 mm) and the width does not exceed 14 inches (356 mm),

b) No surface of the box proper has an area of more than 252 square inches (1626 cm^2),

c) The depth of the box proper is not more than 5 inches (127 mm), and

d) The thickness of a cover, front, door, trim and the like, provided as part of an enclosure intended for flush mounting is as specified in Table 15.1 of the Standard for Enclosures for Electrical Equipment, UL 50.

6.1.3 The enclosure of a pull-out switch shall enclose completely all current-carrying parts, whether dead or alive, when a detachable pull-out member is closed. A pull-out switch member shall be so constructed that no live part will be exposed to unintentional contact by the operator when the pull-out switch member is in any position. See Operating Mechanism, Section 8.

6.1.4 The enclosure shall include a deadfront shield that will allow access to a switch handle without exposing live parts of the wiring.

6.1.5 A deadfront shall be supported independently of any support that will be provided by units that may be field-installed. The deadfront shall be so constructed that it can be readily installed and removed without the likelihood of contacting an uninsulated live part or injuring the insulation of any insulated live part inside the enclosure.

6.1.6 An enclosed pullout switch marked with a Type 3S enclosure designation in addition to complying with the requirements in UL 50 shall have an operating mechanism, if such is provided, that will support the additional weight of the ice and withstand removal of ice by a hand tool to gain access to the interior of the enclosure. Auxiliary means may be provided to break the ice and to provide for operation of an external mechanism.

6.1.7 An enclosed pullout switch marked with a Type 3S enclosure designation after the Icing Test in UL 50 is considered to be acceptable, if while ice loaded, the external operating mechanism can be operated manually or as intended by one person without damage to the enclosure. If an auxiliary mechanism is provided to break the ice, it shall be used. A separate icing test is to be conducted for each maintained position of each operator.

6.1.8 An enclosed pullout switch marked with a Type 12 or 12K enclosure designation, in addition to complying with the requirements in UL 50, shall have no holes other than for a Type 12 mechanism, or equivalent, that is provided with an oil resistant gasket.

6.1.9 If knockouts are provided in the enclosure of a switch, they may be of any size; but at least two of them (or more when multiple conduits are involved) shall be so located that the installation of bushings will not result in spacings between live parts and bushings of less than the minimum requirements of this standard, when they are reamed to accommodate the size of conduit required for the maximum number of gauge of rubber-insulated wires necessitated by the switch rating. This requirement is not intended to prohibit the use of enclosed switches connected to other wiring systems described in the National Electrical Code, ANSI/NFPA No. 70.

6.2 Doors and covers

6.2.1 A door shall be provided to cover a fusible detachable pullout member in the case of an enclosed pullout switch. The door shall be hinged, sliding, or similarly attached so as to prevent its being removed inadvertently.

6.2.2 The door over a fusible detachable pullout switch member in an enclosed pullout switch shall comply with requirements for doors, hinges, and latches as given in the Standard for Enclosures for Electrical Equipment, UL 50.

7 Bases – Insulating Material

7.1 A base for the mounting of uninsulated live parts shall be of strong, not easily ignited moisture-resistant insulating material that is acceptable for the particular application. The base shall be so constructed that it will withstand the most severe conditions likely to be met in service.

7.2 A neutral bus bar is considered to be a live part and shall be mounted on a base that complies with 7.1.

Exception: A neutral need not be insulated from dead metal parts when the switch is marked only for use as service equipment. See 49.5.2.

7.3 Insulating material, including barriers between parts of opposite polarity or material that may be subject to the influence of the arc formed by the opening of the switch, shall be acceptable for the particular application.

7.4 Live screw heads or nuts on the underside of a base intended for surface mounting shall be countersunk not less than 1/8 inch (3.2 mm) in the clear, and then covered with a waterproof insulating, sealing compound that will not soften at a temperature 15°C (27°F) higher than the temperature observed at the point where it is used, but not lower than 65°C (149°F) in any case; except that if such parts are staked, upset, or otherwise kept from loosening, they may be insulated from the mounting surface by material other than sealing compound or by the provision of a spacing through air from the mounting surface of not less than 1/2 inch (12.7 mm).

7.5 A lock washer, properly applied, is acceptable as a means of preventing the loosening of a screw or nut as required in 7.4.

7.6 A determination of the softening point of a sealing compound is to be made in accordance with the Test for Softening Point by Ring and Ball Apparatus, ASTM E28.

8 Operating Mechanism

8.1 The operating mechanism shall be constructed in such a manner as to provide the strength and rigidity necessary to perform its intended function. Screws and nuts serving to attach operating parts to crossbars or other movable members shall be staked, upset, or otherwise locked in position to keep them from loosening under the jars of continued use.

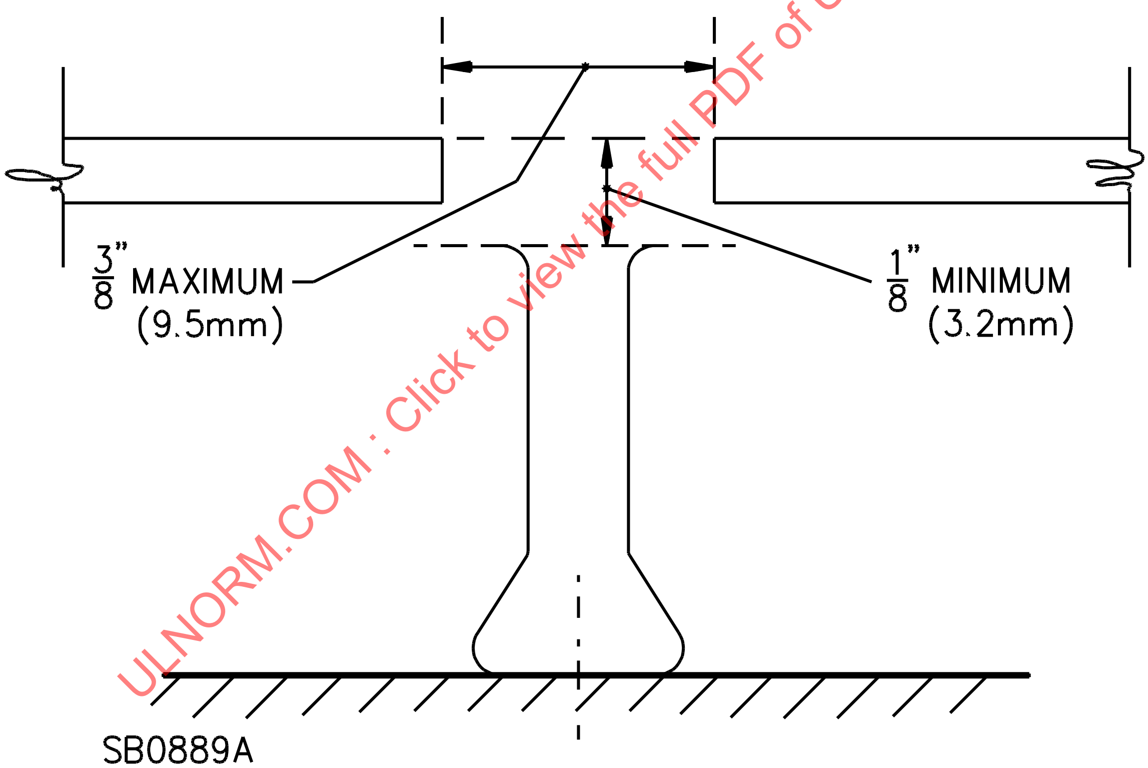
8.2 The accessibility of a live part with respect to unintentional contact as mentioned in 6.1.3 is to be determined with reference to any actual operating condition and with the pull-out member tilted at any angle at which it can be inserted. If the protection of a live part against unintentional contact is accomplished by means of a shield, barrier, or the like that may be moved or deflected under pressure so as to affect either the width of the opening or the recessing of the live part, the dimensions specified are to be investigated with the expected pressure applied.

8.3 A live part is not considered to be exposed to unintentional contact if it is recessed or set back 1/8 inch (3.2 mm) or more from the plane of an opening having at least one dimension not greater than 3/8 inch (9.5 mm), as shown in Figure 8.1. An opening, the smallest dimension of which is more than 3/8 inch (9.5 mm) but not more than 11/16 inch (17.5 mm), is acceptable if the live part is recessed no less than twice the difference between such opening dimension and 5/32 inch (4.0 mm).

8.4 There shall be no interference between the recessed ends of the recessed female contact and the male blade of a removable member that will stop insertion of blades of the removable member at any angle of approach permitted by the construction.

Figure 8.1

Recessing of live parts



8.5 In a fusible pullout switch which has a fuse mounting means as an integral part of the detachable pullout switch member, the member shall not be insertable in a holder for a detachable pullout switch member of the same manufacturer that has a lower current rating. Detachable pullout switch members shall not be interchangeable with members intended to accept a different class of fuse.

Exception No. 1: A Class H fuseholder may also accept a Class K or a Class R fuse.

Exception No. 2: Detachable pullout switch members may be interchangeable with members intended to accept different classes of fuses if, *a) Interchangeability is limited to fuses having the same ampere rating, voltage rating, and short circuit rating, and*

b) The pullout switches have been short-circuit tested for the maximum value of I^2t and I_p of any of the fuses to be used.

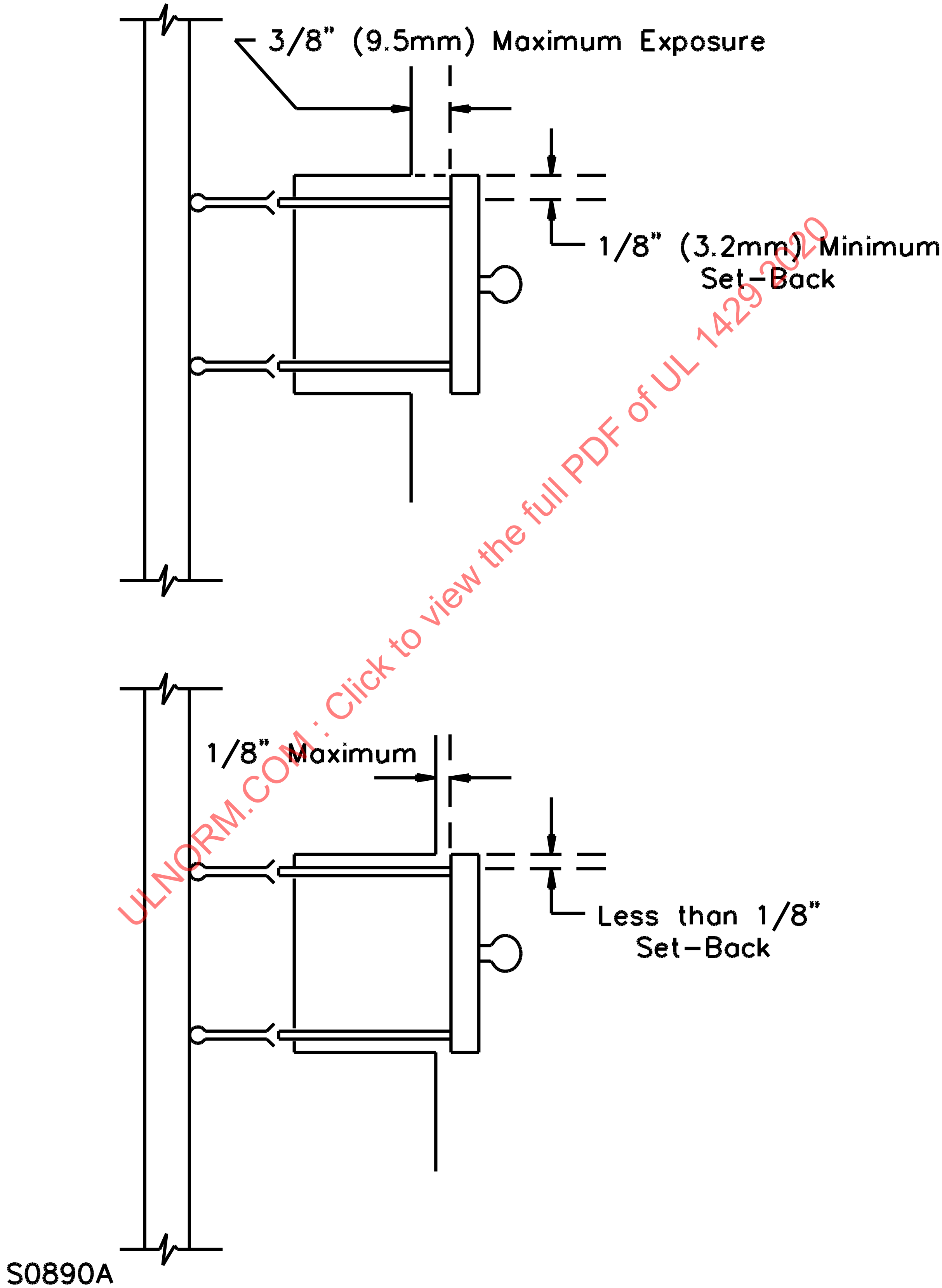
8.6 In a non-fusible pullout switch, a detachable pullout switch member shall not be insertable in a holder for a detachable pullout switch member of the same manufacturer that has a higher current rating.

8.7 With respect to Figure 8.2, the dimensions specified in 8.3 apply also to live parts on a pullout member under any conditions of contact between the blades on the pullout member and the stationary switch contacts.

Exception: The blades or other current-carrying parts may be recessed or set back less than 1/8 inch (3.2 mm) if their exposure while live is not more than 1/8 inch.

Figure 8.2

Recessing of pullout switch



8.8 A handle shall be provided for manipulation of the switch.

8.9 A pullout switch shall be of a type that indicates whether the circuit is open or closed. There shall be an "off" position with the pullout member installed in the base. When the pullout member is installed in the "off" position, it shall be retained in place by the door, when the door is closed and latched or other means shall be provided to retain the pullout member in place. Removal of fuses shall not be depended on to accomplish the "off" position. See 49.2.1.

Exception: The off position may be accomplished by removing a detachable pullout member of an enclosed pullout switch and storing it inside the enclosure. See 49.2.1.

9 Disconnecting Means

9.1 An enclosed pullout switch that has provision for the connection of a grounded service conductor and that does not interrupt the grounded conductor, shall, if marked to indicate that it is acceptable for use as service equipment, be provided with means for disconnecting the grounded service conductor from the load conductors.

9.2 The required disconnecting means may be a link, screw, or similar conducting piece intended to make connection between two terminals. It may be a terminal plate provided with wire connectors or lugs or with wire binding screws and upturned lugs for clamping a 10 AWG (5.3 mm^2) or smaller wire; it may be a single stud provided with wire connectors or lugs, or with nuts and cupped washers for clamping a 10 AWG or smaller wire; or it may be a wire connector that is intended for the connection of a single conductor and also for the connection of two conductors. See also 9.7.

9.3 Where the disconnecting means is a removable link or a switching neutral pole, the provisions for connection of the grounding electrode conductor and the main bonding jumper shall be on the line side of the disconnect link or switching neutral pole.

9.4 An enclosed pullout switch marked as being acceptable for use as service equipment and rated for alternating current shall have provision for connection of the grounding electrode conductor to the grounded service conductor. The size of the grounding electrode conductor shall be assumed to be in accordance with Table 18.1. A soldering lug or other connection means that depends upon solder shall not be used.

9.5 The provision for connection of the grounding-electrode conductor mentioned in 9.4 shall be on the neutral, if a neutral is provided.

Exception: The provision may be on the equipment-grounding terminal assembly, bus, or the like if the main bonding jumper is a bus bar or wire and is connected directly from the neutral to the equipment-grounding terminal assembly.

9.6 An enclosed pullout switch that is marked for service equipment use and rated for alternating current shall have a terminal for a grounded service conductor even though there may be no provision for a load conductor to be connected to the grounded service conductor. If there is no provision for such a load conductor, the grounded service conductor terminals shall:

a) Accommodate a conductor of the same size as the main bonding jumper specified in Table 18.1,

b) Be bonded to the enclosure, and

c) Be directly connected to the grounding electrode conductor terminal.

Exception: The terminals may be omitted if the enclosed switch is marked as covered in 49.7.7.

9.7 A single wire connector may be employed for the disconnecting means between the grounded load conductor and the grounded service conductor, as well as the connection of the grounding electrode conductor, provided the grounded load conductor can be removed without disturbing any other conductors.

10 Overcurrent Protection

10.1 Pullout switches shall be provided with a fuseholder for each ungrounded conductor.

Exception: Fuseholders are not required if the marking in accordance with 49.8.1 is provided.

10.2 Fuseholders shall not be arranged for accommodating fuses in parallel.

10.3 There shall be no fuseholder in series with any conductor that is intentionally grounded.

11 Current-Carrying Parts

11.1 General

11.1.1 A current-carrying part shall be of silver, silver alloy, copper, a copper alloy, aluminum, and aluminum alloy, or other metal acceptable for the application, and shall be adequately rigid. The ampacity of current-carrying parts such as neutrals, interconnecting bus bars, or wiring, where not otherwise specified in these requirements, shall be investigated under the requirements of the Standard for Panelboards, UL 67.

11.1.2 Except for plated No. 10 (4.8 mm diameter) and larger wire-binding screws and nuts and stud terminals, iron or steel, plain or plated, shall not be used for parts that are depended upon to carry current. Plated iron or steel screws, nuts, and stud terminals, if not depended upon to carry current, may be used with soldering lugs and pressure wire connectors.

11.1.3 Copper and brass are not acceptable for the plating of steel wire-binding screws, nuts, and stud terminals; but a plating of cadmium or zinc is acceptable.

11.1.4 An aluminum part shall be plated at joints with nickel, tin, silver or cadmium.

Exception: Plating is not required at welded or brazed joints.

11.1.5 Uninsulated live parts, other than soldering lugs or pressure wire connectors as mentioned in 14.12, shall be so secured to the mounting surface that they will be kept from turning.

11.1.6 Friction between surfaces is not acceptable as a means to prevent turning of uninsulated live parts. Turning may be prevented by the use of two screws or rivets; by shoulders or mortises; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by some other equivalent method.

11.1.7 Where parts are held together by screws, a threaded part shall not have less than two full, clean-cut threads, not finer than the American standard threads given in Table 11.1, if the screw passes entirely through the piece. If the screw does not pass entirely through the threaded part, it shall engage full, clean-cut threads for a distance of not less than the diameter of the screw.

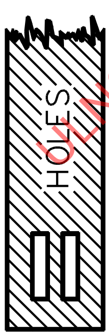
Table 11.1
Machine-screw threads

American National Standard screw size (mm diameter)	Maximum number of threads per inch (per 25.4 mm)
1/4 (6.8)	20
12 (5.5)	24
10 (4.8)	32
8 (4.2)	32
6 (3.5)	36

11.1.8 If a break jaw, or fuse contact is held in a slot or hole milled in a mounting piece, the parts shall fit together closely and shall comply with Figure 11.1.

Figure 11.1

Securing of jaws and contacts

Construction		Rating in amperes	Means of securing
		100 or less	Pinning required, soldering not acceptable
		Over 100	Pinning and soldering required
	Jaw or contact securely swaged on the under-side of the mounting piece	100 or less	Pinning soldering, or both accept-able but neither is required
		Over 100	Soldering required, additional pinning acceptable but not required
	Jaw or contact not securely swaged on the under-side	Any	Pinning and soldering required

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11.1.9 A neutral may be switched. An unswitched (solid) neutral may be mounted on the switch base or on a separate base.

11.2 Wiring terminals

11.2.1 Except as noted in 11.2.4 and 11.2.5, a pullout switch shall be provided with wiring terminals for the connection of conductors having an ampacity not less than the current rating of the device; and the terminals of a switch having a horsepower rating shall be capable of accommodating conductors having an ampacity equal to 125 percent of the motor-running current corresponding to the horsepower rating (see 16.2). A wiring terminal shall be provided with a pressure wire connector; except that a wire-binding screw may be employed at a wiring terminal intended for the connection of a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to retain the conductor under the head of the screw when the screw is loosened enough to enable shifting of the conductor.

11.2.2 A wiring terminal provided for the connection of a service conductor to an enclosed pullout switch marked for service equipment use and rated 30 A or less shall be acceptable for use with a 8 AWG (8.4 mm^2) copper conductor. The terminal shall be acceptable for use with a 6 AWG (13.3 mm^2) aluminum conductor if the enclosed switch is marked for use with aluminum wire.

11.2.3 The sizes of field installed conductors having ampacities as referenced in 11.2.1 shall be determined from Table 11.3 based on:

a) The use of aluminum wire at all terminals, except those terminals identified for use with copper wire only.

b) The use of wire rated 75°C (167°F) for all wire sizes 1/0 AWG and larger.

c) The use of wire rated 60°C (140°F) for all wire sizes 1 AWG and smaller, except that if the switch is marked only for 75°C wire at any terminals in accordance with 49.7.18, conductor size shall be based on the use of wire rated 75°C at those terminals.

11.2.4 Pressure terminal connectors for field connection (line or load) need not be provided if the following conditions are met:

a) Component terminal assemblies shall be available from the equipment manufacturer or one or more acceptable pressure terminal connectors shall be specified for field installation on the equipment,

b) Fastening devices, such as studs, nuts, bolts, spring washers and flat washers, as required for an effective installation shall either be provided as part of the component terminal assembly or be mounted on or separately packaged with the equipment.

c) The installation of the terminal assembly shall not involve the loosening or disassembly of parts other than a cover or other part giving access to the terminal location.

d) If the pressure terminal connector provided in a component terminal assembly requires the use of a special tool for securing the conductor, any necessary instructions shall be included in the component assembly packaged or with the equipment.

e) Installation of the pressure terminal connectors in the intended manner shall result in a product meeting the requirements of this standard.

f) The equipment shall be marked in accordance with 49.7.1.

11.2.5 A terminal may be omitted if the switch is specifically intended to be used with such other equipment that the terminal is unnecessary.

11.2.6 A soldering lug or other connection that depends upon solder shall not be provided for the connection of the service conductors or the service grounding conductor to an enclosed pullout switch marked as acceptable for use as service equipment.

Table 11.3
Ampacity of insulated conductors[a,b]

Wire size		60°C (140°F)		75°C (167°F)	
AWG	mm^2	Copper	Aluminum	Copper	Aluminum
14	2.1	15	–	15	–
12	3.3	20	15	20	15
10	5.3	30	25	30	25
8	8.4	40	30	50	40
6	13.3	55	40	65	50
4	21.2	70	55	85	65
3	26.7	85	65	100	75
2	33.6	95	75	115	90
1	42.4	110	85	130	100
1/0	53.5			150	120
2/0	67.4			175	135
3/0	85.0			200	155
4/0	107			230	180
MCM					
250	127			255	205
300	152			285	230
350	177			310	250
400	203			335	270
500	253			380	310
600	304			420	340
700	355			460	375
750	380			475	385
800	405			490	395
900	456			520	425

[a] For a multiple-conductor connector at a terminal, the value is to be multiplied by the number of conductors that the terminal will accommodate (1/0 AWG or larger).

[b] These values of ampacity apply only if not more than 3 conductors will be field-installed in the conduit. If 4 or more conductors, other than a neutral that carries the unbalanced current, will be installed in a conduit (as may occur because of the number of conduit hubs provided in an outdoor switch, because of the number of wires necessary in certain polyphase systems, or other reasons) the ampacity of each of those conductors is 80 percent of the value given in the table if 4 – 6 conductors are involved, and 70 percent of that value if 7 – 24 conductors.

11.2.7 A wiring terminal provided for the connection of a grounded neutral conductor or an electrode grounding conductor shall be readily accessible so that the wires can be disconnected after installation.

11.2.8 If conductors of the next larger size than that described in 11.2.3 can be inserted into the terminals of a pullout switch, the terminals shall be capable of securing such larger conductors, unless marked as provided in 49.7.21.

11.2.9 A pressure wire connector that is not intended to be removable or interchangeable shall be capable of receiving and holding properly the range of wire sizes with which the switch is intended to be used.

11.2.10 With reference to the requirement in 11.2.9, the range of wire sizes with which an ampere-rated switch may be used is considered to correspond to the range of fuse sizes accommodated by the switch. For a switch having both ampere and horsepower ratings, the range of wire sizes is considered to include those acceptable for the ampere rating and also the wire sizes acceptable for the horsepower ratings at which the switch can be used; except that a connector need not be acceptable for all the horsepower ratings less than the maximum if acceptable markings show the range of acceptable wire sizes.

11.2.11 A pressure wire connector provided with or specified for use with a pullout switch shall comply with the applicable requirements for wire connectors and soldering lugs, as outlined in the Standard for Wire Connectors and Soldering Lugs for Use With Copper Conductors, UL 486A, for Wire Connectors for Use With Aluminum Conductors, UL 486B, or the Standard for Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors, UL 486E.

11.2.12 The tightening torque for a field-wiring terminal shall be as specified by the switch manufacturer and shall be marked as required by 49.7.17. The specified tightening torque shall not be less than 90 percent of the value employed in the static heating test as specified in the Standard for Wire Connectors and Soldering Lugs For Use With Copper Conductors, UL 486A, the Standard for Wire Connectors for Use With Aluminum Conductors, UL 486B, or the Standard for Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors, UL 486E, for that wire size corresponding to the ampere rating of the switch. See 31.1.

Exception: Torque value may be less than 90 percent if the connector is investigated in accordance with UL 486A, UL 486B, or UL 486E, using the lesser assigned torque value.

11.2.13 If the screw-and-washer construction is employed at a wiring terminal, the binding screw shall not be smaller than No. 10 (4.8 mm diameter), with not more than 32 threads per inch (per 25.4 mm).

11.2.14 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick and shall have not less than two full threads in the metal; except that a special alloy plate less than 0.050 inch (1.27 mm) but not less than 0.030 inch (0.76 mm) thick may be accepted if the tapped threads have enough mechanical strength.

11.2.15 A terminal plate may be extruded at the tapped hole so as to give the thickness necessary for at least two full threads, provided that the thickness of the unextruded metal is not less than the pitch of the thread.

11.2.16 A wire-binding screw shall not thread into material other than metal.

11.2.17 The point of attachment of a soldering lug, a pressure wire connector, or a wire-binding screw terminal shall not overhang the base unless the construction is such as to provide enough mechanical strength so that there will not be any reduction of required spacings.

12 Equipment Grounding Terminals

12.1 An enclosed pullout switch shall be provided with a means for terminating line and load equipment-grounding conductors sized in accordance with Table 12.1.

Exception No. 1: An enclosed pullout switch marked in accordance with 49.7.3 or 49.7.4 need not have the equipment grounding means provided.

Exception No. 2: For an enclosed pullout switch marked in accordance with 49.5.2, a terminal for connection of the grounding electrode conductor provided in accordance with 9.4 may be considered to be the line equipment-grounding conductor means if it is acceptable for the wire size specified in Table 12.1.

Exception No. 3: For an enclosed pullout switch marked in accordance with 49.5.4, and employing the construction described in 9.6, a terminal for connection of the grounding-electrode conductor may be considered to be the line equipment-grounding conductor means, if it is acceptable for the wire size specified in Table 12.1.

Exception No. 4: For an enclosed pullout switch marked in accordance with 49.5.4 and employing pressure terminal connectors for the connection of the main bonding jumper, the terminal mounted on the enclosure for the connection of the main bonding jumper may be considered to be the line equipment grounding conductor means if it is acceptable for the wire size specified in Table 12.1.

12.2 An equipment-grounding terminal or terminal assembly and associated parts shall be of a metal or metals that are not likely to be adversely affected by electrolysis in service.

12.3 Metal employed for an equipment-grounding terminal shall be nonferrous, stainless steel, or other metal that is inherently resistant to corrosion, or it shall be protected by a coating of zinc or cadmium that complies with 12.4 or by an equivalent metallic-plated coating.

12.4 With reference to 12.3, a protective coating of zinc or cadmium on other than a mounting screw or wire-binding screw shall be such that it will withstand the metallic coating thickness test for the interval specified in Table 12.2.

12.5 A pressure wire connector employed at an equipment grounding terminal shall comply with the requirements for pressure wire connectors except that:

a) The connector may be of iron or steel,

b) The connector need only comply with the secureness and pullout requirements.

12.6 When installed as intended, an equipment-grounding terminal or terminal assembly shall:

a) Provide a reliable bond to the enclosure, and

b) Be such that the resistance of the connection between an installed equipment-grounding conductor and the enclosure is not more than 0.005 ohm.

Table 12.1
Minimum equipment-grounding conductor

Rating, amperes	Size, AWG or MCM (mm^2)	
	Copper	Aluminum or copper-clad aluminum
15	14 (2.1)	12 (3.3)
20	12 (3.3)	10 (5.3)
30	10 (5.3)	8 (8.4)
40	10 (5.3)	8 (8.4)
60	10 (5.3)	8 (8.4)
100	8 (8.4)	6 (13.3)
200	6 (13.3)	4 (21.1)
300	4 (21.1)	2 (33.6)
400	3 (26.7)	1 (42.4)

Table 12.2
Metallic coating thickness test

Temperature		Time, seconds	
°F	°C	Zinc	Cadmium
65	18.3	106	78
70	21.1	102	76
75	23.9	98	72
80	26.7	94	70
85	29.4	90	68
90	32.2	86	64
95	35.0	84	62

12.7 To determine if a connection complies with the requirement in item b) of 12.6, a current of 30 A is to be passed through the bonding connection. The resulting voltage drop is to be measured between a point – file mark – on the conductor 1/16 inch (1.6 mm) from the connection and a similar point on the frame or enclosure not less than 1/16 inch (1.6 mm) from the bonding connection.

12.8 The equipment-grounding terminal or assembly shall be:

a) Green or the heads of the terminal screws thereof shall be green, or

b) Identified by the marking described in 49.7.5 adjacent to the terminal or on a wiring diagram.

12.9 If parts are held together by screws, including connection of the equipment-grounding terminal or terminal assembly to the enclosure, the threaded part shall not have fewer than two full threads.

13 Field Conversion

13.1 A pullout switch constructed for Class H fuse and field conversion to accept Class J or R fuses shall be marked in accordance with 49.3.5 – 49.3.10 and shall comply with 13.2 – 13.10.

13.2 If a pullout switch, as indicated in 13.1, leaves the factory with complete fuseholders, they shall be positioned and arranged to accept Class H fuses. The switch may be supplied without the load fuse clips or without the complete load fuse base as an alternate to complete fuseholders.

Exception: A switch intended to accept a Class J fuse by repositioning base as indicated in 13.4 may have fuseholder positioned to accept a Class J fuse when the known use is for Class J fuses.

13.3 FIELD ADDITION OF LOAD FUSE BASE OR FUSE CLIPS – A switch shipped from the factory without either the load fuse base or the load fuse clips shall be provided with explicit instructions for ordering the necessary components to complete the switch to accept either Class H, J or R fuses.

13.4 REPOSITIONING LOAD FUSE BASE FOR CLASS J FUSES – If the load side fuseholder assembly (common or individual pole construction) or the individual fuse clips are intended to be repositioned to accept Class J fuses, such repositioning shall be by the use of common tools by front access to the switch, and by using existing mounting holes that are factory provided. See 49.3.6.

13.5 CONVERSION OF LOAD BASE FOR CLASS R FUSES– If the load side fuseholder assembly (common or individual pole construction) or the individual fuse clips are intended to be replaced to permit acceptance of Class R fuses only, such replacement shall be by the use of common tools by front access to the switch. See 49.3.7.

13.6 FUSE CLIP REPLACEMENT OR ADDITION – If only the fuse clips are to be replaced or added, the fuse clip assembly only shall be capable of being replaced or added in such a manner that proper alignment of the clips shall be maintained and other parts such as the terminal assembly shall not be disturbed.

13.7 It shall not be necessary to spread a fuse clip apart or adversely affect the clip in any manner in order to install the fuse clip in place.

13.8 FIELD ADDITION OF REJECTION MEANS FOR CLASS R FUSES – A rejection means for Class R fuses intended to be installed in a load fuse base containing a Class H fuseholder may be added in the field provided:

a) The fuseholder assembly is constructed to receive the rejection means without further modification.

b) The fuse rejection means shall be capable of being installed with common tools or without any tools by front access of the switch.

c) Once installed, the fuse rejection means cannot be removed using common tools without damaging the assembly, rendering it unusable.

d) The fuse rejection means shall have the mechanical strength to comply with the Standard for Class R Fuseholders, UL 512.

13.9 CONVERSION PACKAGE – The package containing the fuseholder bases or clip assemblies shall include all necessary hardware such as screws, lock washers, and the like to secure the fuseholder in place.

13.10 SPACINGS – Spacings as required by Spacings, Section 14, and fuse alignment shall be provided regardless of the class of fuse installed and it shall not be necessary to add barriers or other parts necessary to supplement spacings, but the moving of barriers that are part of the load side fuseholder assembly is acceptable.

14 Spacings

14.1 Except as noted in 14.3, the spacings in a pullout switch shall be as indicated in Table 14.1. Grounded dead metal includes the enclosure and any dead metal that may be in electrical connection with the enclosure.

Table 14.1
Spacings

Voltage between parts involved	Minimum spacings in inches (mm)							
	Between uninsulated live parts of opposite polarity				Between uninsulated live parts and any grounded dead metal			
	Over surface		Through air		Over surface		Through air	
0–125	3/4	(19.1)	1/2	(12.7)	1/2	(12.7)	1/2	(12.7)
126–250	1-1/4	(31.8)	3/4	(19.1)	1/2	(12.7)	1/2	(12.7)
251–600	2	(50.8)	1	(25.4)	1	(25.4)	1/2	(12.7)

14.2 A 4-wire switch having three blades and a solid neutral and rated at 240 V is intended for use on a 3-phase, 4-wire, 120-208 V circuit and, as such, may have 125 V spacings between uninsulated parts connected to the neutral and those connected to any of the other three lines.

14.3 There shall be a spacing of not less than one inch (25.4 mm) between any uninsulated live part and a metal door.

Exception: The spacing may be not less than 1/2 inch (12.7 mm) where the potential is 250 V or less for any of the following conditions:

a) The door is of steel not less than 0.093 inch (2.36 mm) thick if uncoated or 0.097 inch (2.46 mm) thick if galvanized, or

b) The door has the strength and rigidity equivalent to that of a flat door of the same overall length, width and material as specified in (a), or

c) The door is lined with insulating material such as fiber or phenolic composition not less than 1/32 inch (0.8 mm) thick, or

d) Equivalent provision is made to prevent a metal door from being deflected to contact a live part.

14.4 Spacings at the wiring terminals of a 30 A switch are to be measured with the device wired in accordance with Table 14.2. The spacings at wiring terminals employing pressure wire connectors are to be measured with the device wired with conductors having an ampacity not less than the current rating of the switch (see also 16.2). In measuring an over-surface spacing, a metal part such as a screw head or washer interposed between uninsulated live parts of opposite polarity or between uninsulated live parts and grounded metal is considered as reducing the spacing by an amount equal to the dimension of the metal part in the direction of the measurement.

Table 14.2
AWG size of wire to be used in spacings evaluation of 30 A switches (mm^2)

Terminal acceptable for use with	For use as service equipment	Not for use as service equipment
Cooper only	8 (8.4)	10 (5.3)
Cooper/Aluminum	6 (13.3)	8 (8.4)

14.5 Through air and over surface spacings shall also be provided from live parts of a pullout switch to an ungrounded isolated metal handle that is part of the switch.

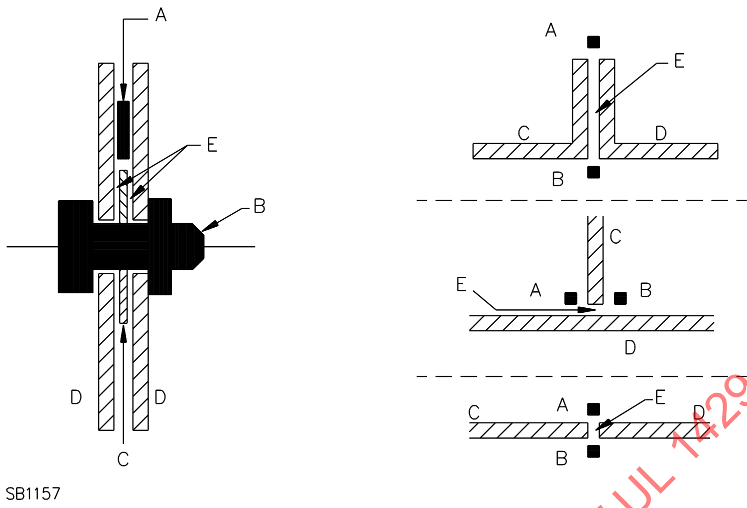
14.6 In measuring over surface spacings, any slots, grooves, and the like, 0.013 inches (0.33 mm) wide or less in the contour of insulating material are to be disregarded.

14.7 Spacings in pullout switches are to be measured with the removable member in both the full "on" and "off" positions.

14.8 Spacings are to be measured through cracks unless a clamped joint has passed the test covered in Clamped Joint Test, Section 32, or unless the joint is sealed with adhesive or cement. A clamped joint is a joint between two pieces of insulation that are under pressure. See Figure 14.1. Adhesive cements, and the like, if used to effect a seal in lieu of a tightly mated joint, shall be acceptable for the purpose, considering such properties as dielectric strength, bond strength, dimensional stability and moisture exposure.

Figure 14.1

Clamped joint



Parts A, B – Live parts of opposite polarity, or a live part and grounded metal part with spacing through the crack between C and D less than required in Table 14.1.

Parts C, D – Insulating barriers clamped tightly together so that the dielectric strength between A and B is greater than the equivalent air spacing.

Part E – The clamped joint.

14.9 The spacing through air or over surface shall be not less than 1/8 inch (3.2 mm) between uninsulated live parts of the same polarity:

a) On the load side of their respective switches for parts in different circuits, and

b) Between the line and load sides of the fuseholder or switch.

14.10 Terminals and other parts intended to be connected to the grounded conductor of a circuit are considered to be uninsulated live parts unless for a switch intended only for alternating current and marked as covered in 49.5.2, such parts are mounted directly on or in permanent electrical connection with the enclosure. A bonding means that may be removed is considered as providing a permanent electrical connection to the enclosure only when marked in accordance with 49.5.1. See also 18.1.

14.11 In measuring between an uninsulated live part and a conduit bushing installed at a knockout, it is to be assumed that a conduit bushing having the dimensions indicated in Table 14.3 is in place but without a lockwasher inside the enclosure.

14.12 Soldering lugs or pressure wire connectors shall be kept from turning to the extent that spacings would be reduced to less than those required in 14.1, and Table 14.1; except that if such minimum or greater spacings are maintained when lugs are turned 30 degrees toward each other or toward other uninsulated live or ground parts, no means to prevent turning need be provided.

Table 14.3
Conduit bushings

Trade size of conduit inches	Overall diameter		Height	
	inches	(mm)	inches	(mm)
1/2	1	(25.4)	3/8	(9.5)
3/4	1-15/64	(31.4)	27/64	(10.7)
1	1-19/32	(40.5)	33/64	(13.1)
1-1/4	1-15/16	(49.2)	9/16	(14.3)
1-1/2	2-13/64	(56.0)	19/32	(15.1)
2	2-45/64	(68.7)	5/8	(15.9)
2-1/2	3-7/32	(81.8)	3/4	(19.1)
3	3-7/8	(98.4)	13/16	(20.6)
3-1/2	4-7/16	(112.7)	15/16	(23.8)

15 Insulating Barriers

15.1 In 15.2 – 15.10 the liner or barrier referred to is the insulating material that separates uninsulated live parts of opposite polarity, or separates uninsulated live parts and a grounded dead-metal part (including the enclosure), where the spacing between the parts would otherwise be less than the required value.

15.2 A barrier or liner that comprises the sole separation:

a) Shall be of material acceptable for supporting an uninsulated live part and

b) Shall be not less than 0.028 inch (0.71 mm) thick.

15.3 A barrier or liner that is not acceptable for the support of uninsulated live parts shall be used only in conjunction with an air space determined to be acceptable for the application.

15.4 A barrier between the enclosure and an uninsulated part electrically connected to a grounded circuit conductor (neutral) may be of fiber, not less than 0.028 inch (0.71 mm) thick.

15.5 Fiber used as an insulating barrier shall be varnished or otherwise treated to reduce the absorption of moisture.

15.6 A barrier or liner that is acceptable for the support of uninsulated live parts may be used in conjunction with not less than one-half the required through-air spacing of Table 14.1 if it is:

a) Not less than 0.013 inch (0.33 mm) thick,

b) Of adequate strength if exposed or otherwise likely to be subjected to physical injury,

c) Effectively held in place, and

d) So located that it will not be adversely affected by operation of the equipment in service.

15.7 Insulating material having a thickness less than that indicated in 15.2 and 15.6 may be accepted if it is found to be acceptable for the particular application.

15.8 With respect to 15.7, a barrier less than 0.028 inch (0.71 mm) thick that is used in accordance with 15.2 shall withstand the application of a 5000 V, 60 Hz potential without breakdown. A barrier less than 0.013 inch (0.33 mm) thick that is used in accordance with 15.6 shall withstand the application of a 2500 V, 60 Hz potential without breakdown. The barrier is to be placed between two flat metal electrodes and the test potential increased to the test value. The maximum potential is not to be maintained for more than one second. The mechanical strength and flammability shall be acceptable for the particular application.

15.9 A wrap of thermoplastic tape, acceptable for use as sole insulation may be employed if:

a) At a point where the spacing prior to the application of the tape is not less than half the required through-air spacing shown in Table 14.1, the wrap is to be not less than 0.013 inch (0.33 mm) thick and is to be applied in two or more layers,

b) At a point where the spacing prior to the application of the tape is less than half the required through-air spacing shown in Table 14.1, the wrap is no less than 0.028 inch (0.71 mm) thick,

c) The tape is not subject to compression,

d) The tape is not wrapped over a sharp edge, and

e) The tape is not subjected to temperatures in excess of 80°C (176°F).

15.10 If spacings would otherwise be less than the required values, thermoplastic tubing acceptable for use as insulation may be employed if:

a) It is not subjected to temperatures higher than that for which the tubing is rated,

b) It is not subjected to compression, repeated flexure, or creasing at a point where the tubing is required to satisfy spacing requirements,

c) All edges of the conductor covered with the tubing are well rounded and free from sharp edges,

d) For chemically dilated tubing, a solvent recommended by the tubing manufacturer is used, and

e) It is rated 600 V.

16 Wiring Space

16.1 The space within the enclosure of an enclosed pullout switch shall be enough to provide ample room for the distribution of wires and cables.

16.2 The adequacy of wiring spaces shall be determined using the size and conductor material of a wire used at a terminal in accordance with 11.2.1, except for ampacities of 100 A or less the size shall be based on 60° C insulated conductors if the markings specifies both 60° C and 75° C wire. If a terminal is acceptable for use with a single conductor, or for use with two or more combinations of conductors in multiple, each of which would be appropriate for that terminal in accordance with 11.2.3 the combination necessitating the largest wiring space shall be used, unless the switch is marked in accordance with 49.7.19. If a terminal is provided for conductors in multiple, the size of each of the conductors shall be based on the use of multiple conduits.

16.3 The clear wiring space at any point, independent of all projections and obstructions, shall not be less in width nor in depth than the values given in Table 16.1.

16.4 The clear wiring space, independent of all projections, obstructions and interference from moving parts of the switching mechanism shall be adequate for the wiring of the device, and shall not be less in total area than 250 percent of the total cross-sectional area of the maximum number of the wires that may be used in such space.

16.5 With reference to 16.4, minimum areas for some of the more common multiple-wire conditions are given in Table 16.1.

16.6 With reference to the requirement of 16.4, if the terminals are marked line and load the number of wires for which wiring space is to be provided is twice the number of switching poles – the maximum number of wires involved when the wires enter the enclosure at the end opposite to the end in which the terminals are located to which they will be connected. If a solid neutral terminal is supplied, only one neutral wire is considered as being run in the side or back wiring space. In any case, the provision of barriers riveted or welded in position so as to keep from the running of wires from end to end is acceptable in place of the wiring space otherwise required.

16.7 In determining if a wiring space complies with the requirements in 16.4 – 16.6, consideration is to be given to the actual size of wires that will be used in the space, but it is to be assumed that wires smaller than those indicated in Table 14.2 will not be used. In computing the actual area of a wiring space, consideration is to be given to all the available space that may be used for the placement of wires and no consideration is to be given to space in which the presence of wires would render neutral terminals inaccessible. See also 11.2.7.

16.8 If a wire is restricted by barriers or other means from being bent in a 90 degree or S bend from the terminal to any usable location in the wall of the enclosure, the distance is to be measured from the end of the barrier or other obstruction.

Table 16.1
Enclosed switch wiring space

Maximum size of wire or cable involved	Minimum width and depth of wiring space		Minimum areas in square inches (mm^2) required for multiple wires based on factor of 2.5													
			Two wires		Three wires		Four wires		Five wires		Six wires		Seven wires	
	inch	(mm)	$inch^2$	(mm^2)	$inch^2$	(mm^2)	$inch^2$	(mm^2)	$inch^2$	(mm^2)	$inch^2$	(mm^2)	$inch^2$	(mm^2)
10 AWG	3/8[a]	9.5	0.23	148	0.34	219	0.46	297	0.57	368	0.68	439	0.80	516
8	1/2	12.7	0.43	277	0.64	413	0.85	548	1.07	690	1.28	826	1.50	968
6	5/8	15.9	0.62	400	0.93	600	1.24	800	1.55	1000	1.86	1200	2.17	1400
4	3/4	19.1	0.80	516	1.20	774	1.60	1032	2.00	1290	2.40	1548	2.80	1806
3	3/4	19.1	0.91	587	1.36	877	1.82	1174	2.27	1465	2.72	1755	3.18	2052
2	7/8	22.2	1.03	665	1.55	1000	2.06	1329	2.58	1665	3.10	2000	3.61	2329
1	1	25.4	1.36	877	2.04	1316	2.72	1755	3.40	2194	4.08	2632	4.76	3071
1/0	1	25.4	1.55	1000	2.33	1503	3.10	2000	3.88	2503	4.66	3006	5.43	3503
2/0	1	25.4	1.79	1155	2.68	1729	3.58	2310	4.47	2884	5.36	3458	6.26	4039
3/0	1-1/8	28.6	2.08	1342	3.11	2006	4.16	2684	5.19	3348	6.22	4013	7.27	4690
4/0	1-1/4	31.8	2.42	1561	3.63	2342	4.84	3123	6.05	3903	7.26	4684	8.47	5465
250 MCM	1-3/8	34.9	2.96	1910	4.44	2865	5.92	3819	7.40	4774	8.88	5729	10.36	6684
300	1-1/2	38.1	3.42	2206	5.13	3310	6.84	4413	8.55	5516	10.26	6619	11.96	7716
350	1-1/2	38.1	3.81	2458	5.72	3690	7.62	4916	9.53	6148	11.44	7381	13.34	8606
400	1-5/8	41.3	4.18	2697	6.27	4045	8.36	5394	10.45	6742	12.54	8090	14.63	9439
500	1-3/4	44.5	4.92	3174	7.38	4761	9.84	6348	12.30	7935	14.76	9523	17.22	11,110
600	1-7/8	47.6	5.97	3852	8.96	5781	11.94	7703	14.93	9632	17.92	11,561	20.90	13,484
700	2	50.8	6.68	4310	10.02	6465	13.36	8619	16.70	10,774	20.04	12,929	23.38	15,083
750	2	50.8	7.04	4542	10.56	6813	14.08	9084	17.60	11,355	21.12	13,626	24.64	15,896
800	2-1/8	54.0	7.39	4768	11.09	7155	14.78	9535	18.48	11,923	22.18	14,310	25.78	16,690
900	2-1/4	57.2	8.09	5219	12.13	7826	16.18	10,439	20.22	13,045	24.26	15,652	28.31	18,264

[a] The minimum clear width and depth of a wiring space in an enclosed switch marked as acceptable for use as service equipment is to be not less than 1/2 inch (12.7 mm) in any case.

16.9 A switch intended to be installed so that line and load conductors pass into the enclosure at the same end, shall have ample space for both the line and load conductors to pass from their terminals to the point of entrance.

17 Wire Bending Space

17.1 The adequacy of wiring spaces shall be determined using the size and conductor material of a wire used at a terminal in accordance with 11.2.1, except for ampacities of 100 A or less the size shall be based on 60° C insulated conductors if the markings specifies both 60° C and 75° C wire. If a terminal is acceptable for use with a single conductor, or for use with two or more combinations of conductors in multiple, each of which would be appropriate for that terminal in accordance with 11.2.3 the combination necessitating the largest wiring space shall be used, unless the switch is marked in accordance with 49.7.19. If a terminal is provided for conductors in multiple, the size of each of the conductors shall be based on the use of multiple conduits.

Table 17.1
Minimum wire-bending space at terminals in inches (mm)

Wire size		Wires per terminal (pole)[a]							
AWG or MCM	(mm^2)	1		2		3		4 or more	
14–10	(2.1–5.3)	Not specified		–		–		–	
8	(8.4)	1-1/2		–		–		–	
6	(13.3)	2		–		–		–	
4	(21.2)	3		–		–		–	
3	(26.7)	3		–		–		–	
2	(33.6)	3-1/2		–		–		–	
1	(42.4)	4-1/2		–		–		–	
1/0	(53.5)	5-1/2		5-1/2		7		–	
2/0	(67.4)	6		6		7-1/2		–	
3/0	(85.0)	6-1/2	(1/2)	6-1/2	(1/2)	8		–	
4/0	(107)	7	(1)	7-1/2	(1-1/2)	8-1/2	(1/2)	–	
250	(127)	8-1/2	(2)	8-1/2	(2)	9	(1)	10	
300	(152)	10	(3)	10	(2)	11	(1)	12	
350	(177)	12	(3)	12	(3)	13	(3)	14	(2)
400	(203)	13	(3)	13	(3)	14	(3)	15	(3)
500	(253)	14	(3)	14	(3)	15	(3)	16	(3)
600	(304)	15	(3)	16	(3)	18	(3)	19	(3)
700	(355)	16	(3)	18	(3)	20	(3)	22	(3)
750	(380)	17	(3)	19	(3)	22	(3)	24	(3)
800	(405)	18		20		22		24	
900	(456)	19		22		24		24	

Table 17.1 Continued on Next Page

Table 17.1 Continued

Wire size AWG or MCM	(mm²)	Wires per terminal (pole)[a]			
		1	2	3	4 or more

[a] Wire bending space shall be permitted to be reduced by the number of inches shown in parentheses under the following conditions:

1. Only removable wire connectors receiving one wire each are used, (there may be more than one removable wire connector per terminal).

2. The removable wire connectors can be removed from their intended location without disturbing structural or electrical parts other than a cover, and can be reinstalled with the conductor in place.

For SI units one inch = 25.4 mm

Table 17.2
Minimum width of gutter and wire-bending space in inches (mm)[a]

Size of wire AWG or MCM	(mm^2)	Wires per terminal (pole) 1		2		3		4		5	
14–10	(2.1–5.3)	Not specified		–	–	–	–	–	–	–	
8–6	(8.4–13.3)	1-1/2	(38.1)	–	–	–	–	–	–	–	
4–3	(21.1–26.7)	2	(50.8)	–	–	–	–	–	–	–	
2	(33.6)	2-1/2	(59.3)	–	–	–	–	–	–	–	
1	(42.4)	3	(76.2)	–	–	–	–	–	–	–	
1/0–2/0	(53.5–67.4)	3-1/2	(88.9)	5	(127)	7	(178)	–	–	–	
3/0–4/0	(85.0–107)	4	(102)	6	(152)	8	(203)	–	–	–	
250	(127)	4-1/2	(114)	6	(152)	8	(203)	10	(254)	–	
300–350	(152–177)	5	(127)	8	(203)	10	(254)	12	(305)	–	
400-500	(203-253)	6	(152)	8	(203)	10	(254)	12	(305)	14	(356)
600-700	(304-355)	8	(203)	10	(254)	12	(305)	14	(356)	16	(406)
750-900	(380-456)	8	(203)	12	(305)	14	(356)	16	(406)	18	(457)

[a] The table includes only those multiple-conductor combinations that are likely to be used. Combinations not mentioned may be given further consideration.

17.2 If knockouts are provided in a wiring space, the width of such a space shall be enough to accommodate (with respect to bending) the maximum size of wire for the particular application; except that wiring spaces of less width may be provided if knockouts of an acceptable size are located elsewhere and if they can be used conveniently to wire the device in the intended manner. For wire sizes 8 AWG (8.4 mm^2) or larger, refer to Table 17.1 and Table 17.2.

17.3 For an enclosed pullout switch the wire-bending space at the line and load terminals shall be as specified in Table 17.1 for the conductor size that corresponds with the maximum ampere (full-load amperes) rating of the enclosed pullout switch. See 17.1.

Exception: Where the neutral line or load, or both, terminal is not directed toward the enclosure wall opposite the corresponding phase line or load terminals, refer to Table 17.2 for the required wire bending space.

17.4 The distance mentioned in 16.8 and 17.3 is to be measured in a straight line from the edge of the wire terminal closest to the wall in a direction perpendicular to the box wall or barrier. The wire terminals shall be turned so that the axis of the wire opening in the connector is as close to perpendicular to the wall of the enclosure as it can assume without defeating any reliable means provided to prevent its turning, such as a boss, shoulder, walls of a recess, multiple bolts securing the connector, or the like. A barrier, shoulder, or the like is to be disregarded when the measurement is being made if it does not reduce the radius to which the wire must be bent. If a terminal is provided with one or more connectors for the connection of conductors in multiple, the distance is to be measured from the wire opening closest to the wall of the enclosure.

Exception: Wire bending space specified in Table 17.2 is measured in a straight line from the center of the wire opening in the direction the wire leaves the terminal. See the exception to 17.3.

18 Provision for Bonding for Enclosed Pullout Switches

18.1 When an insulated neutral is provided, a main bonding jumper consisting of a separate screw, strap, or other means shall be provided to bond the enclosure of an enclosed pullout switch that is intended for use as service equipment to the insulated grounded circuit conductor (the insulated neutral) of an a-c circuit. The bonding means shall be of copper or aluminum and shall have a cross-sectional area as indicated in Table 18.1. The means used to provide the removable bonding means described in 14.10 shall also comply with the foregoing requirements. If an insulated neutral is provided, the construction is to be such that when the bonding means is not used, the spacings given in Table 14.1will be obtained. Unless the intended use and method of installation of the bonding means are obvious, such means is to be accompanied by instructions for installing.

Exception: The metal for the bonding means may consist of steel or brass screws as noted in footnotes a and b of Table 18.1.

18.2 Where bonding between enclosed pullout switch and any fitting, raceway or other cooperating enclosure is effected by means of flanges secured by screws, and with or without gaskets, the resistance of the joint shall not exceed 0.005 ohms. See Bonding Continuity Test, Section 32.

18.3 Where bonding across a joint is provided by a separate member such as a strap, jumper or conductor (other than clamping screws) such bonding shall comply in size or cross-section with the requirements of Table 18.1.

Table 18.1
Minimum size of grounding electrode conductors and main bonding jumper

Ampere rating not exceeding	Size of bonding jumper (minimum)		Cross section of main bonding jumper in square inches (mm^2) (minimum)				Size of grounding electrode conductor (minimum)	
	Copper AWG (mm^2)	Aluminum AWG (mm^2)	Copper		Aluminum		Copper AWG (mm^2)	Aluminum AWG (mm^2)
60	8 (8.4)	6 (13.3)	0.013[a]	(8.4)[a]	0.021[a]	(13.5)[a]	8 (8.4)	6 (13.3)
100	6 (13.3)	4 (21.2)	0.021[a]	(13.5)[a]	0.033[a]	(21.3)[a]	6 (13.3)	4 (21.2)

Table 18.1 Continued on Next Page

Table 18.1 Continued

Ampere rating not exceeding	Size of bonding jumper (minimum)		Cross section of main bonding jumper in square inches (mm^2) (minimum)				Size of grounding electrode conductor (minimum)	
	Copper AWG (mm^2)	Aluminum AWG (mm^2)	Copper		Aluminum		Copper AWG (mm^2)	Aluminum AWG (mm^2)
200	4 (21.2)	2 (33.6)	0.033[b]	(21.3)[b]	0.053[b]	(33.5)[b]	4 (21.2)	2 (33.6)
400	1/0 (53.5)[c]	3/0 (85.0)[c]	0.083[c,d]	(53.5)[c,d]	0.132[c,d]	(85.2)[c,d]	1/0 (53.5)[c]	3/0 (85.0)[c]

[a] A No. 8 (4.2 mm diameter) or larger brass or No. 10 (4.8 mm diameter) or larger steel screw may be used.

[b] A No. 10 (4.8 mm diameter) or larger brass or steel screw may be used.

[c] When the ampere rating is 400 and the wire terminal connectors for the main service conductors are acceptable for two 3/0 AWG copper or two 250 MCM aluminum conductors but will not accept a 600 MCM conductor, these values may be reduced to 2 AWG (0.052 in^2) (33.5 mm^2) copper or 1/0 AWG (0.083 in^2) (53.5 mm^2) aluminum.

[d] A 1/4 inch (6.4 mm) diameter or larger brass or steel screw may be used.

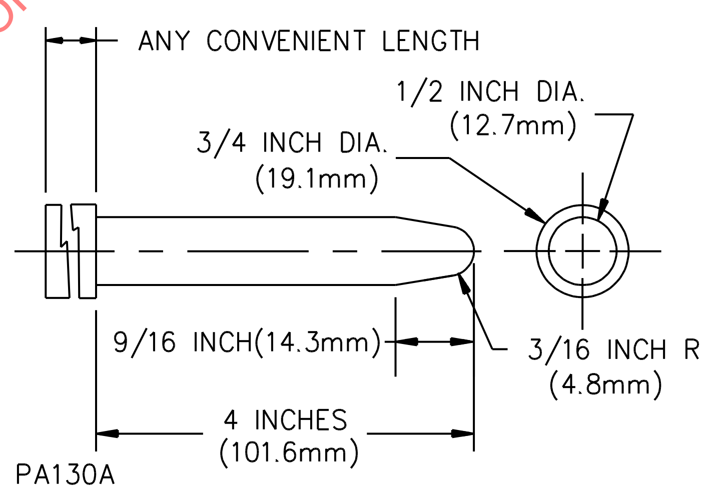
18A Accessibility of Live Parts in Service Equipment

18A.1 Pullout switches marked for service equipment use shall be constructed such that, with the switch in the OFF position, no ungrounded uninsulated live part is exposed to inadvertent contact by persons while servicing any field connected load terminal, including a neutral load terminal, an equipment grounding terminal, or the neutral disconnect link. Exposure to inadvertent contact is determined by use of the probe illustrated in Figure 18A.1. If restriction to the line-side of the service disconnect is dependent on the installation of field installed service conductors, conductors sized in accordance with Table 11.3 shall be installed in the terminals when determining exposure to inadvertent contact. All live parts of the line side service terminal, including the connector body and pressure screw shall be evaluated. For pullout switches suitable for more than one type of fuse or terminal, the evaluation shall be conducted with all types of fuses and terminals.

NOTE: In accordance with the Standard for Electrical Safety in the Workplace, NFPA 70E, an electrically safe work condition should be established prior to working on electrical equipment. Accessibility requirements do not endorse working on energized electrical equipment.

Figure 18A.1

Straight Probe



18A.2 Metal barriers provided to limit exposure to inadvertent contact shall:

a) Have a thickness not less than 0.032 inch (0.81 mm) if uncoated, not less than 0.034 inch (0.86 mm) if galvanized, and not less than 0.050 inch (1.27 mm) if aluminum.

b) Be constructed so that it can be readily removed or repositioned, and then reinstalled, without the likelihood of contacting bare live parts or damage the insulation of any insulated live part.

Exception: Factory installed barriers that limit access to factory installed wiring and terminations are not required to be constructed so that they can be removed or repositioned.

18A.3 Nonmetallic barriers provided to limit exposure to inadvertent contact shall:

a) Comply with requirements in 15.6 for barriers used in conjunction with a minimum air space of 0.013 inch (0.33 mm).

b) Be constructed so that it can be readily removed or repositioned, and then reinstalled, to allow access to the terminal for servicing.

Exception: Factory installed barriers that limit access to factory installed wiring and terminations are not required to be constructed so that they can be removed or repositioned.

18A.4 Pullout switches marked “Suitable for use as service equipment” shall be permitted to provide the protection from inadvertent contact in 18A.1 in a field installable kit when marked in accordance with 49.5.7.

PERFORMANCE

19 General

19.1 Samples of each design and rating to be tested shall be subjected to the tests as shown in Table 19.1 or Table 19.2. The letter in the "Test Sequence" columns indicate the test sequences that are to be performed on an individual sample. All tests identified with the same letter shall be performed on a single previously untested sample, except that a sample that was subjected to previous tests may be reconditioned and used if agreeable to those concerned.

Table 19.1
Fused pullout switches

Test	Test sequence	Class H or K fuse	Class J, R, G, T, or CC fuses
Heating	A	Sec. 20	Sec. 20
Heating With Fuses	B	Sec. 21	Sec. 21
Overload Cycling Heating	C	Sec. 22	Sec. 22
Overload	D	Sec. 23	Sec. 23
Endurance	D	Sec. 24	Sec. 24
Dielectric Voltage-Withstand	D	Sec. 25	Sec. 25
Close-Open	E	–	Sec. 35
Dielectric Voltage-Withstand	E	–	Sec. 36
Short-Circuit Withstand	E	–	Sec. 37

Table 19.1 Continued on Next Page

Table 19.1 Continued

Test	Test sequence	Class H or K fuse	Class J, R, G, T, or CC fuses
Low-Level Dielectric Voltage-Withstand	E	–	Sec. 38[a]
Closing	F	–	Sec. 39
Low-Level Dielectric Voltage-Withstand	F	–	Sec. 40
Strength of Insulating Base and Support	G	Sec. 31	Sec. 31
Bonding Continuity	H	Sec. 32	Sec. 32
Clamped Joint	I	Sec. 32	Sec. 33

[a] If the same sample is used for the Short-Circuit Withstand and Closing Tests, the Low-Level Dielectric Voltage-Withstand Test is not to be conducted following the Short-Circuit Withstand Test.

Table 19.2
Unfused pullout switches

Test	Test sequence	Withstand rating 10kA or lower	Withstand rating more than 10kA
Heating	A	Sec. 20	Sec. 20
Overload	D	Sec. 23	Sec. 23
Endurance	D	Sec. 24	Sec. 24
Dielectric Voltage-Withstand	D	Sec. 25	Sec. 25
Close-Open	E	–	Sec. 35
Dielectric Voltage-Withstand	E	–	Sec. 36
Short-Circuit Withstand	E	Sec. 26[a]	Sec. 37
Low-Level Dielectric Voltage-Withstand	E	Sec. 27[a]	Sec. 38[b]
Closing	F	Sec. 28[a]	Sec. 39
Low-Level Dielectric Voltage-Withstand	F	Sec. 29[a]	Sec. 40
Strength of Insulating Base and Support	G	Sec. 31	Sec. 31
Bonding Continuity	H	Sec. 32	Sec. 32
Clamped Joint	I	Sec. 33	Sec. 33

[a] Tests only applicable to switches where the maximum rating of the specified overcurrent protective device exceeds the current rating of the switch.

[b] If the same sample is used for the Short-Circuit Withstand and Closing Tests, the Low-Level Dielectric Voltage-Withstand Test is not to be conducted following the Short-Circuit Withstand Test.

19.2 If an enclosed pullout switch contains one or more meter sockets, appropriate simulated meters, as specified in the Standard for Meter Sockets, UL 414 shall be installed during the tests.

19.3 If an unfused pullout switch intended to be used on the load side of fuse(s) or molded case circuit breaker in accordance with 48.1 and 49.3.2, is constructed the same as a fused pullout switch and has the same or lower rating, tests on the fused pullout switch shall represent the unfused construction provided the unfused pullout switch meets all three of the following:

a) The conductor that replaces the fuse and fuseholder shall be made of the same material as the switch blade,

b) The cross section of the conductor that replaces the fuse and fuseholder shall not be less than the switch blade or the combined cross section of the fuseholder and test fuse ferrule or blade used during the Temperature Test on the fused switch, and

c) The fuse used in the test is of the same class or electrical rating, or both, as the overcurrent protection device intended to protect the unfused switch.

Exception: An unfused switch having a short circuit withstand rating greater than 10,000 A that is intended to be protected by a circuit breaker may not be represented by a fused switch for the short circuit withstand test.

19.4 A pullout switch shall be tested in an enclosure representing the most severe condition of intended use in regard to:

a) Enclosure size,

b) Spacings between live parts and grounded metal, and

c) Mounting position.

19.5 Unless a device is intended for use on a single-phase circuit only, all tests with the exception of the heating test and dielectric voltage-withstand tests shall be made on a 3-phase circuit. The heating test may be made on either a 3-phase or a single-phase circuit (all poles in series) if acceptable to those concerned.

19.6 The heating test may be conducted at any convenient voltage.

19.7 If a machine is used as the means of test operation, the closure speed and opening speed shall not exceed 30-inch-per-second. The construction of the operator is to be such as to provide positive insertion and withdrawals of pullout type switches.

19.8 Except as noted in 24.1, all current-interrupting tests shall be made on test circuits so adjusted that the closed-circuit voltage is not less than the rated voltage of the switch and the open-circuit voltage is not more than 110 percent of that voltage; except that for a switch rated at more than 25 hp or more than 100 A, the closed-circuit voltage may be as much as 10 percent less than the rated voltage of the switch if the open-circuit voltage is not less than the rated voltage nor more than 110 percent of that voltage. The open-circuit voltage may be more than 110 percent of the rated voltage if agreeable to those concerned.

19.9 To determine if a pullout switch complies with the requirements for short-circuit withstand, low level dielectric voltage-withstand and closing, as given in Sections 26– 29, a representative sample of each rating shall be subjected to the tests. A switch marked with two or more short-circuit withstand ratings shall be tested at each rating unless a test at one rating is representative of performance at the other ratings. See 48.1.

Exception: An unfused switch marked for use with overcurrent protective devices having a continuous current rating not greater than the switch rating and a fused switch incorporating fuseholders of current rating not greater than the switch rating are acceptable for a 10,000 A short-circuit withstand rating without short-circuit testing.

20 Heating Test

20.1 Except as noted in 20.4, no part of a switch shall exceed the temperature rise values specified in Table 20.1 – and, if fuses are used, no fuse link shall melt – when the switch is caused to carry continuously, until constant temperatures are attained, a 60-Hz essentially sinusoidal current as follows:

a) Switch without a horsepower rating: rated current.

b) Switch with a horsepower rating: rated current, or 115 percent of current (from Table 24.2 or Table 24.3) corresponding to the horsepower rating, whichever is greater.

20.2 If a test is necessary to determine if a switch complies with the requirements in 20.1, the device is to be mounted as in actual service, with the door and other openings closed. The switch is to be wired with not less than 4 ft (1.22 m) of black Type RH, TW or THW copper wire per terminal, the wire size corresponding to the current rating of the switch. For a switch rated 60 A or less, the wire size shall also be based on the temperature rating of the wire as indicated by the marking on the switch, see 49.7.15. Where a dual temperature rating is marked 60/75°C (140/167°F) wire, the test is to be conducted with 75°C (167°F) wire. If agreeable to those concerned, insulation of a color other than black may be used. The test may be made at any convenient voltage. A temperature is considered to be constant when three successive readings taken at 15 minute intervals indicate no change.

20.3 Except as noted in 20.4, dummy fuses shall be used in place of regular fuses in clips or female screw shells. A dummy fuse shall be provided in accordance with 8.2 and Table 8.2 of the Standard for Fuseholders, UL 512.

20.4 A switch employing Class T fuses or 400 A Class J fuses shall be tested with fuses in place and when carrying 80 percent of its rated current continuously.

20.5 Temperatures are to be measured by thermocouples consisting of wires no larger than 24 AWG (0.21 mm^2) and no smaller than 30 AWG (0.05 mm^2). When thermocouples are used in determining temperatures in electrical equipment, it is common practice to employ thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer-type instrument. Such equipment is to be used whenever referee temperature measurements by thermocouples are necessary.

20.6 Thermocouples and related instruments are to be accurate and calibrated in accordance with good laboratory practice. The thermocouple wire is to conform with the requirements specified in the Initial Calibration Tolerances for Thermocouples table in Temperature-Measurement Thermocouples, ANSI/ISA MC96.1(1982).

Table 20.1
Maximum acceptable temperature rises

	Material and components	°C	°F
A	Terminals for field-installed conductors:		
	1. Unfused switches	50	90
	2. Fused switches for use with 60°C wire and tested with dummy fuses	30	94
	3. Fused switches for use with 75°C wire and tested with dummy fuses[a]	45	81
	4. Class T fused switches rated 100 A or less for use with 60°C wire	50	90
	5. Class T fused switches rated 100 A or less for use with 75°C wire[a]	65	117
	6. Class J (rated more that 200 A), Class T (rated more than 100 A), and Class L fused switches	60	108
B	All other current-carrying parts:		
	1. Unfused switches	50	90
	2. Fused switches for use with 60°C wire and tested with dummy fuses	30	54
	3. Fused switches for use with 75°C wire and tested with dummy fuses	50	90
	4. Class T, Class J (rated more than 200 A), and Class L fused switches	85	153

[a] Applicable to a connector for copper wire. Also applicable to a connector for aluminum wire or an aluminum-bodied connector, if the connector has a temperature rating of 90°C (194°F).

20.7 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 will result 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.

21 Heating With Fuses Test

21.1 30 and 60 A Class H fuses

21.1.1 A 30 A and 60 A pullout switch intended for use with Class H or K fuses shall be subjected to this test with nonrenewable time delay Class R or K fuses.

21.1.2 The selected fuses shall be subjected to a heating test in free air in open type fuseholders at 110 percent of rated current in accordance with the temperature test procedure in the Standard for Low-Voltage Fuses Part 6: Class H Non-Renewable Fuses, UL 248-6. The fuse ferrule and body temperatures shall be measured using thermocouples.

21.1.3 The fuses shall then be inserted in the pullout switch fuseholders and withdrawn ten times each.

21.1.4 The same fuses shall then be placed in the pullout switch and the switch subjected to a temperature test with the current adjusted to 80 percent of the switch rating. The pullout switch shall be mounted in a metal enclosure as described in 19.4. Except for using Class R or K fuses in place of dummy fuses, and the current, the test conditions shall be as described in the Heating Test, Section 20. The fuse thermocouples shall be located at the same points as when tested in the open.

21.1.5 The temperature rise on the fuse ferrule and on the body when tested in accordance with 21.1.4 shall not exceed the temperature rise on the same fuse recorded during the test described in 21.1.2. The temperature rise on insulating or sealing materials of the switch shall be at least 40°C (72°F) less than the maximum temperature in degrees C (F) for which they have been found acceptable. The temperature rise at field wiring terminals shall not be more than 50° C (90° F) for terminals identified for use with 60° C (140°F) wire and 65°C (117°F) for terminals identified for use with 75°C (169°F) wire.

21.2 Class CC, G, J, and R fuses

21.2.1 Pullout switches rated 60 A or less and intended for use with Class CC, G, J or R fuses shall be subjected to a heating test at 80 percent of the switch rated current. The pullout switch shall be mounted in a metal enclosure as described in 19.4. Fuses having the same rating as the switch shall be used. Class R fuses shall be of other than the dual element type. Except for fuses being used in place of dummy fuses, and the current, the test conditions shall be as described in the Heating Test, Section 20.

21.2.2 During this test, the temperature rise on the line and load terminals shall be not more than 50°C (90°F) for terminals identified for use with 60°C (140°F) wire and 65°C (117°F) for terminals identified for use with 75°C (169°F) wire and on other current-carrying parts shall not be more than 35°C (63°F) above the values given in Table 20.1. No fuse link shall melt during the test. The temperature rise on insulating or sealing materials of the switch shall be at least 40° C (104° F) less than the maximum temperature in degrees C for which the materials have been found acceptable.

22 Overload-Cycle-Heating Test

22.1 As outlined for the heating test 20.2, 20.5– 20.7 dummy fuses are to be used that are reduced in cross section or are made of material that will produce the required results. The dummy fuses may also be heated internally or externally by a resistance energized from a separate source to produce the required results. The surfaces of the ferrule or blade of each dummy fuse that make electrical contact with the clip of the fuseholder are to be made of unplated copper or copper alloy and are to be cleaned and reconditioned as necessary. These surfaces are then to be allowed to oxidize at room ambient for at least 30 days before being inserted in the fuseholders. The current is to be adjusted to 100 ±10 percent of the rating of the switch so as to produce a temperature rise not less than noted in Table 22.1 on all fuse clips. The switch is then to be cycled at the above mentioned current at a rate of 8 hours on and 4 hours off for 24 hours. During the second on period, the current is to be readjusted if necessary to bring the temperatures on the fuse clips back to the required temperatures, and actual temperatures are to be recorded after conditions are constant. The switch is then to be cycled for 60 operations at the rate of 8 hours on and 4 hours off. The temperature rises are to be recorded at the end of every sixth cycle. No temperature rise recorded shall differ more than 10°C (18°F) from the average of all temperature rises measured at that point.

Exception: The Overload Cycle-Heating Test is not required for bolt-on type fuse constructions.

Table 22.1
Adjusted temperature rise

Switch rating, amperes	Temperature rise above room
30 – 100	30°C (54°F) plus T[a]
101 – 200	40°C (72°F) plus T[a]

[a] T is the temperature rise obtained in the Heating Test, Section 20.

23 Overload Test

23.1 A pullout switch shall perform successfully when operated manually for 50 cycles, or by means of a machine in accordance with 19.7, making and breaking 150 percent of its rated current, except as noted in 23.3. The rate of speed shall be the number of cycles per minute given in Table 24.1, the test potential shall be as described in 19.8, and the power factory for an a-c switch shall be 0.75 to 0.80. There shall not be electrical or mechanical malfunction of the device, and there shall not be undue pitting, burning or welding of the contacts.

Table 23.1
Overload test cycles for horsepower rated switches

Switch rating in horsepower	Number of cycles of operation
100 and less	50
Over 100	10

23.2 A horsepower-rated pullout switch shall perform successfully when operated manually for the number of cycles indicated in Table 23.1 making and breaking the current given in Table 23.2 and Table 23.3. The rate of speed shall be the number of cycles per minute given in Table 24.1 (operation with current), the switch rating in amperes being assumed to be equal to 60 percent of the required overload test current; and the power factor for an a-c switch shall be from 0.40 to 0.50. There shall not be electrical or mechanical malfunction of the device and there shall not be undue pitting, burning, or welding of the contacts. See 49.1.8.

Exception: A switch rated in excess of 100 hp need not be operated faster than 1 cycle per minute.

Table 23.2
Overload-test currents in amperes for alternating-current switches

Switch rating in horse-power	120 V			240 V			480 V			600 V		
	Single-phase	2-Phase, 4-wire	3-phase	Single-phase	2-Phase, 4-wire	3-phase	Single-phase	2-Phase, 4-wire	3-phase	Single-phase	2-Phase, 4-wire	3-phase
1/2	58.8	–	40	29.4	–	20	–	–	10	–	–	8
3/4	82.8	28.8	50	41.4	14.4	25	21.0	7.2	12.5	16.8	6	10
1	96	38.4	60	48	19.2	30	24.0	9.6	15	19.2	7.8	12
1-1/2	120	54.0	80	60	27.0	40	30.0	13.8	20	24	10.8	16
2	144	70.8	100	72	35.4	50	36	18.0	25	28.8	14.4	20
3	204	99.6	–	102	49.8	64	51	25.2	32	40.8	19.8	25.6
5	336	158	–	168	79.2	92	84	39.6	46	67.2	31.8	36.8
7-1/2	480	228	–	240	114	127	126	54	63.5	96	48	50.8
10	600	288	–	300	144	162	156	72	81	120	60	64.8
15	810	432	504	–	216	232	–	108	116	–	84	93
20	–	564	648	–	282	290	–	138	145	–	114	116
25	–	708	816	–	354	365	–	174	183	–	144	146
30	–	828	960	–	414	435	–	210	218	–	168	174
40	–	1080	1250	–	540	580	–	270	290	–	216	232
50	–	1360	1560	–	678	725	–	336	363	–	270	290
60	–	–	–	–	–	870	–	–	435	–	–	348
75	–	–	–	–	–	1085	–	–	543	–	–	434
100	–	–	–	–	–	1450	–	–	725	–	–	580
125	–	–	–	–	–	1815	–	–	908	–	–	726
150	–	–	–	–	–	2170	–	–	1085	–	–	868
200	–	–	–	–	–	2900	–	–	1450	–	–	1160
250	–	–	–	–	–	–	–	–	1825	–	–	1460
300	–	–	–	–	–	–	–	–	2200	–	–	1760
350	–	–	–	–	–	–	–	–	2550	–	–	2040

Table 23.3
Overload-test currents in amperes for direct-current switches

Switch rating in horsepower	125 V	250 V	600 V
1	38	19	7
1-1/2	53	26	10
2	68	34	14
3	100	49	20
5	160	80	33
7-1/2	232	116	48

Table 23.3 Continued on Next Page

Table 23.3 Continued

Switch rating in horsepower	125 V	250 V	600 V
10	304	152	64
15	448	220	92
20	592	288	124
25	–	356	152
30	–	424	184
40	–	560	244
50	–	692	300

23.3 A general-use switch that also has a horsepower rating greater than 100 hp shall be subjected to the overload tests required in 23.1 and 23.2. If both tests are performed on the same sample, the number of operations required in 23.1 may be reduced to 40.

23.4 In determining if a pullout switch complies with the requirements in 23.1 – 23.3, test conditions are to be as described in 23.5 – 23.11.

23.5 A pullout switch shall be mounted in a representative enclosure, see 19.4, with a dead-front in place as in actual service. A door or cover may be open as necessary to operate the switch, but any other openings shall be closed. The line terminals shall be connected to a supply circuit as described in 23.6 – 23.11, and the load terminals shall be connected to the necessary resistance or impedance.

23.6 A switch intended for use on d-c circuits and a switch not specifically marked for alternating current only shall be tested with direct current, with a noninductive resistance load, and with the device so connected that the enclosure will be positive in potential with respect to the nearest arcing point.

23.7 A switch intended for a-c circuits only shall be tested with alternating current with an inductive load. The test shall be made on a circuit having a frequency of 60 Hz, except that a lower frequency may be employed if agreeable to those concerned. Resistance and reactance components of the load shall not be connected in parallel, except that an air-core reactor in any phase may be shunted by resistance, the loss in which is approximately 1 percent of the total power consumption in that phase. The shunting resistance used with an air-core reactor may be calculated from the formula

$$R_{SH} = 100\left(\frac{1}{PF} - PF\right)\frac{E}{I}$$

in which:

PF is the power factor,

E is the closed circuit phase voltage, and

I is the phase current.

23.8 A switch intended for use on circuits having one conductor grounded shall be tested with the enclosure connected through a 30 A cartridge fuse to the grounded conductor. If an enclosed switch is intended for use on other types of circuits, the enclosure shall be connected through a similar fuse to the live pole least likely to strike the ground.

23.9 A 2-wire and a 3-wire enclosed switch intended for use on either 3-wire d-c or single-phase, a-c circuits with grounded neutral shall be tested on a 3-wire d-c circuit with grounded neutral, with the switch connected to the outside conductors of the circuit, and with the enclosure grounded as indicated in 23.8. If the enclosed switch is intended for use with alternating current only, it shall be tested with alternating current in a similar manner and in accordance with 23.7.

23.10 A 3-wire switch without a solid neutral intended for use on a-c circuits other than that described in 23.9 and a 4-wire switch having a solid neutral shall be tested on a 3-phase circuit with a 3-phase balanced load.

23.11 A 4-wire switch without a solid neutral and a 5-wire switch shall be tested on a single-phase circuit with connections to adjacent poles, one pole being that nearest the enclosure. If the spacings between the poles differ, an additional test shall be made with connections to the pair of poles having the least separation.

24 Endurance Test

24.1 A pullout switch shall perform successfully when operated manually or by means of a machine in accordance with 19.7 for the number of cycles and at the rate of speed indicated in Table 24.1 making and breaking its rated current. The test potential, if direct current is used, shall be within 5 percent of the rated voltage of the switch; the test potential, if alternating current is used, shall be as described in 19.8, and the power factor for an a-c switch shall be 0.75 to 0.80. There shall be no electrical or mechanical malfunction of the device nor undue pitting, burning, or welding of the contacts.

Table 24.1
Endurance test cycles

Switch rating in amperes	Number of cycles of operation per minute[a]	Number of cycles of operation		
		With current	Without current	Total
100 or less	6	6000	4000	10,000
200	5	6000	2000	8,000
400	4	1000	5000	6000

[a] The indicated number of cycles of operation per minute applies only to that part of the test made with current. When no current is used, the switch may be operated at any convenient speed.

24.2 During the endurance test, the switch blades may be lubricated as needed to resume intended operation.

24.3 For horsepower-rated switches, full-load motor-running currents are given in Table 24.2 and Table 24.3. The endurance test is to be made with whichever is greater – the rated current of the device or the current selected from the appropriate table.

24.4 The current for the common wire of a 2-phase, 3-wire system is 1.414 times the value in Table 24.2 for a 2-phase, 4-wire system.

24.5 In determining if a pullout switch complies with the requirements in 24.1 – 24.4, test conditions are to be as described in 23.5 – 23.11.

Table 24.2
Endurance-test currents in amperes for alternating-current switches

Switch rating in horsepower	120 V			240 V			480 V			600 V		
	Single-phase	2-Phase, 4-wire	3-Phase	Single-phase	2-Phase, 4-wire	3-phase	Single-phase	2-Phase, 4-wire	3-Phase	Single-Phase	2-Phase, 4-Wire	3-Phase
1/2	9.8	–	4.4	–	–	2.2	–	–	1.1	–	–	0.9
3/4	13.8	4.8	6.4	6.9	2.4	3.2	3.5	1.2	1.6	2.8	1.0	1.3
1	16	6.4	8.4	8	3.2	4.2	4.0	1.6	2.1	3.2	1.3	1.7
1-1/2	20	9.0	12	10	4.5	6	5.0	2.3	3	4.0	1.8	2.4
2	24	11.8	13.6	12	5.9	6.8	6.0	3.0	3.4	4.8	2.4	2.7
3	34	16.6	19.2	17	8.3	9.6	8.5	4.2	4.8	6.8	3.3	3.9
5	56	26.4	30.4	28	13.2	15.2	14.0	6.6	7.6	11.2	5.3	6.1
7-1/2	80	38	44	40	19	22	21	9	11	16	8	9
10	100	48	56	50	24	28	26	12	14	20	10	11
15	135	72	84	68	36	42	34	18	21	27	14	17
20	–	94	108	88	47	54	44	23	27	35	19	22
25	–	118	136	110	59	68	55	29	34	44	24	27
30	–	138	160	136	69	80	68	35	40	54	28	32
40	–	180	208	176	90	104	88	45	52	70	36	41
50	–	226	260	216	113	130	108	56	65	86	45	52
60	–	–	–	–	–	154	–	–	77	–	–	62
75	–	–	–	–	–	192	–	–	96	–	–	77
100	–	–	–	–	–	248	–	–	124	–	–	99
125	–	–	–	–	–	312	–	–	156	–	–	125
150	–	–	–	–	–	360	–	–	180	–	–	144
200	–	–	–	–	–	480	–	–	240	–	–	192
250	–	–	–	–	–	–	–	–	302	–	–	242
300	–	–	–	–	–	–	–	–	361	–	–	289
350	–	–	–	–	–	–	–	–	414	–	–	336

Table 24.3
Endurance-test currents in amperes for direct-current switches

Switch rating in horsepower	125 V	250 V	600 V
1	9.4	4.7	1.8
1-1/2	13.2	6.6	2.6
2	17	8.5	3.4
3	25	12.2	5.0
5	40	20	8.3

Table 24.3 Continued on Next Page

Table 24.3 Continued

Switch rating in horsepower	125 V	250 V	600 V
7-1/2	58	29	12
10	76	38	16
15	112	55	23
20	148	72	31
25	–	89	38
30	–	106	46
40	–	140	61
50	–	173	75

25 Dielectric Voltage-Withstand Test

25.1 A switch (with fuses, if any, in place) shall withstand for 1 minute without breakdown the application of a 60 Hz essentially sinusoidal potential of 1000 V plus twice the maximum rated voltage:

a) Between the line and load terminals with the switch open – that is, with the switch in the off position with the pullout head removed and with pullout head inserted in the off position.

b) Between terminals of opposite polarity with the switch closed, and

c) Between live parts and the overall enclosure:

1) With the pullout member removed,

2) With the pullout member inserted in the "off" position, and

3) With the pullout member, with fuses in place, inserted in the "on" position.

d) Between live parts and any isolated metal handle that is part of the switch.

25.2 To determine if a pullout switch complies with the requirement in 25.1, it shall be mounted in a representative enclosure, see 19.4, with a dead-front in place as in actual service. It shall be stressed by means of a 500 VA or larger transformer, the output voltage of which can be varied. The applied potential is to be increased from zero until the required test value is reached and is to be held at that value 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.

Exception: The transformer may be less than 500 VA, if the output voltage is measured directly.

26 Short-Circuit Withstand Test

26.1 An unfused pullout switch, having a 5,000, 7,500 or a 10,000 A short-circuit withstand rating and marked for use with overcurrent protective devices having a continuous current rating greater than that of the switch, shall be subjected to the tests outlined in 26.2 – 26.6. The 5,000 and 7,500 A levels are applicable only to combinations of the switch and a circuit breaker. A previously untested sample may be used.

26.2 A circuit of 5,000, 7,500, or 10,000 A rms available symmetrical current, (see 26.1), shall be closed on the sample. For a switch marked for use with external fuses or a specified circuit breaker, the switch shall withstand the designated current until the overcurrent protective device(s) (see 26.4) opens. For a switch not marked as requiring a specific circuit breaker the test current shall be maintained for 3 cycles. After the circuit is opened:

a) The fuse connected to the enclosure shall not have opened,

b) There shall be no breakage to the extent that the integrity of the mounting of live parts is impaired,

c) The door shall be kept by its latch, without bolt or lock installed therein, from being blown open. Deformation of the case alone is considered to be acceptable.

d) The switch shall be capable of being opened manually with the handle,

e) Fuses, if within the switch, shall not be completely ejected from the clips, and no fuse shall bridge from a fuse clip to dead metal, and

f) The pullout head shall not be ejected from its receiving jaws.

26.3 For the test mentioned in 26.2:

a) The open-circuit voltage of the power-supply circuit is not to be less than the maximum rated voltage of the switch.

b) The available rms symmetrical short-circuit current in amperes is not to be less than 5,000, 7,500, or 10,000 A, as appropriate.

c) The circuit is to be as indicated in Figure 37.1. External overcurrent protective devices are to be connected where the "CL" fuses are indicated. See 26.4.

d) The power factor of the circuit is to be 0.45 – 0.50, lagging, and,

e) The enclosure of the switch is to be connected through a 30 A nonrenewable cartridge fuse acceptable for branch circuit use. The fuse shall have a voltage rating not less than the rating of the switch being tested. It is to be connected to the pole of the switch considered least likely to arc to the enclosure. This connection is to be made to the load side of the limiting impedance by a 10 AWG (5.3 mm^2) copper wire having a length of 4 – 6 feet (1.22 – 1.83 m).

Exception: The fuse may be connected to the grounded conductor if the switch is intended for use on a grounded system.

26.4 The overcurrent protective devices indicated in 26.2 are to be externally connected Class H fuses (maximum rating for the case size of the rating specified) or circuit breakers of the type and rating indicated by the marking.

26.5 The test specified in 26.2 may be performed without overcurrent protective devices if it can be shown that the test-circuit current was maintained for a period of time at least equal to the opening time of the specified overcurrent protective devices at the level of current involved.

26.6 For the performance of the test, the line and load terminals of the switch are to be connected to the corresponding test-circuit terminals by short copper wire leads, maximum of 4 feet (1.22 m) per terminal, each of which has an ampacity not less than the current rating of the switch.

27 Low Level Dielectric Voltage-Withstand Test

27.1 Unless the same sample is to be subjected to the closing test, a switch that has been subjected to the short-circuit withstand test shall comply with the requirements in 25.1 and 25.2, except that the test potential is to be twice the rated voltage of the switch but not less than 900 V.

28 Closing Test

28.1 A sample of the switch as described in 26.1 shall be closed as indicated in 19.7 on a circuit capable of providing a current equal to the short-circuit withstand rating. After the circuit has cleared, the switch shall comply with the requirements as specified in 26.2 (a), (b), (d) and (e).

28.2 The sample for this test is to be that used for the short-circuit withstand test or a previously untested sample may be employed. The conditions of the closing test are to be the same as for the short-circuit withstand test, 26.3– 26.6. Complete physical closure of the switch contacts need not be established.

29 Low Level Dielectric Voltage-Withstand Test

29.1 The dielectric voltage-withstand test described in 25.1 and 25.2 shall be repeated following the closing test, except that the test potential shall be twice the rated voltage of the switch but not less than 900 V.

30 Test Calibration

30.1 Test circuits intended to deliver a maximum 10,000 A rms symmetrical current shall be calibrated as described in the Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, UL 489.

31 Strength of Insulating Base and Support Test

31.1 The insulating base of a pullout switch shall not be damaged when wire connectors securing short lengths of conductors of rated ampacity are tightened to 110 percent of the torque value marked on the switch. For a switch marked for use with copper/aluminum conductors, the wire connectors shall be tightened to the highest torque value of either conductor.

31.2 Damage is considered to have occurred if the base insulating material cracks or rotates; bosses, recesses, or other means to prevent turning do not perform their intended function; straps or bus bars bend or twist; or members move at electrical joints. Minor chipping or flaking of brittle insulating material is acceptable if the performance is not otherwise impaired. Momentary flexing of metallic members without permanent deformation is acceptable.

32 Bonding Continuity Test

32.1 The resistance of a bond (see 6.1.6, 6.1.7, 18.2) shall be determined by calculation from the voltage drop measured between two file marks, each located not more than 1/16 inch (1.6 mm) on opposite sides of the joint with 30 A flowing through the connection. All gaskets shall be in place and fastening devices pulled up tight in the intended manner. The resistance of the joint shall not exceed 0.005 ohms.

33 Clamped Joint Test

33.1 A clamped joint between two insulators, see Figure 14.1, is to be tested using two samples.

a) The first sample shall have the clamped joint defeated by drilling 1/8 inch (3.2 mm) diameter hole through the joint between the insulators at a point of minimum spacing between the metal parts on the opposite sides of the joint. The 60 Hz dielectric breakdown voltage through this hole shall then be determined by applying a gradually increasing voltage until breakdown occurs.

b) To be considered a "clamped" joint, the second sample with the clamped joint intact shall not breakdown at a potential of less than:

1) 5,000 V rms, 60 Hz, or

2) 110 percent of the breakdown voltage of the first sample determined as specified in (a) above, whichever is greater. The potential is to be increased to the required value and held for not less than one second.

PERFORMANCE – HIGHER THAN 10 kA AVAILABLE FAULT CURRENT CIRCUITS

34 General

34.1 These requirements specify the additional performance requirements with which switches shall comply if they are marked for use on circuits having available fault currents greater than 10 kA. See 48.1.

35 Close-Open Test

35.1 A switch shall be capable of being operated to make and break 600 percent of its rated current for the number of operations indicated in Table 35.1.

Table 35.1
Close-open test operation

Type of switch	Number of operations
Polyphase	3
Single Phase	5

35.2 For the test mentioned in 35.1, a previously untested sample is to be used. The line terminals of the switch are to be connected to the power supply circuit and the load terminals of the switch are to be connected to an inductive load. The power factor of the load is to be 0.45–0.50 except a lower power factor may be used if agreeable to those concerned. A shunting resistance as described in 23.7 may be employed. The circuit on which the test is conducted shall have a normal frequency recovery voltage (see 43.6.1 – 43.6.3) equal to the rated voltage of the device, except that the recovery voltage need not be determined if the closed-circuit voltage is not less than 90 percent of the rated voltage of the device. The open-circuit voltage shall not be more than 110 percent of the rated voltage except that a higher open-circuit voltage may be used if agreeable to those concerned. The rate of operation is not specified. The blades and jaws may be serviced before each operation. A ground fuse as described in 23.8 is to be used.

35.3 Upon completion of the test, the test sample is not to be serviced in any manner before conducting the dielectric voltage-withstand test, 36.1. After completion of the dielectric voltage-withstand test, the switch may be serviced prior to the short-circuit withstand test.

35.4 Servicing is considered to be filing, lubricating, deburring, and the like. There is to be no disassembly of the device to accomplish the servicing. Servicing is not to include replacement of any part.

35.5 At the conclusion of the test, the switch shall be in operating condition. The fuse described in 23.8 shall not have opened. Burning or pitting of the contacts is considered to be acceptable, but line-to-line breakdown is considered to be unacceptable.

36 Dielectric Voltage-Withstand Test

36.1 The dielectric voltage-withstand test described in 25.1 and 25.2 shall be conducted on the sample following the close-open test.

37 Short-Circuit Withstand Test

37.1 After completion of the test described in 36.1, a circuit capable of providing the maximum short-circuit withstand current for which the switch is rated shall be closed on that sample. The switch shall withstand the designated current until the overcurrent protective devices (see 37.3) open, and after the circuit is opened:

a) The fuse connected to the enclosure shall not have opened,

b) There shall be no breakage to the extent that the integrity of the mounting of live parts is impaired,

c) The door shall be kept by its latch, without bolt or lock installed therein, from being blown open. Deformation of the case alone is not considered to constitute an unacceptable result,

d) Neither end of a bar or tube as described in 37.5 shall be completely ejected from the fuse clips and no line end of a bar or tube shall bridge from a fuse clip to dead metal,

e) The switch shall be capable of being opened manually with the operating handle, and

f) The pullout head shall not be ejected from its receiving jaws.

g) For enclosed pullout switches containing meter sockets, the current through the meter socket shall not exceed 30 kA peak.

37.2 For the test mentioned in 37.1:

a) The open-circuit voltage of the power-supply circuit is not to be less than the maximum rated voltage of the switch.

b) The available rms symmetrical short-circuit current in amperes is not to be less than the marked short-circuit withstand current rating of the switch.

c) The circuit is to be as indicated in Figure 37.1 with any overcurrent protection device on the load side and is to include the necessary measuring equipment and the fuse-mounting means. A circuit breaker is to be used if specified for use with an unfused switch.

Exception: Overcurrent protection means may be connected on the line side of an unfused switch, if the switch is marked as indicated in Exception No. 4 to 49.3.2.

d) The power factor of the circuit is to be 0.25 – 0.30 lagging for a circuit of 10,001 – 20,000 A, and 0.15–0.20 for circuits over 20,000 A.

e) The enclosure of the switch is to be connected through a 30 A nonrenewable, type fuse to the pole of the switch considered least likely to arc to the enclosure. The fuse shall have a voltage rating not less than the rating of the switch being tested. This connection is to be made to the load side of the limiting impedance by a 10 AWG (5.3 mm^2) copper wire having a length of 4 – 6 ft (1.22 – 1.83 m).

Exception: The fuse may be connected to the grounded conductor if the switch is intended for use on a grounded system.

37.3 The overcurrent protective devices specified in 37.1 shall be one of the following:

a) For fused switches, fuses as described in 37.6, or

b) For unfused switches, externally connected fuses as described in 37.6 or circuit breakers as marked on the switch.

37.4 The tests specified in 37.1 may be performed without overcurrent protection devices if it can be shown that the test circuit current was maintained for a period of time at least equal to the opening time of the specified overcurrent protective devices at the level of current involved.

37.5 For the performance of the test, the line and load terminals of the switch are to be connected to the corresponding test-circuit terminals by short copper wire leads, maximum of 4 feet (1.22 m) per terminal, each of which has an ampacity not less than the current rating of the switch. For a switch with an integral fuseholder, a copper bus or tube, having a cross section not smaller than the blade (or ferrule) of the fuse that the fuseholder is intended to accommodate, is to be installed in each fuseholder in the switch. Each of these bars or tubes may be individually reinforced to enable it to withstand the short-circuit forces. If the fuse is intended to be secured in place by bolts, the test is to be conducted with the bolts in place if the bar or tube would not otherwise remain in position. Otherwise, the test is to be performed with the bolts omitted.

37.6 Fuses, used shall have characteristics representing the peak let-through current (I_p) and clearing I^2t values associated with the maximum rated fuses the device either accepts or is to be externally protected by. For an unfused switch it is assumed that protection will be provided by the maximum fuse in the case size of the indicated fuse. Each of these fuses is to be of such characteristics that, when tested on a single-phase circuit, it will permit a peak let-through current and a clearing I^2t of not less than the corresponding values specified in the requirements for the class and current and voltage ratings of the fuse intended for use in the switch being tested. Special test fuses of the same physical dimensions as a fuse the switch is intended to accommodate may be used in place of the dummy fuses in the switch. To obtain the required values of these characteristics, it may be necessary to employ a fuse having a current rating larger than that of the fuse which the switch accommodates and of a different class.

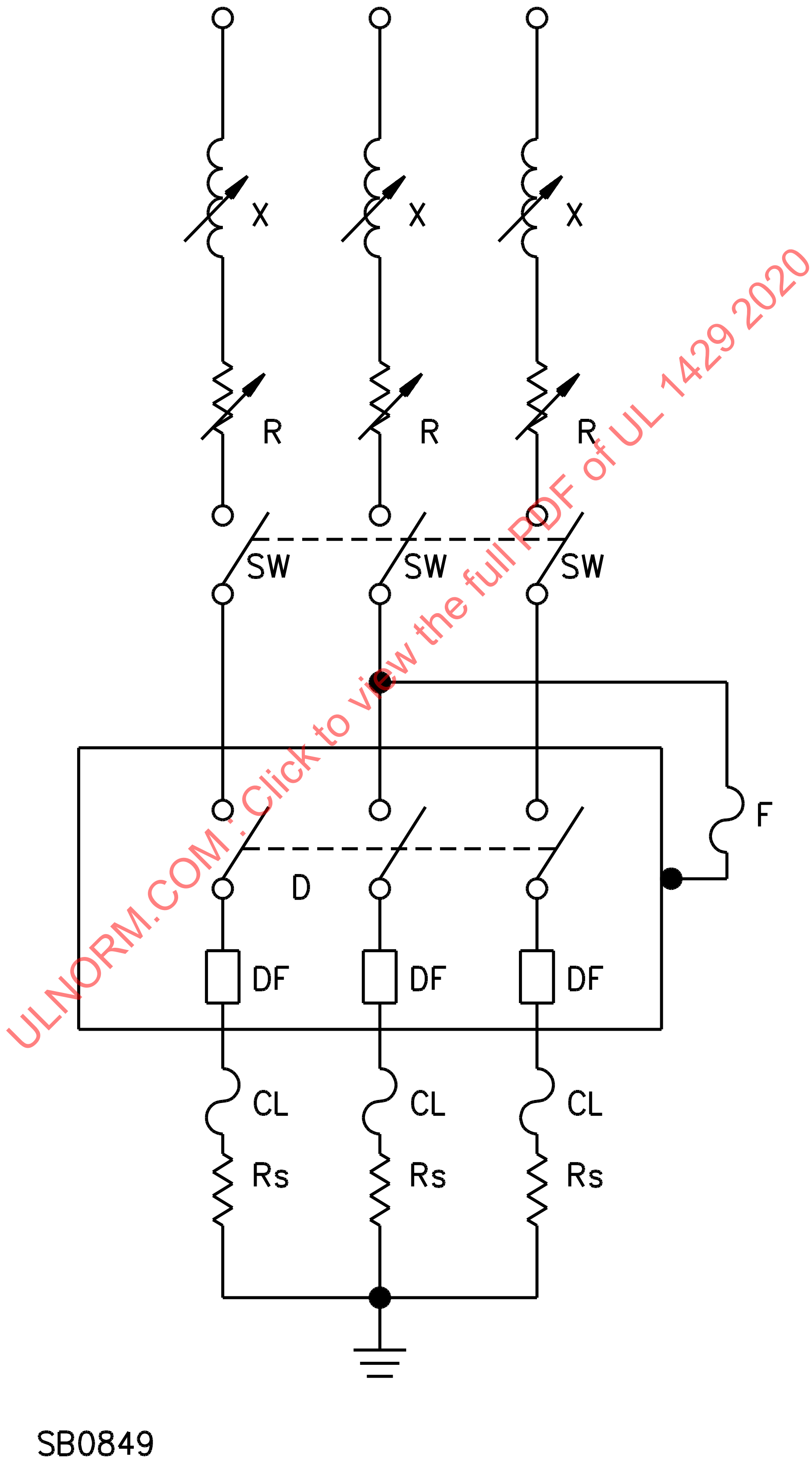
37.7 Fuses used for tests are to be selected from a lot from which two samples have been selected if the fuses are of Class CC, G, J, R (K5), or T and that have been calibrated to determine their I^2t and I_p characteristics comply with the prescribed values called for in 37.6.

37.8 The current available and other circuit characteristics are to be determined as indicated in Sections 41 – 43.

37.9 With the device in full closed position, the test circuit is to be closed on the device. For devices tested on a single-phase circuit, controlled closing shall be employed so that maximum current flow (I_p) is obtained. The closing angle shall be essentially at the zero of the voltage wave (maximum offset) or later, to produce the start of arcing within 30 electrical degrees prior to system peak voltage.

Figure 37.1

Circuit for withstand and closing tests supply rated voltage 3 phase – 60 HZ



38 Low Level Dielectric Voltage-Withstand Test

38.1 Unless the same sample is to be subjected to the closing test, a switch that has been subjected to the short-circuit withstand test shall comply with the requirements in 25.1 and 25.2, except that the test potential is to be twice the rated voltage of the switch but not less than 900 V.

39 Closing Test

39.1 A switch shall be closed as indicated in 19.7 on a circuit capable of providing the maximum short-circuit withstand current for which the switch is rated. After the circuit has cleared, the switch shall comply with the requirements in 37.1 (a), (b), (d) and (e).

39.2 The sample for this test is to be that used for the short-circuit withstand test or a previously untested sample may be employed. The conditions of the closing test are to be the same as for the short-circuit withstand test, 37.2– 37.8. Complete physical closure of the switch contacts need not be established.

40 Low Level Dielectric Voltage-Withstand Test

40.1 The dielectric voltage-withstand test described in 25.1 and 25.2 shall be repeated following the closing test, except that the test potential shall be twice the rated voltage of the switch but not less than 900 V.

41 Galvanometers

41.1 The galvanometers in a magnetic oscillograph employed for recording voltage and current during circuit calibration and switch testing shall have a flat (±5 percent) frequency response from 50 to 1200 Hz.

41.2 Using an audio-oscillator having output impedance and output voltage capable of driving a magnetic-oscillograph galvanometer and capable of delivering at least 100 mA rms with a wave form that remains sinusoidal over a frequency range of 50 – 1200 Hz, gradually increase the frequency of the signal applied to the galvanometer and determine that the peak-to-peak amplitude of the galvanometer deflection does not increase or decrease by more than 5 percent from the deflection at 60 Hz throughout this frequency range when corrected output voltage is supplied to the galvanometer, and the sensitivity is adjusted to produce a deflection not less than 0.98 inch (25 mm).

41.3 Galvanometers shall be calibrated as described in 41.4 – 41.8.

41.4 When a shunt is used to determine the circuit characteristics, a d-c calibrating voltage should be used. The voltage applied to the oscillograph galvanometer circuit is to result in a deflection of the galvanometer approximately equivalent to that which is expected when the same galvanometer circuit is connected to the shunt and the nominal short-circuit current is flowing. The voltage is to be applied so as to cause the galvanometer to deflect in both directions. Additional calibration is to be made using approximately 50 percent and 150 percent of the voltage used to obtain the deflection indicated above. The sensitivity of the galvanometer circuit in volts per inch (or millimeter) is to be determined from the deflection measured in each case, and the results of the six trials averaged. The peak amperes per inch (or millimeter) is obtained by dividing the sensitivity by the resistance of the shunt. This multiplying factor is used for the determination of the rms current as described in 43.2.

41.5 A 60 Hz sine-wave potential may be used for calibrating the galvanometer circuit, using the same general method described in 41.4. The resulting factor must be multiplied by 1.414.

41.6 When a current transformer is sued to determine the circuit characteristics, an alternating-current is used to calibrate the galvanometer circuit. The value of current applied to the galvanometer circuit is to result in a deflection of the galvanometer approximately equivalent to that which is expected when the same galvanometer is connected to the secondary of the current transformer and nominal short-circuit current is flowing in the primary. Additional calibrations are to be made at approximately 50 percent and 150 percent of the current used to obtain the deflection indicated above. The sensitivity of the galvanometer circuit in amperes rms per inch (or millimeter) is to be determined in each case and the results averaged. The average sensitivity is multiplied by the current-transformer ratio and by 1.414 to obtain peak amperes per inch. This constant is used for the determination of the rms current as described in 43.2.1.

41.7 All the galvanometer elements employed are to align properly in the oscillograph, or the displacement differences are to be noted and used as needed.

41.8 The sensitivity of the galvanometers and the recording speed is to be capable of providing a record from which values of voltage, current, and power factor can be measured accurately. The recording speed is to be not less than 60 inches (1.53 m) per second and higher speeds are recommended.

42 Circuit Measurement Verification

42.1 A noninductive (coaxial) shunt that has been found acceptable for use as a reference (coaxial) shunt shall be used to verify the manufacturer's instrumentation. This may be accomplished by connecting the shunt in series with the instrumentation of each phase of the manufacturer's test circuit. A single-phase circuit of the same voltage and current as that required for the switch test is to be used.

42.2 The circuit is to be closed as nearly as possible at the angle that will produce a current wave with maximum offset. The short-circuit current and voltage are to be recorded. The primary voltage is to be recorded if primary closing is used. The current and power factor measured by the reference shunt should be within 5 percent of that measured using the manufacturer's instrumentation.

42.3 If three reference shunts are available, one can be inserted in each of the phase legs and a 3-phase circuit established at the same voltage and current as the test circuit. Controlled closing is not required for polyphase circuits. The same instrumentation accuracy is applicable as stated in 42.2.

42.4 With the secondary open-circuited, the transformer is to be energized and the voltage at the test terminal observed to see if rectification is taking place. If rectification is occurring, the circuit is not acceptable for test purposes because the voltage and current will not be sinusoidal. Six random closings are to be made to demonstrate that residual flux in the transformer core will not cause rectification. If testing is done by closing the secondary circuit, this check can be omitted providing testing is not commenced before the transformer has been energized for approximately 2 seconds, or longer if an investigation of the test equipment shows that a longer time is necessary.

42.5 When the verification of the accuracy of the manufacturer's instrumentation is completed, the reference shunts are to be removed from the circuit – they are not to be used during the final calibration of the test circuit nor during the testing of the devices.

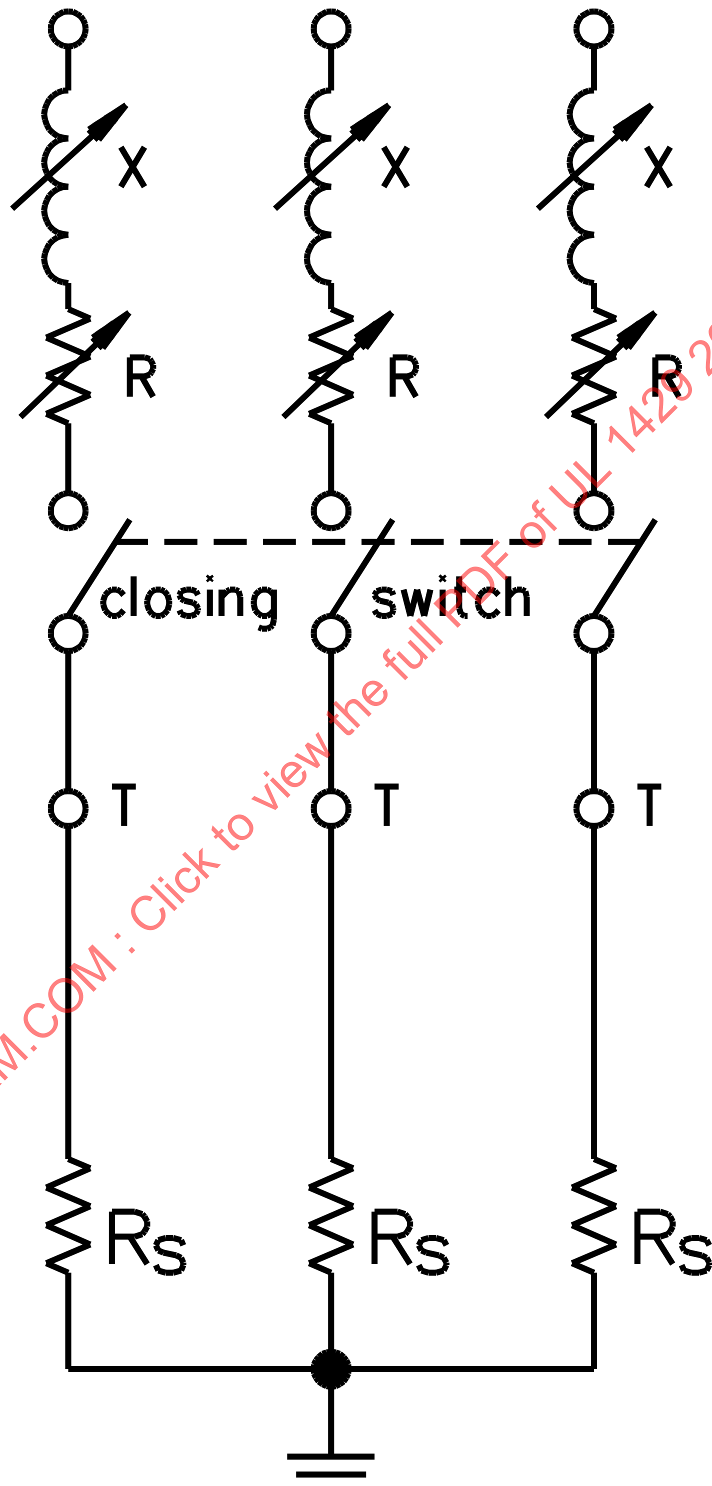
43 Calibration of Test Circuit

43.1 Details

43.1.1 The test circuit shall be calibrated as described in 43.2.1 – 43.6.3. Assuming that shunts are used for current measurement the calibration tests are to be conducted with the test terminals connected as indicated in Figure 43.1.

Figure 43.1

Test circuit verification supply – rated voltage, 3-phase – 60 HZ



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43.2 Current

43.2.1 The rms symmetrical current is to be determined by measuring the a-c component of the wave at the instant 1/2 cycle (on the basis of a power frequency timing wave) after the initiation of the short circuit. The current is to be calculated in accordance with Figure 7 of the Standard Test Procedure for AC High-Voltage Circuit Breakers Rated On a Symmetrical Basis, ANSI/IEEE C37.09.

43.2.2 A 3-phase test circuit is to have the impedances of each phase essentially equal. The total rms symmetrical current is to be the average of the symmetrical current of the individual phases.

43.2.3 For a single-phase circuit, one test is to be made at the closing angle that will produce maximum current offset for the power factor employed. If methods employed for power factor measurement do not require an asymmetrical closing (see 43.5.3) the current may be determined under symmetrical closing conditions.

43.4 Voltage

43.4.1 The open-circuit voltage is not to be less than 100 percent nor more than 105 percent of the rated voltage for the test being conducted, except that a voltage higher than 105 percent may be employed if agreeable to all concerned.

43.5 Power factor

43.5.1 The power factor is to be determined at the instant 1/2 cycle, on the basis of a power frequency timing wave, after the short-circuit occurs. The total asymmetrical rms amperes and the total symmetrical rms amperes are to be measured in accordance with 43.2.1 and the ratio M_A or M_M calculated as follows:

$$Ratio\ M_A\ (for\ 3\ \varphi\ \ test) = \frac{Total\ \ 3\ phases - Asymmetrical\ \ RMS\ \ Amps}{Total\ \ 3\ phases - Symmetrical\ \ RMS\ \ Amps}$$

$$Ratio\ M_M\ (for\ 1\ \varphi\ \ test) = \frac{Asymmetrical\ \ RMS\ \ Amps}{Symmetrical\ \ RMS\ \ Amps}$$

Using ratio M_A or M_M the power factor is determined from Table 43.1 or the equations in 43.5.2.

43.5.2 The following formulas may be used to calculate the power factor:

$$pf = Cos\left\{Arctan\left[\frac{2\pi}{In\left[\frac{2}{M_M^2 - 1}\right]}\right]\right\}$$

$$pf = Cos\left\{Arctan\left[\frac{2\pi}{In\left[\frac{2}{2.25\,M_A^2 - 2.5 + \frac{0.25}{M_A^2}}\right]}\right]\right\}$$

43.5.3 If it can be shown for a given circuit that the same results are obtained as with the method described in 43.5.1, other methods of determining power factor, such as the decremental method or a procedure involving use of less than full excitation of the test generator, may be employed.

43.6 Recovery voltage

43.6.1 Recovery voltage is defined as the rms value of the normal frequency a-c voltage that exists across the test terminals after the opening of the circuit.

43.6.2 The recovery voltage is to be at least equal to the rated voltage of the device. The peak value of the recovery voltage within the first full half cycle after clearing and for the next three successive peaks is to be at least equal to 1.414 times the rms value of the rated voltage of the device. Each of the peaks is to be displaced by not more than ±10 electrical degrees from the peak values of the open circuit secondary voltage. The average of the instantaneous values of the recovery voltage of each of the first four half cycles measured at the 45 and 135 degree points on the wave is not to be less than 85 percent of the rms value of the rated voltage of the device. The instantaneous value of the recovery voltage measured at the 45 and 135 degree points of each of the first four half cycles is to be in no case less than 75 percent of the rms value of the rated voltage of the device.

43.6.3 If, in a circuit that employs secondary closing, there is no attenuation or phase displacement of the first full cycle of the recovery-voltage wave, when compared with the open-circuit secondary-voltage wave before current flows, the detailed measurement of recovery-voltage characteristics as indicated in 43.6.2 is not required.

Table 43.1
Short-circuit power factor

Short-circuit power factor, percent	Ratio M_M	Ratio M_A	Short-circuit power factor, percent	Ratio M_M	Ratio M_A
0	1.732	1.394	30	1.130	1.066
1	1.697	1.374	31	1.122	1.062
2	1.662	1.354	32	1.113	1.057
3	1.630	1.336	33	1.106	1.053
4	1.599	1.318	34	1.098	1.050
5	1.569	1.302	35	1.091	1.046
6	1.540	1.286	36	1.085	1.043
7	1.512	1.271	37	1.079	1.040
8	1.486	1.256	38	1.073	1.037
9	1.461	1.242	39	1.068	1.034
10	1.437	1.229	40	1.062	1.031
11	1.413	1.216	41	1.058	1.029
12	1.391	1.204	42	1.053	1.027
13	1.370	1.193	43	1.049	1.025
14	1.350	1.182	44	1.045	1.023
15	1.331	1.172	45	1.041	1.021
16	1.312	1.162	46	1.038	1.019
17	1.295	1.152	47	1.035	1.017
18	1.278	1.144	48	1.032	1.016
19	1.262	1.135	49	1.029	1.014

Table 43.1 Continued on Next Page