

UL 1008

Transfer Switch Equipment



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UL Standard for Safety for Transfer Switch Equipment, UL 1008

Fifth Edition, Dated November 25, 1996

Revisions: This Standard contains revisions through and including October 12, 2007.

SUMMARY OF TOPICS:

These revisions to ANSI/UL 1008 include the following changes in requirements:

New Section Covering Power Input Panels

Revisions to Enclosure References

Relocating the Conduit Hub Secureness Test from the Construction Section to the Performance Section

Clarification of Operating Mechanism States

Revisions to Optional Standby Requirements

New Section Covering Transformer Grounding

Clarification of Disconnecting Means Requirements Clarification of Disconnecting Means Requirements to Correlate 19.9 with NFPA 70-445.18

Clarification of Service Entrance Requirements

Editorial Corrections

UL Standards for Safety are developed and maintained in the Standard Generalized Markup Language (SGML). SGML -- an international standard (ISO 8879-1986) -- is a descriptive markup language that describes a document's structure and purpose, rather than its physical appearance on a page. Due to formatting differences resulting from the use of UL's new electronic publishing system, please note that additional pages (on which no requirements have been changed) may be included in revision pages due to relocation of existing text and reformatting of the Standard.

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

The revisions dated October 12, 2007 include a reprinted title page (page1) for this Standard.

The new and revised requirements are substantially in accordance with UL's Proposal(s) on this subject dated April 27, 2007 and September 7, 2007.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

As indicated on the title page (page1), this UL Standard for Safety has been adopted by the Department of Defense.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: <http://ulstandardsinfo.net.ul.com/ulforeword.html>

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New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing, Recognition and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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Standard for Transfer Switch Equipment

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Fifth Edition

November 25, 1996

The most recent designation of ANSI/UL 1008 as an American National Standard (ANSI) occurred on October 9, 2007.

This ANSI/UL Standard for Safety, which consists of the Fifth edition, with revisions through October 12, 2007, is under continuous maintenance, whereby each revision is ANSI approved upon publication.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc. and is not part of the ANSI standard.

The Department of Defense (DoD) has adopted UL 1008 on December 9, 1983. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <http://csds.ul.com>.

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INTRODUCTION

1 Scope

1.1 These requirements cover automatic, non-automatic (manual), and by-pass/isolation transfer switches intended for use in ordinary locations to provide for lighting and power as follows:

- a) Automatic transfer switches and by-pass/isolation switches for use in emergency systems in accordance with Articles 517-Health Care Facilities, 700-Emergency Systems, 701-Legally Required Standby Systems, and 702-Optional Standby Systems of the National Electrical Code, ANSI/NFPA 70 and the National Fire Protection Association Standard for Health Care Facilities ANSI/NFPA 99.
- b) Transfer switches for use in optional stand-by systems in accordance with Article 702 of the National Electrical Code, ANSI/NFPA 70.
- c) In legally required stand-by systems in accordance with Article 701 of the National Electrical Code, ANSI/NFPA 70.
- d) Automatic transfer switches and by-pass/isolation switches for use in accordance with the National Fire Protection Association Standard for Centrifugal Fire Pumps, ANSI/NFPA 20.
- e) Non-Automatic transfer switches for use in accordance with Articles 517-Health Care Facilities, and 702-Optional Standby Systems of the National Electrical Code, ANSI/NFPA 70 and the National Fire Protection Association Standard for Health Care Facilities, ANSI/NFPA 99.

Revised 1.1 effective June 29, 2002

1.2 An automatic transfer switch for use in a legally required stand-by system is identical to that used for an emergency system.

1.3 These requirements cover transfer switch equipment rated at 6000 A or less and 600 V or less.

1.3 added September 18, 1996

1.4 These requirements cover transfer switches together with their associated control devices including voltage sensing relays, frequency sensing relays, time delay relays, and the like.

1.5 An automatic transfer switch as covered by these requirements is a device that automatically transfers a common load from a normal supply to an alternate supply in the event of failure of the normal supply, and automatically returns the load to the normal supply when the normal supply is restored.

Exception: An automatic transfer switch is allowed to be provided with a logic control circuit that inhibits automatic operation of the device from either a normal to an alternate supply, or from an alternate to a normal supply when the switch reverts to automatic operation upon loss of power to the load.

1.5 revised September 18, 1996

1.6 A non-automatic transfer switch as covered by these requirements is a device, operated manually by a physical action, or electrically by a remote control, for transferring a common load between a normal and alternate supply.

1.6 added September 18, 1996

1.7 A transfer switch may incorporate overcurrent protection for the main power circuits.

1.8 These requirements cover completely enclosed transfer switches and also open types intended for mounting in other equipment such as switchboards.

1.9 Transfer switches are rated in amperes and are generally considered to be acceptable for total system transfer, which includes control of motors, electric-discharge lamps, electric-heating loads, and tungsten-filament lamp loads as referred to in 1.10.

1.10 A transfer switch intended for total system transfer as indicated in 1.9 is considered to be acceptable for the control of tungsten-filament lamp loads not exceeding 30 percent of the switch ampere rating unless the switch has been investigated for a higher percentage of lamp load and marked accordingly.

1.11 A transfer switch may be limited to use with one or more specific types of load if investigated accordingly and marked as indicated in 41.12.

1.12 These requirements also cover by-pass/isolation switches that can be used to manually select an available power source to feed load circuits and to provide for total isolation of an automatic transfer switch. These switches may be completely enclosed, enclosed with transfer switch or the open type intended for mounting in other equipment.

1.12.1 These requirements also cover transfer switches and bypass/isolation switches with an optional short-time current rating if investigated accordingly and marked as indicated in 41.20.1. Short-time current is the maximum amount of fault current a switch can withstand at a specified voltage for a given amount of time and remain functional.

1.12.1 added January 9, 2002

1.13 Deleted January 9, 2002

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 used in the products covered by this standard.

2.1 revised June 29, 2001

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.

2.2 revised June 29, 2001

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

2.3 revised June 29, 2001

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.

2.4 revised June 29, 2001

2.5 A component not marked with a short-circuit current rating is considered rated for use in a circuit having a maximum available fault current as shown in Table 2.1.

Added 2.5 effective June 29, 2002

2.6 The short-circuit current available in the secondary circuit of a transformer rated 10 kVA or less is considered to be 5000 amperes or less.

Added 2.6 effective June 29, 2002

2.7 The short-circuit current available on the load side of a 15 ampere current-limiting circuit breaker or Class CC, G, J, RK1, RK5, or T fuse is considered to be 5000 amperes. In a single phase 120-volt circuit, the short-circuit current available on the load side of a 20 ampere circuit breaker or Class CC, G, J, RK1, RK5, or T fuse is considered to be 10,000 amperes or less.

Added 2.7 effective June 29, 2002

Table 2.1
Assumed maximum short-circuit current ratings for unmarked components

Added Table 2.1 effective June 29, 2002

Component	Short-circuit current rating, kA
1. Circuit breaker (including GFCI type)	5
2. Clock-operated switch	5
3. Fuseholder	10
4. Lighting fixture (circuit) internal	5
5. Miniature fuse	10 ^a
6. Plug fuse	10
7. Industrial control equipment:	
a. Auxiliary device	5
b. Motor controllers or switches (other than mercury tube type)	5
c. Mercury tube switches:	
Rated over 60 amperes or over 250 volts	5
Rated 250 volts or less, 60 amperes or less, and over 2 kVA	3.5 ^b

Table 2.1 Continued

Component	Short-circuit current rating, kA
Rated 250 volts or less and 2 kVA or less	1 ^b
8. Meter socket base	10
9. Photoelectric switches	5
10. Receptacle (GFCI type)	2
11. Receptacle (other than GFCI type)	10
12. Snap switch	5
13. Terminal block	10
14. Thermostat	5
^a The use of these fuses is limited to 125-volt circuits that do not leave the transfer switch. ^b This rating is below the minimum specified in Table 34.1 and the component shall either: 1) Be investigated for the minimum short-circuit current rating specified in Table 34.1 or 2) Be located on the load-side of a suitable current-limiting overcurrent protective device.	

3 Units of Measurement

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

3.1 revised June 29, 2001

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 Transfer switches shall employ materials throughout which are acceptable for the particular use, and shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

5.2 A transfer switch intended for use as service equipment shall comply with the applicable requirements for service equipment and be marked in accordance with 41.3.

6 Enclosure

6.1 An enclosure provided shall comply with the Standard for Industrial Control Equipment, UL 508. See also 6.2 and 6.3.

6.2 For a transfer switch intended for use as service equipment, the enclosure thickness shall not be less than 0.053 inch (1.35 mm) if of uncoated steel, 0.056 inch (1.42 mm) if of zinc-coated steel, and 0.075 inch (1.91 mm) if of aluminum.

6.3 The enclosure of a transfer switch rated 800 A or more may be provided with ventilating openings which comply with the requirements in 6.4 – 6.18.

6.4 A ventilating opening shall be designed and located so that no flame or molten metal is emitted during arcing normally encountered during acceptable performance of the overload test described in 28.1 and the withstand and closing tests described in Withstand, Section 34.

6.5 Unless the opening is remote from the arcing part, the requirement in 6.4 necessitates the interposing of an acceptable barrier between a ventilating opening and a possible source of arcing such as a switch, fuse, and the like, as noted in 6.6 – 6.8.

6.6 The barrier shall be of such dimensions and so located that straight lines drawn from any arcing part past the edge of the barrier define an area at the plane of the opening 1/4 inch (6.4 mm) beyond the edges of the opening.

6.7 A sheet steel barrier shall not be less than 0.053 inch (1.35 mm) thick if uncoated and not less than 0.056 inch (1.42 mm) thick if zinc-coated.

Exception: The barrier may be of steel of less thickness provided that its strength and rigidity is not less than that of a flat sheet of steel having the same dimensions as the barrier and having the specified thickness.

6.8 A nonmetallic barrier shall not be less than 1/4 inch (6.4 mm) thick and shall be supported to give acceptable strength and rigidity.

Exception: The thickness of a nonmetallic barrier may be less than 1/4 inch (6.4 mm) if the barrier is so located and supported that it is not subject to mechanical abuse during installation and is so located that it has acceptable strength and rigidity.

6.9 A ventilating opening in an enclosure shall have such size or shape, or shall be so covered by screening or by an expanded, perforated, or louvered metal panel, that a test rod having the diameter specified in 6.10 will not enter the opening.

6.10 The test rod mentioned in 6.9 shall be 33/64 inch (13.1 mm) in diameter if the plane of the opening is less than 4 inches (102 mm) from an uninsulated live part, or 49/64 inch (19.4 mm) in diameter if the plane of the opening is 4 inches (102 mm) or more from such parts.

6.11 A louver shall not be more than 12 inches (305 mm) long.

6.12 The size, shape, and location of a ventilating opening shall not unduly weaken the overall enclosure.

6.13 The total area of enclosure material removed from a wall for the purpose of ventilation or for the insertion of a ventilating panel or screen together with total area of ventilating openings formed from the enclosure material shall not exceed 25 percent of the area of the entire surface of any wall in which such ventilating openings are located.

6.14 The 25 percent limitation mentioned in 6.13 may be exceeded provided that means of reinforcement, such as stiffeners, are employed and the enclosure complies with 6.12.

6.15 The area of an opening covered by a louvered, perforated, or expanded metal panel that is thinner than the enclosure, shall not exceed 200 square inches (0.129 m²). A ventilated closing panel of 0.053 inch (1.35 mm) if uncoated, 0.056 inch (1.42 mm) if zinc-coated or thinner steel or wire mesh of 14 AWG (1.63 mm diameter) or smaller wire shall not be used to enclose an opening of more than 80 square inches (0.052 m²).

6.15 revised May 28, 2004

6.16 The wires of a screen of a ventilating opening shall not be smaller than 16 AWG (1.29 mm diameter) if the screen openings are 1/2 square inch (323 mm²) or less in area, and not smaller than 12 AWG (2.05 mm diameter) for larger screen openings. A supplementary screen of smaller openings may be additionally provided. The supplementary screen is not to be considered in the evaluation of the ventilating opening screen.

6.16 revised May 28, 2004

6.17 Perforated sheet steel and sheet steel employed for expanded-metal mesh shall not be less than 0.042 inch (1.07 mm) thick if uncoated, or 0.045 inch (1.14 mm) thick if zinc-coated, if the mesh openings or perforations are 1/2 square inch (323 mm²) or less in area, and shall be not less than 0.080 inch (2.03 mm) thick if uncoated or 0.084 inch (2.13 mm) thick if zinc-coated for larger openings.

Exception: Where the indentation of a guard or enclosure cannot alter the clearance between uninsulated live parts and grounded metal so as to affect performance adversely or reduce spacings below the minimum values in Table 22.1, 0.020 inch (0.51 mm) if uncoated or 0.023 inch (0.58 mm) if zinc-coated expanded metal mesh may be employed. See 6.15.

6.18 A ventilating opening in the top of the enclosure shall be covered by a hood or protective shield spaced above the opening to reduce the possibility of the entry of foreign material.

6.19 An enclosure shall be marked with a type number indicating the external conditions for which it is acceptable. See Table 6.1. The marking may be on the inside or outside surface but shall be visible after installation. See 41.53.

Table 6.1
Enclosure types and tests

Table 6.1 revised October 12, 2007

Designation	Intended use and description	Requirement or qualification tests ^a
1	Indoor use primarily to provide protection against contact with the enclosed equipment and against a limited amount of falling dirt.	Rod Entry ^b and Rust Resistance or Corrosion Protection
2	Indoor use to provide a degree of protection against limited amounts of falling water and dirt.	Drip, Rod Entry ^b and Rust Resistance or Corrosion Protection
3	Outdoor use to provide a degree of protection against windblown dust and windblown rain; undamaged by the formation of ice on the enclosure	Outdoor Dust or Hose, Icing, Protection Against Corrosion and Rain
3R	Outdoor use to provide a degree of protection against falling rain; undamaged by the formation of ice on the enclosure.	Icing, Protection Against Corrosion, Rain and Rod Entry
3S	Outdoor use to provide a degree of protection against windblown dust, windblown rain, and sleet; external mechanisms remain operable while ice laden.	Outdoor Dust or Hose, Icing, Protection Against Corrosion and Rain
4	Either indoor or outdoor use to provide a degree of protection against falling rain, splashing water, and hose-directed water; undamaged by the formation of ice on the enclosure.	Hosedown, Icing and Protection Against Corrosion
4X	Either indoor or outdoor use to provide a degree of protection against falling rain, splashing water, and hose-directed water; undamaged by the formation of ice on the enclosure; resists corrosion.	Hosedown, Icing, and Protection Against Corrosion
6	Indoor or outdoor use to provide against the entry of water during temporary, limited submersion, undamaged by the formation of ice on the enclosure.	Icing, Protection Against Corrosion and Submersion
6P	Indoor and outdoor use to provide a degree of protection against the entry of water during prolonged submersion at limited depths.	Air Pressure, Icing and Protection Against Corrosion
12, 12K	Indoor use to provide a degree of protection against dust, dirt, fiber flyings, dripping water, and external condensation of noncorrosive liquids	Indoor Dust or Atomized Water, Drip and Rust Resistance or Corrosion Protection

Table 6.1 Continued

Designation	Intended use and description	Requirement or qualification tests ^a
13	Indoor use to provide a degree of protection against lint, dust seepage, external condensation and spraying of water, oil, and noncorrosive liquids.	Oil and Rust Resistance or Corrosion Protection
^a For description of tests, see the Standard for Enclosures for Electrical Equipment, UL 50. ^b For description of tests, see 6.10.		

6.20 An enclosure that complies with the requirements for more than one type of enclosure may have multiple designations.

6.21 An enclosure marked Type 3, 3S, 4, 4X, 6, or 6P may additionally be marked "Raintight" or "Rainproof". An enclosure marked Type 3R may additionally be marked "Rainproof". See 41.53.

6.22 An external operating means – such as those for a disconnect, a pilot device, or a resetting operation – mounted on or through an enclosure shall withstand the tests specified for the enclosure.

6.23 Marking and instructions on the exterior of an enclosure shall be permanent. See 42.1.

6.24 An enclosure shall be subjected to the tests specified in Table 6.1, and shall comply with the construction requirements applicable to an enclosure of the type number or numbers with which it is marked.

6.24 revised October 12, 2007

6.25 A watertight connection at conduit entrances shall be a conduit hub or the equivalent, such as a knockout or fitting, located so that when conduit is connected and the enclosure is mounted in the intended manner, the enclosure is found to be acceptable when subjected to the tests specified in Table 6.1.

6.25 revised October 12, 2007

7 Connections for Wiring Systems

7.1 If knockouts are provided in the enclosure of transfer switches, 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 in Spacings, Section 22, when they are reamed for the size of conduit required for the maximum number and gauge of wires necessitated by the switch rating.

7.2 A conduit hub for rigid conduit shall be threaded. The hub shall have a wall thickness not less than that of the corresponding trade-size of rigid conduit before the hub is threaded. The conduit hub shall not depend upon friction alone to prevent its turning, and shall comply with Section 38B, Conduit Hub Secureness Test. See Conduit Hub Secureness Test, Section 38B.

7.2 revised October 12, 2007

7.3 A tapped hole for the attachment of threaded rigid conduit shall be provided with:

- a) An end-stop, or shall be so located that a standard bushing may be attached to the end of the conduit, and
- b) A tapered thread in equipment for outdoor use, if not provided with an end stop, and
- c) At least three full threads when tapped all the way through the wall of an enclosure, or with at least 3-1/2 full threads and a smooth, well-rounded inlet hole having a diameter approximately the same as the internal diameter of a standard bushing to provide protection for the conductors equivalent to that provided by such a bushing.

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8 Corrosion Protection

8.1 Iron and steel parts other than bearings and so forth, where such protection is impracticable, shall be protected against corrosion by enameling, galvanizing, Sherardizing, plating, or other equivalent means.

8.2 The requirement of 8.1 applies to all enclosing cases whether of sheet steel or cast iron, and to all springs and other parts upon which proper mechanical operation may depend. It does not apply to parts such as washers, screws, bolts, and the like, if any damage of such unprotected parts would not be likely to result in the equipment being affected adversely. Parts made of stainless steel (properly polished or treated, if necessary) do not require additional protection against corrosion. Bearing surfaces should be of such materials and construction to resist binding due to corrosion.

9 Insulating Material

9.1 Material for the support of uninsulated live parts shall be porcelain, phenolic or cold molded composition, or other material acceptable for the support of such parts, and shall be capable of withstanding the most severe conditions likely to be met in service.

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

10 Bases

10.1 A base, if consisting of a flat sheet of impregnated asbestos cement or phenolic composition, shall not be less in thickness than indicated in Table 10.1.

Table 10.1
Thickness of bases

Maximum dimensions of base in inches (mm)	Minimum acceptable thickness of base in inches ^a (mm) ^a
15 x 24 (381 x 610)	3/8 (9.5)
24 x 48 (610 x 1220)	1/2 (12.7)
36 x 48 (914 x 1220)	5/8 (15.9)
larger than 36 x 48 (914 x 1220)	3/4 (19.1)
^a Material of less thickness is acceptable if found to have the strength and rigidity required for the application.	

10.2 A live screwhead or nut on the underside of a base designed for surface mounting shall be counter-sunk not less than 1/8 inch (3.2 mm) in the clear, and covered to a depth of not less than 1/8 inch (3.2 mm) with a waterproof, insulating sealing compound.

Exception: If the screw or nut is prevented from loosening by being staked or upset, by a lock washer, or by other means, it may be insulated from the mounting surface by material other than sealing compound or by providing a spacing from the mounting surface not less than that indicated in Table 22.1.

10.3 The sealing compound mentioned in 10.2 shall not melt at a temperature 15°C (27°F) higher than its operating temperature, and not less than 90°C (194°F) in any case.

10.4 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(1992).

11 Mounting of Parts

11.1 All parts of transfer switches shall be securely mounted in position and prevented from loosening or turning if such motion may affect adversely the intended performance of the equipment, or may affect the risk of fire and injury to persons incident to the operation of the equipment.

11.2 Uninsulated live parts other than pressure wire connectors, shall be secured to their supporting surfaces so that they will be prevented from turning or shifting in position if such motion may result in a reduction of spacings to less than those indicated in Table 22.1. The security of contact assemblies shall be such as to provide the continued alignment of contacts. See 22.17.

11.3 Friction between surfaces is not acceptable as a means to prevent turning, loosening, or shifting of a part as required in 11.1 and 11.2, but a lock washer, properly applied, may be accepted.

12 Guarding and Accessibility of Live Parts

12.1 Uninsulated live parts of control circuits mounted on doors shall be guarded or enclosed, to reduce the risk of unintentional contact, when the door is opened for maintenance of equipment or removal of drawout equipment.

Exception: Uninsulated live parts of control circuits that operate at less than 30 V and are supplied in accordance with 22.10 need not be so guarded or enclosed.

12.1 revised October 12, 2007

12.2 Any barrier intended to be removed during routine maintenance or servicing shall be marked in accordance with 41.52.

12.2 revised February 12, 1999

13 Current-Carrying Parts

13.1 A current-carrying part shall have mechanical strength and current-carrying capacity for the service, and shall be of metal that is acceptable for the particular application.

13.2 If parts are held together by screws, a threaded part shall have no fewer than two full, clean-cut threads engaged. If the screw does not extend all the way through a threaded part, the taper or lead and the first full thread are to be disregarded in a determination of the number of threads engaged.

14 Installation-Wiring Connections

Section 14 deleted September 18, 1996



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15 Field Wiring Terminals

15.1 Transfer switch equipment shall be provided with terminals (pressure wire connectors) for the connection of each conductor intended to be field installed. The terminals shall be sized to accommodate conductors having an ampacity equal to or greater than the current rating of the circuit for which they provide connection.

Exception No. 1: A wire binding screw is not prohibited from being provided as noted in 15.6.

Exception No. 2: No terminals are required in a transfer switch intended for connection to bus bars.

Exception No. 3: Terminal connectors for field connection (line or load) are not required to be provided when all the following conditions are met:

- a) Component terminal assemblies shall be available from the transfer switch manufacturer, or one or more pressure terminal connectors shall be specified for field installation on the transfer switch;*
- b) Fastening devices such as studs, nuts, bolts, washers, and similar parts, 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 transfer switch; and*
- c) Marking is provided in accordance with 41.42 and 41.43.*

15.1 added September 18, 1996

15.2 With reference to conductor ampacity in 15.1, sizes of field-installed conductors shall be determined as follows. For current specified in Table 15.1:

- a) 75°C (167°F) ampacity shall be used for 1/0 AWG (53.5 mm²) or larger conductors and
- b) 60°C (140°F) ampacity shall be used for 1 AWG (42.2 mm²) or smaller conductors.

Exception: 75°C ampacity shall be used for 1 AWG or smaller conductors when the switch is marked 75°C wire in accordance with 41.40.

15.2 revised May 28, 2004

Table 15.1
Ampacity of insulated conductors^{a,b}

Table 15.1 added September 18, 1996

Wire size		60°C (140°F)		75°C (167°F)	
AWG or kcmil	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	125	100	150	120
2/0	67.4			175	135
3/0	85			200	155
4/0	107.2			230	180
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
1000	507			545	445
1250	633			590	485
1500	760			625	520
1750	887			650	545
2000	1010			665	560

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

^b These values of ampacity apply only when not more than 3 conductors are intended to be field installed in the conduit. When 4 or more conductors, other than a neutral that carries the unbalanced current, are intended to be installed in a conduit (which is possible because of the number of conduit hubs provided in an outdoor switch, because the number of wires in certain polyphase systems, or other reasons) the ampacity of each of those conductors is 80 percent of the value given in the table when 4 – 6 conductors are involved, and 70 percent of that value when 7 – 24 conductors are involved.

15.3 A wiring terminal without a marked wire size range shall hold the next larger size conductor than that specified in 15.2 when the terminal is sized to receive the larger size conductor.

Exception: This requirement does not apply to equipment marked to restrict its use to the smaller size conductor.

15.3 added September 18, 1996

15.4 The terminal (pressure wire connector) provided shall be the same type as employed during the short-circuit test.

Exception No. 1: Alternate wire connectors are not prohibited from being used in a transfer switch without conducting a short circuit test when the short circuit current let-through divided by the number of conductors per phase results in a current of 50,000 A RMS (70,700 A peak) per conductor or less, and the short circuit current rating of the transfer switch is less than 100,000 A RMS.

Exception No. 2: Alternate wire connectors are not prohibited from being used in a transfer switch in which the short circuit current rating per conductor is greater than 50,000 A without conducting a short circuit test providing the short-circuit current rating of the transfer switch is less than 100,000 A, and the following conditions are met:

a) The number of conductors per lug is equal to or greater than the number of conductors as tested and

b) The average pullout force – in accordance with the Standard for Wire Connectors, UL 486A-486B – of three samples of the alternate wire connector is equal to or greater than the average pullout force of three samples of the wire connectors used in the short circuit test.

15.4 revised May 28, 2004

15.5 Pressure wire connectors shall be employed for 8 AWG (8.4 mm²) and larger conductors. For 10 AWG (5.3 mm²) and smaller wires, the parts to which wiring connections are made shall consist of clamps or binding screws with terminal plates having upturned lugs or the equivalent to hold the wires in position.

15.5 revised May 28, 2004

15.6 If a wire-binding screw is employed, the screw shall not be smaller than No. 8 (4.2 mm diameter); except that a No. 6 screw (3.5 mm diameter) may be used for the connection of a 14 AWG (2.1 mm²) or smaller conductor.

15.6 revised May 28, 2004

15.7 A wire-binding screw shall thread into metal.

15.8 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick for a No. 8 (4.2 mm diameter) or larger screw, and not less than 0.030 inch (0.76 mm) thick for a No. 6 (3.5 mm diameter) screw, and shall have no fewer than two full threads in the metal.

Exception: A terminal plate may have the metal extruded at the tapped hole for the binding screw so as to provide two full threads. Other constructions may be employed if they provide equivalent ruggedness of the terminal plate and thread security of the wire-binding screw.

15.9 A pressure wire connector provided with or specified for use with a transfer switch shall comply with the Standard for Wire Connectors, UL 486A-486B.

15.9 revised May 28, 2004

15.10 The tightening torque for a field-wiring terminal shall be as specified by the transfer switch manufacturer and shall be marked as required by 41.51. 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, UL 486A-486B, for that wire size corresponding to the ampere rating of the transfer switch. See 38.1.

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

15.10 revised May 28, 2004

15A Field Wiring Leads

Added Section 15A effective June 29, 2002

15A.1 The requirements described in 15A.2 - 15A.5 apply to leads provided at the factory for wiring in the field:

15A.2 The field wiring leads of a transfer switch shall be sized in accordance with Table 15.1.

15A.3 A field wiring lead shall be provided with strain relief. The strain relief shall reduce transmittal of forces due to compression, tension or rotation to the leads of terminals, splices, or wiring within the switch. The strain relief shall reduce the likelihood of displacement that is able to result in:

- a) Mechanical damage to the leads,
- b) Exposure of the leads to a temperature higher than its rated temperature,
- c) Reduction of spacings that force the lead to contact other than intended live parts, or
- d) Other detrimental affects.

15A.4 The strain relief mentioned in 15A.3 shall withstand the stress of normal handling without damage to itself or the equipment. See Strain Relief Tests for Leads, Section 38A.

15A.5 Green coloring with or without one or more yellow stripes and white or gray coloring shall not be used for the covering of a conductor unless intended for connection to grounding and grounded conductors respectively.

15A.5 revised May 28, 2004

15A.6 The free length of a wiring lead shall be as required for the application, but not less than 6 inches in length.

15B Conduit

Added Section 15B effective June 29, 2002

15B.1 When conduit is supplied at the factory, the size, length, wiring ampacity, and fittings shall comply with the requirements of Chapter 3 of the National Electrical Code, ANSI/NFPA 70.

15B.2 If leads are provided and brought out through factory-attached conduit, a conduit fitting shall be provided at the free end of the conduit, or the conductor insulation at the free end of the conduit shall be protected from the sharp edges of the conduit during shipping by means of a tape wrap, a fiber bushing secured in place, or the equivalent.

15B.3 If conduit is supplied, the enclosure shall be accessible to tighten the locknut of the conduit or conduit fitting.

Exception No. 1: Access to the fitting or locknut is not required if the conduit opening is threaded and complies with the Standard for Electrical Enclosures, UL50.

Exception No. 2: Access to the fitting or locknut is not required if a conduit hub is used.

16 Internal Wiring

16.1 The internal wiring of transfer switches shall consist of general use wire or appliance wiring material acceptable for the particular application when considered with respect to the temperature and voltage and conditions of service to which the wiring is likely to be subjected.

16.2 Appliance wiring material of one or more of the types indicated in Table 16.1 may be used for internal wiring when considered with respect to the requirements in 16.1.

16.3 Appliance wiring material having lesser thicknesses of insulation than those indicated in Table 16.1 may be used for a particular application, provided the insulation, when considered with respect to temperature and voltage and condition of service, is equivalent to one of those given in that table.

Table 16.1
Appliance-wiring material

Type of insulation	Minimum acceptable thickness of insulation	
	600-V applications	300-V applications
Thermoplastic	0.028 inch (0.71 mm)	0.028 inch (0.71mm) ^a
Rubber	0.028 inch (0.71 mm) plus an impregnated- braid cover	0.013 inch (0.33 mm) plus an impregnated- braid cover, or 0.028 inch (0.71 mm) without a braid cover
Neoprene	0.041 inch (1.04 mm)	0.013 inch (0.33 mm) plus an impregnated- braid cover, or 0.028 inch (0.71 mm) without a braid cover
Silicone	0.028 inch (0.71 mm) plus an impregnated-braid cover	0.013 inch (0.33 mm) plus an impregnated- braid cover, or 0.028 inch (0.71 mm) without a braid cover ^b
	0.028 inch (0.71 mm) without a braid cover ^b	
^a May be 0.013 inch (0.33 mm) only for short, moving pigtails or coil leads in a small device, provided such leads make no more than casual contact with parts of opposite polarity and with grounded parts.		

Table 16.1 Continued

Type of insulation	Minimum acceptable thickness of insulation	
	600-V applications	300-V applications
^b Only if routed away from live parts of opposite polarity and protected from mechanical damage both during installation of field wiring and while in operation, unless material has resistance to mechanical damage equivalent to 0.028 inch (0.71 mm) with braid.		

16.4 Supplementary insulation, such as coated-fabric or extruded thermoplastic insulating tubing, shall not be adversely affected physically or electrically by the temperature to which it may be subjected in service.

16.5 Wireways shall be smooth and entirely free from sharp edges, burrs, fins, moving parts, and the like, which may cause abrasion of the conductor insulation. Holes in sheet-metal walls through which insulated wires pass shall be provided with a bushing if the wall is 0.042 inch (1.06 mm) or less thick. Holes in walls thicker than 0.042 inch shall have smooth, well-rounded edges.

16.6 All joints and connections shall be mechanically secure and shall provide effective electrical contact without strain on connections and terminals.

16.7 Stranded conductors clamped under wire-binding screws or similar parts shall have the individual strands restrained by being soldered together or by cupped washers or the equivalent to provide connections.

16.8 A splice shall be provided with insulation equivalent to that of the wires involved.

17 Grounding and Bonding

17.1 Transfer switches shall have provision for grounding all dead metal parts that are exposed or that are likely to be touched by a person during adjustment or intended operation of the device, and that are likely to become energized.

17.2 Small, isolated (insulated) dead metal parts are not required to be grounded.

17.3 The provision of a knockout or other opening in a metal enclosure for the connection of armored cable, conduit, metal raceway, or the like is acceptable as means for grounding.

17.4 A transfer switch marked as being acceptable for use as service equipment 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 17.1. A soldering lug or other connection means that depends upon solder is not acceptable.

17.5 The provision for connection of the grounding-electrode conductor mentioned in 17.4 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.

17.6 A transfer switch that is marked for service equipment use shall have a terminal for a grounded service conductor even though it has no provision for a load conductor to be connected to the grounded service conductor. If there is no provision for such a grounded load conductor, the grounded service conductor terminal shall:

- a) Accommodate a conductor of the same size as the main bonding jumper specified in Table 17.1,
- b) Be bonded to the enclosure, or have provisions for being bonded, and
- c) Be directly connected to the grounding electrode conductor terminal, or have provisions for being directly connected to the grounding electrode conductor terminal.

Exception: The terminals may be omitted if the transfer switch is marked as covered in 41.10.

17.6 revised October 12, 2007

Table 17.1
Size of grounding electrode conductors and main bonding jumper

Table 17.1 revised May 28, 2004

Ampere rating not exceeding	Size of main bonding jumper (minimum) ^{e,g,h}		Cross section of main bonding jumper in square inches (mm ²) (minimum) ^{e,g}				Size of grounding electrode conductor (minimum)	
	Copper	Aluminum	Copper		Aluminum		Copper	Aluminum
90	8 AWG	6 AWG	0.013 ^a	(8.4) ^a	0.021 ^a	(13.5) ^a	8 AWG	6 AWG
100	6	4	0.021 ^a	(13.5) ^a	0.033 ^a	(21.3) ^a	6	4
125	6	4	0.021 ^a	(13.5) ^a	0.033 ^a	(21.3) ^a	6	4
150	6	4	0.021 ^b	(13.5) ^b	0.033 ^b	(21.3) ^b	6	4
200	4	2	0.033 ^b	(21.3) ^b	0.052 ^b	(33.5) ^b	4	2
225	2	0	0.052 ^{c,d}	(33.5) ^{c,d}	0.083 ^{c,d}	(53.5) ^{c,d}	2	0
400	0 ^f	3/0 ^f	0.083 ^{d,f}	(53.5) ^{d,f}	0.132 ^{d,f}	(85.2) ^{d,f}	0 ^f	3/0 ^f
500	0	3/0	0.083	(53.5)	0.132	(85.2)	0	3/0
600	2/0	4/0	0.105	(67.7)	0.166	(107)	2/0	4/0
800	2/0	4/0	0.105	(67.7)	0.166	(107)	2/0	4/0
1000	3/0	250 MCM	0.132	(85.2)	0.196	(126)	3/0	250 MCM
1200	250 MCM	250	0.177	(114)	0.196	(126)	3/0	250
1600	300	400	0.236	(152)	0.294	(190)	3/0	250
2000	400	500	0.294	(190)	0.353	(228)	3/0	250
2500	500	700	0.353	(228)	0.515	(332)	3/0	250
3000	600	750	0.412	(266)	0.589	(380)	3/0	250
4000	750	1000	0.589	(380)	0.810	(523)	3/0	250

^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 or larger brass or steel screw may be used.

^c A No. 10 or larger brass screw may be used.

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

^e The cross section may be reduced to 12.5 percent of the total cross section of the largest main service conductor(s) of the same material (copper or aluminum) for any phase on service equipment rated 1200 A and above. This applies when the cross section of the service conductors is limited by the wire terminal connectors provided.

^f 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 conductor but will not accept a 600 MCM conductor, these values may be reduced to 2 AWG (0.052 square-inch) (33.5 mm²) copper or 0 AWG (0.083 square-inch) (53.5 mm²) aluminum.

^g For service equipment rated 1200 A or more that has wiring terminals intended to connect service conductor wires sized larger than 600 MCM copper or 750 MCM aluminum, the cross section of the main bonding jumper shall be at least 12.5 percent of the total cross section of the largest main service conductor(s) of the same material (copper or aluminum) for any phase.

^h These are also sizes for the grounded service conductor of 17.5.

17.7 A transfer switch marked as being acceptable for service equipment shall be provided with a main bonding jumper consisting of a separate screw, strap, or other means to bond the enclosure to the grounded circuit conductor of an alternating-current circuit, and the construction shall be such that when the bonding means is not used, the spacings given in Table 22.1 will exist. Unless the intended use and method of installation of the bonding means are obvious, instructions for its installation shall be provided.

17.8 If there is provision for a load conductor to be connected to the grounded service conductor, a conductor or terminal connected to the grounded service conductor shall be insulated from the enclosure as the unit is shipped from the factory.

17.9 The main bonding jumper shall be of copper or aluminum and shall have a cross sectional area as specified in Table 17.1.

Exception: Steel or brass screws may be used as covered in the footnotes of Table 17.1.

18 Disconnecting Means

18.1 If a transfer switch, that is marked to indicate it is acceptable for use as service equipment, has provision for the connection of a grounded load conductor and does not interrupt the grounded load conductor, other means shall be provided for disconnecting the grounded service conductor from the load conductor.

18.2 The disconnecting means required in 18.1 may be a link or similar conducting piece constructed to make connection between two terminals or it may be a terminal plate or stud provided with wire connectors.

18.3 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 that the grounded load conductor can be removed without disturbing any other conductors.

18.4 If a disconnecting means as described in 18.2 is provided, there shall be provision for the separate connection of the grounded line and load conductors.

18.5 The grounding-electrode conductor terminal covered in 17.4 and the main bonding jumper covered in 17.5 shall connect to the neutral on the supply side of the service disconnecting means for the neutral covered in 18.1. See 17.5.

19 Operating Mechanism

19.1 The operating mechanism of a transfer switch shall be constructed to provide reliable and positive electrical and mechanical performance under all conditions of intended operation.

19.2 Provision shall be made to reduce the possibility of adjusting screws and similar adjustable parts from loosening under the conditions of actual use.

19.3 An automatic transfer switch shall incorporate the required control equipment to initiate transfer from the normal supply to the alternate supply upon the interruption of any or all phases of the normal supply.

19.3 revised September 18, 1996

19.4 An automatic transfer switch shall be permitted to be additionally controlled by equipment to provide a time delay in either or both directions of transfer. Equipment shall also be permitted to be provided to initiate transfer under low normal voltage conditions and by voltage-frequency measurement in the alternate supply.

19.4 revised September 18, 1996

19.5 Other than as allowed by 19.6 and 19.10, the operating mechanism shall be such that the load cannot remain simultaneously disconnected from both the normal and alternate supplies when either or both supplies are available with voltage and frequency sufficient to permit proper operation. If intended for use with paralleled engine generator sets, transfer to the generator source or sources may be inhibited until sufficient power for the connected load is available. See 41.18 and 41.19.

Exception: In the case of a transfer switch limited to use on optional standby systems in accordance with Article 702 of the National Electrical Code, ANSI/NFPA 70, the operating mechanism is allowed to disconnect both the normal and alternate supplies, regardless of supply availability, as long as this intentional neutral position is factory-installed in the mechanism and can be reliably maintained.

19.5 revised October 12, 2007

19.6 The mechanism of a transfer switch intended for use with paralleled engine-generator sets as indicated in 19.5 may be arranged to disconnect from the alternate source (generators) in the event of shut down of one or more of the paralleled engine-generator sets.

19.7 The operating mechanism of the normal and emergency contacts of an automatic transfer switch for use in emergency systems shall be electrically operated.

Added 19.7 effective September 18, 1997

19.8 The normal and emergency contacts of an automatic transfer switch intended for use in emergency systems shall be mechanically held in a closed position.

Added 19.8 effective September 18, 1997

19.9 A transfer switch marked for service equipment use in accordance with 41.3, or 41.5 shall be provided with an externally accessible, manually operable means to disconnect all ungrounded supply conductors of both the normal and the alternate sources under any condition of the normal and alternate supplies.

Exception No. 1: An electrically operated switch or circuit breaker need not be capable of being externally disconnected by hand if it can be manually disconnected after opening a door.

Exception No. 2: The disconnecting means for control circuit conductors need not be externally accessible when all of the following conditions are met:

- a) The transfer switch is marked as shown in 41.57;*
- b) The transfer capability is disabled when both normal and alternate power disconnects are open;*
- c) The disconnecting means is accessible by opening the enclosure or removing a deadfront; and*
- d) The construction complies with the exception to 19.12.*

Exception No. 3: A transfer switch may be provided with a single disconnect on the normal source only when the alternate source is intended to be a feeder and the transfer switch is marked in accordance with 41.58.

19.9 revised October 12, 2007

19.9.1 An externally operable disconnect means shall be capable of being operated without exposing the operator to contact with live parts.

19.9.1 added October 12, 2007

19.10 A transfer switch that incorporates integral overcurrent protective devices in the main power circuits and that will not automatically transfer from one source to another as a result of the opening of one or more of these overcurrent devices shall be marked in accordance with 41.19.

19.11 An automatic transfer switch may be arranged with overlapping contacts to provide closed transition between synchronized supplies (alternate supply is closed before normal supply is opened). The control circuit of such an automatic transfer switch shall be arranged to cause transfer to the available supply if only one supply is available and to prevent transfer in either direction if both supplies are available unless they are synchronized. Such a switch shall be marked in accordance with 41.54.

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19.12 A transfer switch provided with means to permit manual operation of the mechanism shall have such means externally operable without opening the enclosure.

Exception: A transfer switch having manual operating means provided for maintenance and servicing which is accessible only by opening the enclosure, shall have all arcing parts, except the control circuit, shielded to protect the operator against arcing in the event of an inadvertent operation of the switch under load. The manual operating means, including the control circuit, shall be so located with respect to other components that it is accessible for operation without subjecting the operator to the risk of electric shock or injury from adjacent moving parts. In addition, a switch having manual operating means shall be marked to indicate that an adverse condition may develop if the switch operates under load. See 41.11.

19.13 A transfer switch having an external manual operating means that can permit opening or closing of the switch contacts at a rate of speed substantially slower than that caused by the automatic operating means shall be additionally investigated. See 28.3.

19.14 A quick-make quick-break mechanism is considered to comply with 19.11 without further investigation.

19.15 Means shall be provided to reduce the possibility of automatic operation during the manual transfer if automatic operation can result in risk of electric shock or injury to operating personnel.

19.16 If the means used to comply with 19.15 renders the control circuit non-functional, audio, or visual signals or equivalent means shall be provided to indicate the status of the control circuit.

19.17 The operating mechanism shall be interlocked to reduce the possibility of simultaneous connection to both the normal and alternate supplies.

Exception: Closed transition switches are allowed to be simultaneously connected to both supplies as indicated in 19.11.

Revised 19.17 effective September 18, 1997

19.18 Where an electric interlock is provided, the circuit wiring shall be factory connected and located entirely within the transfer switch enclosure. It shall be additionally protected from possible damage due to the operation of the transfer mechanism or during any servicing of the switch.

19.18 revised May 28, 2004

19.19 The electric interlocking system described in 19.18 shall be evaluated to the requirements of the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

19.19 revised May 28, 2004

19.20 The electric interlock system described in 19.18 shall be provided with an alarm or test means to indicate an inoperative condition of the interlocking system, if the failure analysis indicated in 19.19 results in showing that a single failure renders the system inoperative.

19.20 revised May 28, 2004

19.21 The interlocking mechanism shall continue to operate in the intended manner at the conclusion of the performance tests. In addition, all wiring connections shall be examined to determine that there has been no adverse effect – for example, connections should not become loose, parts should not rotate, and the like.

19.22 The mechanism and interlocking means shall be constructed to reduce the possibility of transfer in either direction in the event of welding of one or more contacts in the power circuit.

19.23 An automatic transfer switch shall be provided with at least one manually operated dead front test switch to simulate loss of the normal supply or provision shall be made for the connection of a remote test switch or switches.

19.23 revised May 28, 2004

19.24 Circuits for remote test switches for automatic transfer switches shall be arranged so that shorting or opening of the circuit or test switch does not reduce the possibility of transfer to the alternate source in the event of loss of the normal source.

19.24 revised September 18, 1996

19.25 Control circuits that are depended upon for the proper operation of a transfer switch shall be located wholly within the transfer switch enclosure and shall not have overload protective devices connected in them but may have short-circuit and ground-fault protection.

Exception No. 1: The control circuit of a transfer switch shall have short-circuit protection and a disconnecting means suitable for the available current of the supply if the transfer switch is marked for service equipment use in accordance with 41.3 or 41.5 and its control circuit is connected ahead of the service disconnecting means.

Exception No. 2: There may be provision for extending the control circuits from a transfer switch to an adjacent by-pass/isolation switch or to (an) external engine-generator set(s), if a marking indicates that the control circuit wiring is to be in conduit. See 41.28.

Exception No. 3: In a transfer switch limited to use on an optional standby systems in accordance with Article 702 of the National Electrical Code, the control circuit may extend outside the enclosure if misoperation of the circuit cannot result in asynchronous paralleling of the two sources.

19.25 revised October 12, 2007

19.26 If an electrical motor on a drive mechanism is provided with overload protection, the motor shall be protected against locked-rotor burnout only.

19.27 To be in compliance with 19.26 the overload protector shall not open during the endurance test.