Association of Standardization and Certification
NMX-J-162-ANCE-2016
Fourth Edition

CSA Group
CSA-C22.2 No. 4-16
Eighth Edition

Underwriters Laboratories Inc.
UL 98
Fourteenth Edition

Enclosed and Dead-Front Switches

February 12, 2016

(Title Page Reprinted: January 16, 2023)

Approved American National Standard

ANSI/UL 98-2023

Standard for Safety for Enclosed and Dead-Front Switches

Eighth Edition, Dated February 12, 2016

Summary of Topics

This revision dated January 16, 2023 includes the following changes in requirements:

– Barriers to Address Inadvertent Contact on Line Side of Service Disconnect; 6.4.2 – 6.4.5, 9.2.64, and Figure 6.

– Revision of Values for Dielectric Test Frequencies; 6.6.2.5, 7.5.1, and 7.6.1

– Overload and Endurance Time Constant Correction/Addition; 7.3.1.1, 7.3.1.2, 7.3.2.3, 7.4.1.

Commitment for Amendments

This standard is issued jointly by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (operating as “CSA Group”), and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to ANCE, CSA Group, or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of ANCE, CSA Group, and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue. ANCE will incorporate the same revisions into a new edition of the standard bearing the same date of issue as the CSA Group and UL pages.

ISBN 978-1-77139-928-9 © 2016 Canadian Standards Association

This Standard is subject to review five years from the date of publication, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquiries@csagroup.org and include "Proposal for change" in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

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This ANSI/UL Standard for Safety consists of the Fourteenth edition including revisions through January 16, 2023. The most recent designation of ANSI/UL 98 as an American National Standard (ANSI) occurred on January 16, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

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Preface

This is the harmonized ANCE, CSA Group, and UL standard for *Enclosed and Dead-Front Switches*. It is the Fourth edition of NMX-J-162-ANCE, the Eighth edition of CSA C22.2 No. 4, and the Fourteenth edition of UL 98. This harmonized standard has been jointly revised on January 16, 2023. For this purpose, CSA Group and UL are issuing revision pages dated January 16, 2023, and ANCE is issuing a new edition dated January 16, 2023.

This harmonized standard was prepared by the Association of Standardization and Certification (ANCE), CSA Group, and Underwriters Laboratories Inc., (UL). The efforts and support of the Technical Harmonization Committee for Enclosed Switches, of the Council on the Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA), are gratefully acknowledged.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

This standard was reviewed by the CSA Subcommittee on Enclosed and Dead-Front Switches, under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee.

Where reference is made to a specific number of samples to be tested, the specified number shall be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of harmonization

This standard uses the IEC format but is not based on, nor is it considered equivalent to, an IEC standard. This standard is published as an equivalent standard for ANCE, CSA Group, and UL.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

Reasons for differences from IEC

The THC determined the safe use of enclosed and dead-front switches is dependent on the design and performance of the products in relation to the North American Electrical Codes with which they are intended to be installed.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

6.3.9 A switch so constructed that it will tend to close by gravity shall be provided with means for holding the operating mechanism in the off position.

6.3.10 Switches rated greater than 250 V, 30 A shall have the design of the operating mechanism in conjunction with the contact structure, such that in normal operation, the operator of the switch cannot restrain the operation of the contacts after they have initially touched or parted when closing or opening the switch. Isolating switches complying with 6.3.8 and 9.2.12 are exempt from this requirement.

6.4 Accessibility of live parts

6.4.1 Openings in enclosures that provide access to live parts shall be evaluated in accordance with Annex A, Ref. No. 14.

6.4.2 Enclosed 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 or fuseholder, 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 6. 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 8 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 enclosed switches suitable for more than one type of fuse or terminals, 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. In Canada, refer to CSA Z462, Workplace electrical safety.

6.4.3 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 they 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.

NOTE: 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.

6.4.4 Nonmetallic barriers provided to limit exposure to inadvertent contact shall:

a) Comply with requirements in 6.6.2.6 for barriers used in conjunction with a minimum air space of 0.013 inch (0.33 mm).

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

NOTE: 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.

6.4.5 Enclosed switches marked “Suitable for use as service equipment” shall be permitted to provide the protection from inadvertent contact in 6.4.2 in a field installable kit when marked in accordance with 9.2.64.

6.6.2.3 A barrier located between the enclosure and an uninsulated live part electrically connected to a grounded circuit conductor (neutral) may be of vulcanized fiber.

6.6.2.4 A barrier material having values below those contained in Table 1 may be accepted based on acceptable end-product performance tests.

6.6.2.5 A barrier of insulating material other than vulcanized fiber may have a thickness less than 0.71 mm (0.028 inch) if it withstands a 48 – 62 Hz dielectric-withstand voltage of 5 000 V applied in accordance with 7.14.

6.6.2.6 A barrier used in conjunction with a minimum air space of 0.33 mm (0.013 inch) shall be:

a) Of material that has insulating properties as specified in 6.5.1 or, other than vulcanized fiber, complying with Table 5,

b) Of such strength to withstand the stress associated with normal handling, installation, and use of the equipment,

c) Secured in place,

d) Located so that it will not be adversely affected by operation of the equipment in service, and

e) Of a minimum thickness of 0.71 mm (0.028 inch).

6.6.2.7 Vulcanized fiber with a minimum thickness of 0.71 mm (0.028 inch) and used in conjunction with a minimum 0.71 mm (0.028 inch) air space need not comply with 6.5.1.

6.6.2.8 Material other than vulcanized fiber used in conjunction with an air space of 50% or more of the required through air spacing may have a thickness:

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

b) Less than 0.33 mm (0.013 inch) if it withstands a 60 Hz dielectric-withstand voltage of 2 500 V applied in accordance with the requirements in 7.14.

6.6.2.9 A barrier material having values below those contained in Table 5 may be accepted based on acceptable end-product performance tests.

Table 5
Minimum values for insulating barriers used in place of spacing in conjunction with minimum air space of 0.33 mm (0.013 inch)

Test specified[f]	Flammability rating of material[e]			
	V-0 or VTM-0	V-1 or VTM-1	V-2 or VTM-2	HB
Hot wire ignition (HWI)[d], ignition time in sec. (Annex A, Ref. No. 3)	7	15	30	30
High current arc ignition (HAI)[c], number of arcs (Annex A, Ref. No. 10)	15	30	30	60
Comparative tracking index (CTI)[a] under moist conditions[b], Volts (Annex A, Ref. No. 2)	100	100	100	100
[a] Not applicable if the over-surface spacing is greater than or equal to 12.7 mm (1/2 inch).				
[b] Material surface is in contact with or in close proximity (within 0.8 mm (1/32 inch)) to:				

Table 5 Continued on Next Page

7.2.13 The deadfront switch being tested shall be mounted in the open, not in a panelboard, with the front in a vertical plane and the load terminals at one side. Connections shall be made with cables in accordance with 7.2.4, and loading shall be in accordance with 7.2.1 or 7.2.10 as appropriate. Where wire cannot be connected to the line end of the switch, copper bus bars shall be connected to the line terminals. The bus bars shall have an ampacity not more than the rating of the switch based on a current density not less than 1.55 A/mm^2 (1 000 A/in^2), shall extend approximately 76 mm (3 inches) beyond the switch enclosure, and shall terminate in wire connectors appropriate for the rating of the switch. Bus bars of cross-section other than specified above may be used if agreeable to the submitter and the testing agency.

7.2.14 Temperatures shall be recorded for the top two load terminals, on the top front corner of the wire connectors farthest from the center of the switch.

7.2.15 The same sample used in the test of 7.2.13 shall be tested in the same manner, except that the conductors to the lower switch pole shall be disconnected from the switch and reconnected together outside and below the switch enclosure or shell. Results shall be considered acceptable if the temperature rises on the top two load terminals are not higher than those observed in the test of 7.2.13.

7.2.16 A two-pole deadfront switch marked for multi-phase application having a steel shell as described in 7.2.12, and that has an enclosure smaller than the equivalent three-pole switch of the same voltage and ampere rating, shall be subjected to the test described in 7.2.13 except that

a) Dummy fuses shall be used in the two poles,

b) A 3-phase current shall be adjusted to 100 percent of the switch rating, and

c) The third-phase conductor shall be connected outside and below the enclosure or shell.

Results shall be considered acceptable if the temperature rises at the load terminals do not exceed 30°C. A switch employing Class L, C, or T fuses or 400 or 600 A Class J fuses shall be tested with fuses in place and when carrying 80 percent of its rated current. Results shall be considered acceptable if temperatures at the load terminals comply with Table 16.

7.3 Overload test

7.3.1 General

7.3.1.1 A general-use switch shall perform successfully when operated:

a) For 50 cycles,

b) Making and breaking 150 percent of its rated current, except as noted in 7.3.1.3 and 7.3.2.10,

c) With the rate of speed being the number of cycles per minute given in Table 19,

d) At the test voltage described in 7.3.2.4,

e) For ac rated switches, a load with a power factor of 0.75 – 0.80 maximum; and

f) For dc rated switches, with a noninductive resistance load.

There shall not be any electrical or mechanical malfunction of the device or welding of the contacts. The ground fuse shall not have opened. Burning or pitting of the contacts shall be considered to be acceptable, but line-to-line breakdown shall be considered to be unacceptable.

7.3.1.2 A horsepower- or kilowatt-rated switch shall perform successfully when operated:

a) For 50 cycles of operation for switches rated 74.6 kW or 100 horsepower or kilowatt and less, or 10 cycles of operations for switches rated over 74.6 kW or 100 horsepower,

b) Making and breaking current given in Table 17 and Table 18,

c) With the rate of speed being the number of cycles per minute given in Table 19 (operations with current); the switch rating in amperes shall be assumed to be equal to 60 percent of the required overload test current. A switch rated in excess of 74.6 kW or 100 hp need not be operated faster than 1 cycle per minute,

d) A test voltage as described in 7.3.2.4;

e) For ac rated switches, a load with a power factor of 0.45 – 0.50 maximum; and

f) For dc rated switches, a load with a time constant of not less than 0.003 seconds.

There shall not be any electrical or mechanical malfunction of the device or welding of the contacts. The ground fuse shall not have opened. Burning or pitting of the contacts shall be considered to be acceptable, but line-to-line breakdown shall be considered to be unacceptable.

Table 17
Overload-test currents in amperes for alternating-current switches

Switch in rating		120 V			240 V			480 V			600 V		
kW	hp	1φ	2φ 4-Wire	3φ	1φ	2φ 4-Wire	3φ	1φ	2φ 4-Wire	3φ	1φ	2φ 4-Wire	3φ
0.125	1/6	26.4	–	–	13.2	–	–	–	–	–	–	–	–
0.187	1/4	34.8	–	–	17.4	–	–	–	–	–	–	–	–
0.248	1/3	43.2	–	–	21.6	–	–	–	–	–	–	–	–
0.373	1/2	58.8	–	40	29.4	–	20	–	–	10	–	–	8
0.56	3/4	82.8	28.8	50	41.4	14.4	25	21	7.2	12.5	16.8	6	10
0.746	1	96	38.4	60	48	19.2	30	24	9.6	15	19.2	7.8	12
1.119	1-1/2	120	54	80	60	27	40	30	13.8	20	24	10.8	16
1.492	2	144	70.8	100	72	35.4	50	36	18	25	28.8	14.4	20
2.238	3	204	99.6		102	49.8	64	51	25.2	32	40.8	19.8	25.6
3.73	5	336	158		168	79.2	92	84	39.6	46	67.2	31.8	36.8
5.6	7-1/2	480	228		240	114	127	126	54	63.5	96	48	50.8
7.46	10	600	288		300	144	162	156	72	81	120	60	64.8
11.19	15		432			216	232		108	116		84	93
14.92	20		564			282	290		138	145		114	116
18.65	25		708			354	365		174	183		144	146
22.38	30		828			414	435		210	218		168	174
29.84	40		1 080			540	580		270	290		216	232
37.3	50		1 360			678	725		336	363		270	290
44.76	60						870			435			348
55.95	75						1 085			543			434
74.6	100						1 450			725			580

Table 17 Continued on Next Page

b) With the line connected to the hinge jaws and the load connected to the other set of contact jaws,

c) With the line connected to one set of contact jaws and the load connected to the hinge jaws, and

d) With the line connected to the other set of contact jaws and the load connected to the hinge jaws.

7.3.1.5 A double-throw switch for use as optional standby systems in accordance with Annex A, Ref. No. 1, shall be tested according to one of the following methods:

a) Subjected to the overload test using both sets of contacts simultaneously. During the test, the source of one set of contacts shall be displaced 120 electrical degrees from the source of the other set of contacts for a 3-phase supply or 180 electrical degrees for a single-phase supply.

b) If the double-throw switch is provided with a mechanical means to reduce the likelihood of the load switching from the normal source of supply to an alternate source of supply in one continuous motion, testing in accordance with 7.3.1.4 shall be permitted.

c) If the double-throw switch is constructed such that the movable contact of the normal supply is not in motion at the same time as the movable contact of the alternate supply, testing in accordance with 7.3.1.4 shall be permitted.

7.3.1.6 A cycle for a double throw-switch for use as optional standby systems in accordance Annex A, Ref. No. 1, is defined as making and breaking the required test current on both sets of contacts.

7.3.2 Test conditions

7.3.2.1 A switch shall be mounted as in actual service with the door or cover and any other openings closed. The line terminals shall be connected to a supply circuit, and the load terminals shall be connected to the necessary resistance or impedance.

7.3.2.2 A deadfront switch shall be mounted in a panelboard or on a representative chassis, provided spacings from live parts in the switch to the main bus structure and to grounded chassis metal are representative of those in the complete panelboard.

7.3.2.3 A switch intended for use on dc circuits and a switch not specially marked for alternating current only shall be tested with direct current, and with the device so connected that the enclosure will be positive in potential with respect to the nearest arcing point.

7.3.2.4 The open-circuit voltage shall not be less than 100 percent of the rated voltage of the switch, and the closed-circuit voltage shall not be less than 90 percent of the rated voltage of the switch or the normal-frequency recovery voltage shall be equal to the rated voltage of the device.

7.3.2.5 A switch intended for ac circuits only shall be tested with alternating current with an inductive load. The test shall be made on a circuit having a maximum frequency of 60 Hz. 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 following formula:

$$R_{SH} = 100[(1 / PF) - PF]E / I$$

in which PF is the power factor, E is the closed-circuit phase voltage, and I is the phase current.

7.3.2.6 A switch intended for use on circuits having one conductor grounded shall be tested with the enclosure connected through a 30 ampere non-delay, non-renewable-type 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 to ground.

7.3.2.7 A 2-wire and a 3-wire switch intended for use on either 3-wire dc or single-phase ac circuits with grounded neutral shall be tested on a 3-wire dc circuit with grounded neutral, with the switch connected to the outside conductors of the circuit, and with the enclosure grounded as indicated in 7.3.2.6. If the switch is intended for use with alternating current only, it shall be tested with alternating current in a similar manner and in accordance with 7.3.2.5.

7.3.2.8 A 3-wire switch without a solid neutral intended for use on ac circuits other than that described in 7.3.2.7 and a 4-wire switch having a solid neutral shall be tested on a 3-phase circuit with a 3-phase balanced load.

7.3.2.9 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.

7.3.2.10 A switch marked for isolating use only and rated at more than 1 200 A at 250 V or less shall be subjected to the overload test with a current of 1 800 A. A switch marked for isolation use only and rated at more than 600 A at more than 250 V shall be subjected to the overload test with current 900 A. See 9.2.12.

7.4 Endurance test

7.4.1 The same switch previously subjected to the overload test shall perform successfully when operated:

a) For the number of cycles and rate of speed indicated in Table 19,

b) Making and breaking 100 percent of its rated current. Switches for isolating use only, rated at more than 1 200 A at 250 V or less, and switches rated at more than 600 A at more than 250 V may be operated without current, if the switch is marked in accordance with 9.2.12,

c) With the test potential as described in 7.3.2.4 for an ac switch and within 5 percent of the rated voltage of the switch if direct current is used, and

d) For ac rated switches, a load with a power factor of 0.75 – 0.80 maximum; and

e) For dc rated switches, a noninductive resistance load.

There shall not be any electrical or mechanical malfunction of the device or welding of the contacts. The ground fuse shall not have opened. Burning or pitting of the contacts shall be considered to be acceptable, but line-to-line breakdown shall be considered to be unacceptable.

7.4.2 For a switch having both ampere and horsepower or kilowatt horsepower ratings, the endurance test for the horsepower- or kilowatt-rated sample need not be conducted if represented by the endurance test for the general-use rating.

7.5 Dielectric voltage-withstand test

7.5.1 A single-throw switch (with fuses, if any, in place) shall withstand for 1 minute without breakdown the application of a 48 – 62 Hz essentially sinusoidal voltage of 1 000 V plus twice the maximum rated voltage:

a) Between live parts and the enclosure with the switch closed,

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

c) Between the line and load terminals with the switch open.

7.5.2 A double-throw switch for use in optional standby systems in accordance with Annex A, Ref. No. 1, shall have the potential voltage applied:

a) Between live parts and the enclosure with the contact alternately closed to each supply source,

b) Between terminals of opposite polarity with the contacts closed,

c) Between live parts of different circuits, and

d) Between terminals of the normal source and the alternate source with the switch in both normal and alternate positions.

7.5.3 To determine if a switch complies with the requirements in Clause 7.5, Dielectric voltage-withstand test, the device shall be stressed by means of a 500 VA or larger transformer, the output voltage of which can be varied. The applied voltage shall be increased from zero until the required test value is reached and held at that value for 1 minute. The increase in the applied voltage shall be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by the voltmeter. A transformer less than 500 VA shall be permitted if the output voltage is measured directly.

7.6 Clamped joint test

7.6.1 A clamped joint between two insulators (reference 6.6.1.18) shall be tested using two samples:

a) The clamped joint on the first sample shall be opened up to produce a space 3.2 mm (1/8 inch) wide. This may be accomplished by loosening the clamping means or by drilling a 3.2 mm (1/8 inch) diameter hole at the joint between the insulators at a point of minimum spacing between the metal parts on the opposite sides of the joint. The drilled hole shall not decrease spacings between the opposite polarity parts as measured through the crack between the insulators. The 48 – 62 Hz dielectric breakdown voltage through this hole shall then be determined by applying a gradually increasing voltage (500 V per second) until breakdown occurs.

b) The second sample, with the clamped joint intact, shall be subjected to a gradually increasing 48 – 62 Hz voltage until 110 percent of the breakdown voltage of item (a) has been reached. If the breakdown voltage of item (a) is less than 4 600 V rms, the voltage to be applied to the second sample shall be further increased to 5 000 V rms and held for 1 second. There shall be no electrical breakdown of the second sample.

7.7 Close-open test

7.7.1 Switches rated higher than 10 000 amperes short-circuit current shall comply with the Close-open test requirements in 7.7.2 – 7.7.6.

7.7.2 A deadfront switch shall be mounted and connected to the test circuit in the same manner as for the overload test as specified in 7.3.2.2.

9.2.56 The characters in the markings described in 9.2.52 – 9.2.54 shall not be less than 2.4 mm (3/32 inch) high.

9.2.57 With respect to the requirement in 6.7.2.21, a switch shall be marked to indicate the specific tightening torque for each wire connector in the switch that is intended for field wiring. If different connectors are used for line or load, the specific torques to be applied to each connector shall be clearly indicated.

9.2.58 A switch shall be marked in a readily visible location to indicate the required temperature rating of all field-installed conductors.

9.2.59 A terminal of a switch capable of securing two or more combinations of conductors in multiple, any of which has an ampacity acceptable for the applications, shall be identified and marked unless the switch is acceptable for use with the combination of wires requiring the largest wiring space, in accordance with 6.10.2.2. The terminal shall be identified by a prominent marking, such as on a wiring diagram, that will state the number and sizes of wires of which the terminal is acceptable.

9.2.60 A marking employing a wording differing from that given in 9.2.50 – 9.2.54 shall be permitted if it clearly and completely conveys the significant information. Any abbreviation designating copper and aluminum shall be "AL-CU", "CU-AL", or equivalent.

9.2.61 In an enclosed switch provided with fuseholders for branch circuits, all branch circuit terminals shall be so marked that the connections of each branch circuit can be readily identified, unless the relative arrangement of the terminals makes this unnecessary. This marking shall appear either on, or near to, the terminal plates and shall not appear only on parts that must be removed in order to wire the switch. A wiring diagram shall be considered a satisfactory alternative.

9.2.62 The month and year of manufacture, at least, shall be marked on each enclosed switch in a location accessible without the use of other than normally available tools such as screwdrivers, pliers, and wrenches.

Note: Date coding, serial numbers, or equivalent means may be used.

9.2.63 A double-throw switch investigated for use in optional standby systems in accordance with Annex A, Ref. No. 1, shall be marked, "Manually-operated switch suitable for use in optional standby power systems in accordance with _____". (where the “blank” is to be filled in with the appropriate text from Annex A, Ref. No. 1) or similar wording. The marking shall be an integral part of the marking containing the manufacturer's name and the electrical rating, unless it is an integral part of another required marking of the switch.

9.2.64 Enclosed switches marked “Suitable for use as service equipment” and provided with protection from inadvertent contact in a field installable kit, as permitted in 6.4.5, shall be marked “Install Service Barrier Kit, Cat. Number ____” or equivalent.

9.3 Electrically tripped switches

9.3.1 In addition to the requirements of 9.2, a switch provided with electrical tripping means shall be marked with the control circuit ratings as follows:

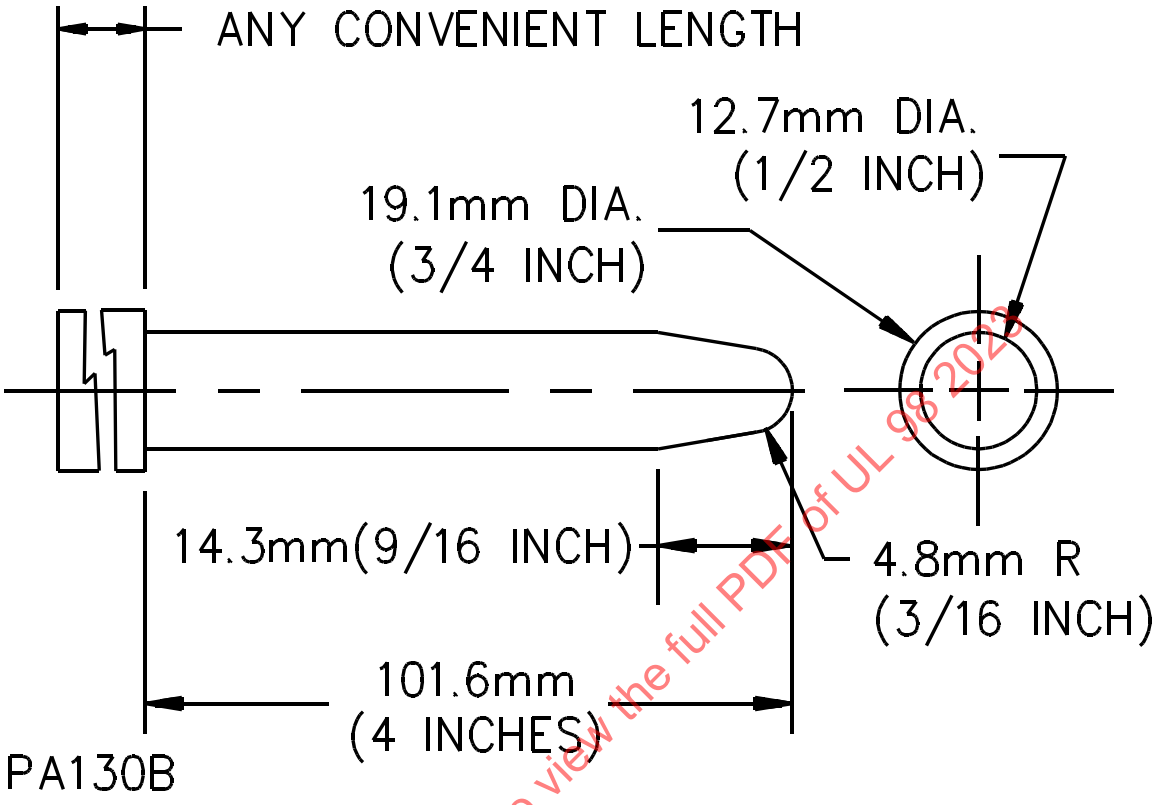
a) Voltage and frequency (or "DC") of tripping circuit, and

b) Amperes, including inrush and sealed value for ac rated devices.

9.3.2 If control fuses are provided, the rating shall be marked adjacent to the control circuit fuseholder.

Figure 6

Straight probe



Revision History

CSA C22.2 No. 4:16, Enclosed and dead-front switches — originally published February 2016

Note: *For information about the **CSA Standards Update Service**, go to **store.csagroup.org** or e-mail techsupport@csagroup.org.*

Update No. 1 — August 2019	**Revision symbol (in margin)**
Title page, copyright page, Preface, and Clauses 1.1, 6.1.3 d), 6.1.7, 6.1.8, 6.4.1, 7.1.7, 7.2.10, 8.2.1, 8.3.1, and 9.2.47, Tables 2, 10, 14, 15, 16, 17, 18, 19, 20, 21, 22, 25, and 26 and Annex A • Update your copy by inserting these revised pages. • Keep the pages you remove for reference.	|

National Standard of Canada — October 2020
Outside front cover, National Standard of Canada text, title page. This Standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

The following is a list of revisions, additions and deletions to CSA C22.2 No. 4:16:

National Standard of Canada — October 2020

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National Standard of Canada

CSA C22.2 No. 4:16
Enclosed and dead-front switches

ICS 29.120.40; 29.120.50
ISBN 978-1-77139-928-9

Association of Standardization and Certification
NMX-J-162-ANCE-2016
Fourth Edition

CSA Group
CSA-C22.2 No. 4-16
Eighth Edition

Underwriters Laboratories Inc.
UL 98
Fourteenth Edition

Enclosed and Dead-Front Switches

February 12, 2016

(Title Page Reprinted: August 30, 2019)

ANSI/UL 98-2019

Revision History

C22.2 No. 4-16, Enclosed and dead-front switches — originally published February 2016

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Update No. 1 — August 2019	**Revision symbol (in margin)**
Title page, copyright page, Preface, and Clauses 1.1, 6.1.3 d), 6.1.7, 6.1.8, 6.4.1, 7.1.7, 7.2.10, 8.2.1, 8.3.1, and 9.2.47, Tables 2, 10, 14, 15, 16, 17, 18, 19, 20, 21, 22, 25, and 26 and Annex A • Update your copy by inserting these revised pages. • Keep the pages you remove for reference.	|

Safety for Enclosed and Dead-Front Switches

Eigth Edition, Dated February 12, 2016

Summary of Topics

This revision dated August 30, 2019, includes the following changes in requirements:

Revisions for Field Installed Barriers

Addition of Requirements for Class CA, CB and G Fuses

Revisions for the Addition of Voltage Ratings From 601 to 1000 V

As noted in the Commitment for Amendments statement located on the back side of the title page, UL, CSA, and ANCE are committed to updating this harmonized standard jointly.

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Commitment for Amendments

This standard is issued jointly by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (operating as "CSA Group"), and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to ANCE, CSA Group, or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of ANCE, CSA Group, and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue. ANCE will incorporate the same revisions into a new edition of the standard bearing the same date of issue as the CSA Group and UL pages.

ISBN 978-1-77139-928-9 © 2016 Canadian Standards Association

This Standard is subject to review five years from the date of publication, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquires@csagroup.org and include ″Proposal for change″ in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

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This ANSI/UL Standard for Safety consists of the Fourteenth edition including revisions through August 30, 2019. The most recent designation of ANSI/UL 98 as an American National Standard (ANSI) occurred on August 30, 2019. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

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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SUPPLEMENT SA - Enclosed and Deadfront Switches Intended for Marine Use

Preface

This is the harmonized ANCE, CSA Group, and UL standard for *Enclosed and Dead-Front Switches*. It is the Fourth edition of NMX-J-162-ANCE, the Eighth edition of CSA C22.2 No. 4, and the Fourteenth edition of UL 98. This harmonized standard has been jointly revised on August 30, 2019. For this purpose, CSA Group and UL are issuing revision pages dated August 30, 2019, and ANCE is issuing a new edition dated August 30, 2019.

This harmonized standard was prepared by the Association of Standardization and Certification (ANCE), CSA Group, and Underwriters Laboratories Inc., (UL). The efforts and support of the Technical Harmonization Committee for Enclosed Switches, of the Council on the Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA), are gratefully acknowledged.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

This standard was reviewed by the CSA Subcommittee on Enclosed and Dead-Front Switches, under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee.

Where reference is made to a specific number of samples to be tested, the specified number shall be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of harmonization

This standard uses the IEC format but is not based on, nor is it considered equivalent to, an IEC standard. This standard is published as an equivalent standard for ANCE, CSA Group, and UL.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

Reasons for differences from IEC

The THC determined the safe use of enclosed and dead-front switches is dependent on the design and performance of the products in relation to the North American Electrical Codes with which they are intended to be installed.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

1 Scope

1.1 These requirements cover individually enclosed air switches, rated 4000 A or less at 1000 V or less, having all current-carrying parts enclosed, manually operable by means of external handles, and intended to be employed in accordance with the national installation codes listed in Annex A, Ref. No. 1.

1.2 As used in this Standard, the term switch is intended to mean an enclosed switch or deadfront switch unless specifically stated otherwise.

1.3 These requirements also cover deadfront switches that have all current-carrying parts enclosed when mounted in an enclosed panelboard, deadfront switchboard, or the like. These switches are manually operable by means of external handles and are intended to be employed in accordance with the national installation codes listed in Annex A, Ref. No. 1.

1.4 These requirements cover enclosed switches with or without provision for fuses suitable for use as branch circuit, feeder, and service overcurrent protection.

1.5 The following fuses are deemed suitable for use as branch circuit, feeder, and service overcurrent protection:

a) Cartridge Fuses (Ref. Annex B, Low-Voltage Fuses – Parts 1 – 10, 12 and 15),

b) Plug Fuses (Ref. Annex B, Low-Voltage Fuses – Parts 1 and 11), and

c) Special Purposes Fuses marked as meeting the performance specifications of a specific Class Fuse.

1.6 These requirements cover enclosed switches intended for general use and having ampere ratings, with or without horsepower or kilowatt ratings, and enclosed switches intended for motor-circuit use only and having horsepower or kilowatt ratings but no general-use ampere ratings.

1.7 These requirements cover double-throw switches intended for use in optional standby systems (see Annex A, Ref. No. 1).

1.8 These requirements cover fused electrically tripped switches rated over 600 A and rated 600 A or less employing Class J, R or T fuses.

1.9 These requirements also cover electrically tripped switches that have been investigated to determine their acceptability for ground-fault protection when combined with ground-fault sensing and relaying equipment as follows:

a) Switches for use with Class I ground-fault sensing and relaying equipment include those that are capable of interrupting 12 times their rated current or that have integral means to prevent disconnecting as levels of fault current exceeding the contact interrupting capability of the switch.

b) Switches for use with Class II ground-fault sensing and relaying equipment are capable of interrupting 10 times their rated current and are for use in ground-fault protection systems in which means to prevent disconnecting at levels of fault current exceeding the contact interrupting capability of the switch are incorporated within the ground-fault sensing and relaying equipment when combined with Class I and II ground-fault sensing and relaying equipment.

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5.36 PLUG FUSE – fuse consisting of a current-responsive element inside a housing with coaxial terminals on one end, one terminal being a threaded metal ring or shell on the outside of the housing.

5.37 POLE OF A SWITCHING DEVICE – the portion of a switching device associated exclusively with one electrically separated conducting path of its main circuit and excluding those portions which provide a means for mounting and operating all poles together.

5.38 PRESSURE WIRE CONNECTOR – a reusable connector into which the conductor (wire) is secured by mechanical pressure applied by integral screw, cone, or other mechanical parts.

5.39 RATING – a designated limit of operating characteristics based on specified conditions of current, voltage, frequency, and such.

5.40 SERVICE EQUIPMENT – the necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply.

5.41 SHORT-CIRCUIT CURRENT RATING – the maximum available rms symmetrical ac current or maximum available dc current (which is marked on the switch) to which the (fused or unfused) switch is intended to be connected when protected by the specified overcurrent protective device or devices.

5.42 SINGLE-THROW SWITCH – a switch which has an open and a closed circuit position only.

5.43 SWITCH – a device, manually operated, unless otherwise designated, for opening and closing or for changing the connection of a circuit.

5.44 SWITCHING DEVICE – called ″single-pole″ if it has only one pole. If it has more than one pole, it is called ″multipole″ (two-pole, three-pole, and so on) provided the poles are coupled in such a manner as to operate together.

5.45 TYPE TESTS – tests made to determine the adequacy of the design of a particular type, style, or model of equipment or its component parts to meet its assigned ratings and to operate satisfactorily under usual service conditions. Type tests should be made only on representative equipment to substantiate the ratings assigned to all other apparatus of basically the same design. These tests are not intended to be used as a part of normal production. The applicable portion of these type tests may also be used to evaluate modifications of a previous design and to assure that performance has not been adversely affected. Test data from previous similar designs may be used for current designs, where appropriate.

6 Construction

6.1 General

6.1.1 A switch shall employ materials throughout that are acceptable for the particular use, and shall be made and finished with the degree of uniformity and quality of work practicable in a well-equipped factory.

6.1.2 All parts of a switch shall be assembled in place when the switch is shipped from the factory, except as noted in 6.1.3.

6.1.3 A switch may have provision for factory- or field-installed accessories such as neutral assemblies or auxiliary switches provided that:

a) The switch is for use with and 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 either:

i) Securely attached at the factory to either the switch or to the accessory to be installed, or

ii) Provided in the form of a kit made available by the manufacturer that complies with 6.1.7 and 6.1.8.

e) The accessory is an essentially complete unit and does not require detailed assembly in the field. Cutting, splicing of existing wires, or resoldering of connections shall not be permitted, and

f) The accessory and switch are marked in accordance with 9.2.47.

6.1.4 With reference to 6.1.3, screws for mounting the neutral assembly shall be furnished with that assembly but need not be assembled in place.

6.1.5 A switch (including all of its parts) shall be strong and rigid enough for the intended application.

6.1.6 All ferrous metal parts other than enclosures, unless of corrosion-resistant material, shall be galvanized, painted, enameled, plated, or otherwise acceptably treated to provide protection against corrosion.

6.1.7 A DC rated multipole switch that requires poles to be wired in series and allows for different series configurations of the poles, barriers and/or jumpers may be field installed if all of the following are met:

a) Barriers are either supplied with or made available by the manufacturer as part of a kit;

b) Jumpers, if other than wire, are supplied with the barriers mentioned in a) or made available by the manufacturer as part of the kit;

c) The kit complies with 6.1.3 (c), (e), and (f);

d) The kit contains all required hardware; and

e) Instructions for the use of barriers and/or jumpers are permanently marked on the switch for each of the different configurations. In lieu of applying all markings to the switch, a separate document shall be included with the switch and the switch shall be marked with a permanently affixed label that reads: ″For the proper configuration of connections of the terminals, refer to Publication No. _____ provided with this switch.″ The document shall include:

1) The switch manufacturer's name and type designation or equivalent;

2) Publication number and date or equivalent;

3) Switch electrical ratings, number of poles; and

4) A schematic of each of the intended wiring configurations for each marked rating.

6.1.8 If the manufacturer's instructions specify the installer is to provide the wire, detailed information as to the wire size, insulation type, length, strip length, and physical configuration shall be provided. If the instructions require the wire to be bent with a radius less than the cold bend mandrel requirements of Annex A, Ref. No. 16, the jumpers shall be provided with the switch or kit as required in 6.1.7.

6.2 Enclosure

6.2.1 An overall enclosure shall comply with the requirements in Annex A, Ref. No. 4, except for modifications and additional requirements as specially described in this Standard.

6.2.2 A deadfront switch shall comply with the requirements in Annex A, Ref. No. 4, only with regard to those parts of its enclosure that will be exposed when the switch is installed behind the deadfront of a panelboard or the like.

6.2.3 The entire enclosure of a switch intended for surface mounting and the box proper of a switch intended for flush mounting shall be permitted to be formed of steel not less than 1.07 mm (0.042 inch) thick (base metal thickness not including a coating thickness) if:

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

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

c) The thickness of a cover, front, door, trim, and similar parts, provided as part of an enclosure intended for flush mounting, is as specified in Annex A, Ref. No. 4.

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6.2.4 An opening for a closely fitting operating handle shall be permitted if the opening is substantially closed when the switch handle is in any operating position. The clearance between the edge of the hole and the handle shall not exceed 2.4 mm (3/32 inch) on either side (one side only) and 3.2 mm (1/8 inch) total (both sides). The clearances shall be measured with the handle in the full on and off positions. The handle and its supporting member shall be assembled in the position resulting in the largest clearance that can result from ordinary factory assembly.

6.2.5 A single door may be provided regardless of the width of a door.

6.2.6 A door or cover intended to give access to fuses shall be hinged, sliding, or similarly attached so as to prevent its removal.

6.2.7 Switches shall be provided with a means for locking the door closed. Switches marked as suitable for use as service equipment shall be provided with a means for sealing.

6.2.8 The enclosure shall be constructed so that all doors can be opened to a minimum of 90 degrees from the closed position.

6.2.9 When knockouts are provided in the enclosure of a switch, they shall be located so that the installation of conduit bushings will not result in electrical spacings less than the minimum requirements of this Standard. In measuring electrical spacings it shall be assumed that the bushings are of suitable size for the largest conduit that can be used.

6.2.10 An external operating means, such as one for a disconnect, a pilot device, or a resetting operation, mounted on or through an enclosure shall withstand the environmental tests specified in Annex A, Ref. No. 4, for the marked enclosure type.

6.3 Operating mechanism

6.3.1 The operating mechanism shall be designed and 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 prevent loosening under the jars of continued use. Stops shall be provided so as to remove undue strain from switch parts.

6.3.2 A handle shall be provided for convenient operation of a switch and shall be constructed so as not to present a risk of fire, electric shock, or injury to persons. An operating handle and door of conducting material shall be in electrical connection with the enclosure.

6.3.3 A metal rod using the wall of the box as a bearing shall be considered to be in electrical connection with the enclosure.

6.3.4 If the position of a switch is indicated by the position of the operating handle, there shall be definite off and on positions for the handle, and the construction of the operating mechanism shall be such that the handle cannot be left readily at or near the off position when the switch is on. See also 9.2.13.

6.3.5 If a switch is operated such that movement of the operating handle is vertical between the on and off positions resulting in one position being above the other position, then the upper position shall be the on position. A switching device having more than one on position, such as a double-throw switch, need not comply with this requirement.

6.3.6 A handle or other member that indicates the position of the switch contacts (closed or open) shall be so constructed that the door, front, or cover cannot be secured in place in the intended manner so that the handle or member indicates off with the switch contacts in the closed position.

6.3.7 There shall be provision for locking an enclosed switch in the off position without opening the enclosure.

6.3.8 An isolating switch shall have provision for locking the switch in the on position. A current-interrupting switch may have provision for locking the switch in the on position.

6.3.9 A switch so constructed that it will tend to close by gravity shall be provided with means for holding the operating mechanism in the off position.

6.3.10 Switches rated greater than 250 V, 30 A shall have the design of the operating mechanism in conjunction with the contact structure, such that in normal operation, the operator of the switch cannot restrain the operation of the contacts after they have initially touched or parted when closing or opening the switch. Isolating switches complying with 6.3.8 and 9.2.12 are exempt from this requirement.

6.4 Accessibility of live parts

6.4.1 Openings in enclosures that provide access to live parts shall be evaluated in accordance with Annex A, Ref. No. 4.

6.5 Electrical insulation material

6.5.1 Insulation material in contact with live parts shall have at least the minimum values specified in Table 1 and additionally be subjected to the mold stress relief test in 7.13.

6.5.2 An insulation material having values below those contained in Table 1 may be accepted based on acceptable end-product performance tests. See Annex A, Ref. No. 9.

Note: This requirement does not apply in Canada.

6.5.3 The mold stress relief test is not required for rigid thermosetting materials.

Table 1
Minimum values for insulating materials

	Flammability rating of material			
Test specified	**V-0**	**V-1**	**V-2**	**HB**
Hot wire ignition (HWI)[e], ignition time in sec. (Annex A, Ref. No. 3)	7	15	30	30
High current arc ignition (HAI)[d], number of arcs (Annex A, Ref. No. 10)	15	30	30	60
Comparative tracking index (CTI) under moist conditions[c], volts (Annex A, Ref. No. 2)	175[a,b]	175[a,b]	175[a,b]	175[a,b]

a) A material having a minimum comparative tracking value of 100 may be used if the voltage involved is 250 volts or less.

b) Not applicable if the over-surface spacing is greater than or equal to 12.7 mm (1/2 inch).

c) Material surface is in contact with or in close proximity [within 0.8 mm (1/32 inch)] to:

1) uninsulated live parts of opposite polarity, or

2) uninsulated live parts and either

i) metal parts that may be grounded in service, or

ii) any surface exposed to contact.

d) Material is in contact with or in close proximity to uninsulated live parts 0.8 mm (1/32 inch) for nonarcing parts or 12.7 mm (1/2 inch) for arcing parts.

e) Material is in contact with or close proximity to uninsulated live parts [within 0.8 mm (1/32 inch)].

6.5.4 The overall thickness of switch bases shall not be less than 12.5 mm (1/2 inch) if made of porcelain.

6.5.5 Vulcanized fiber, impregnated hard wood, and molded composition are acceptable as materials for crossbars. Cold-molded and phenolic compositions are acceptable generally, but ordinary fiber, rubber, and so-called hot-molded shellac and tar compositions shall not be used for the mounting of uninsulated live parts.

6.6 Spacings

6.6.1 General

6.6.1.1 Except as noted in 6.6.1.4 – 6.6.1.6, the spacings in a switch shall be as indicated in Table 2. Grounded metal includes the enclosure and any metal that may be in electrical connection with the enclosure.

Table 2
Minimum spacings[a]

Voltage between parts involved	Minimum spacings in mm (inches)							
	Between uninsulated live parts of opposite polarity				Between uninsulated live parts and any grounded metal			
	Over surface		Through air		Over surface		Through air	
0 – 130	19	(3/4)	12.5	(1/2)	12.5	(1/2)	12.5	(1/2)
131 – 250	31	(1-1/4)	19	(3/4)	12.5	(1/2)	12.5	(1/2)
251 – 600	50	(2)	25	(1)	25	(1)	12.5	(1/2)
601 – 1000	50	(2)	25	(1)	25	(1)	12.5	(1/2)

[a] The SI units are minimum values and are not a direct conversion from the corresponding values in inches.

6.6.1.2 Terminals and other live parts intended to be connected to the grounded conductor of a circuit shall be considered to be uninsulated live parts unless such parts are mounted directly on or in permanent electrical connection with the enclosure.

6.6.1.3 If the connection mentioned in 6.6.1.2 is solely by means of a screw, strap, or other bonding device that can be readily removed and is not depended upon to perform a mechanical function, the switch shall:

a) Comply with the requirement in 6.6.1.1 when the bonding device is removed, or

b) Be marked as described in 9.2.33.

6.6.1.4 The spacings between screw-shells of plug fuseholders that are protected by surrounding walls of insulating material, and between such screw-shells and a metal cover plate, may be less than those indicated in Table 2 but not less than 6.4 mm (1/4 inch) in any case, if the depth of the receptacle, as measured from the top of the wall to the plane of the center contact, is not less than 19.1 mm (3/4 inch).

6.6.1.5 The distance between a door or cover over a fuseholder and:

a) The center contact of an Edison-base plug fuseholder shall not be less than 39.7 mm (1-9/16 inches).

b) The center contact of a Type S plug fuseholder shall not be less than 33.3 mm (1-5/16 inches).

6.6.1.6 The spacings given in Table 2 are not required to be maintained between switch blades and the enclosure cover when the switch is in the off position and the blades are deenergized, but such spacings shall not be less than 3.2 mm (1/8 inches).

6.6.1.7 In measuring between an uninsulated live part and a conduit bushing installed at a knockout, it shall be assumed that a conduit bushing having the dimensions specified in Table 3 is in place.

6.10.11 The wire-bending space from a connector to any barrier or other obstruction that is part of an enclosed switch shall be as specified in Table 11.

6.10.12 A separate neutral block shall be permitted in a wiring gutter if it does not obstruct the required wiring space.

6.10.13 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 shall be measured from the end of the barrier or other obstruction.

6.10.14 The distance mentioned in 6.10.10 and 6.10.11 shall 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 terminal 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 shall be disregarded when the measurement is being made if it does not reduce the radius to which wire must be bent. If a terminal is provided with one or more connectors for the connection of conductors in multiple, the distance shall be measured from the wire opening closest to the wall of the enclosure. Side wire-bending space, such as at a neutral in side gutter, may be measured in a straight line from the center of the wire opening in the direction the wire leaves the terminal.

6.10.15 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.

6.10.16 The construction and arrangement of the operating mechanism and its relation to the wiring space shall be such that it will not cause damage to wires with which it may come in contact during switch operation.

Table 10
Minimum wire-bending space at terminals[a]

Wire size		Wires per terminal (pole)[b]							
mm²	AWG or kcmil	1		2		3		4 or more	
		mm	in	mm	in	mm	in	mm	in
2.1 – 5.3	14 – 10	Not specified		–	–	–	–	–	–
8.4	8	38.1	1-1/2	–	–	–	–	–	–
13.3	6	50.8	2	–	–	–	–	–	–
21.2	4	76.2	3	–	–	–	–	–	–
26.7	3	76.2	3	–	–	–	–	–	–
33.6	2	88.9	3-1/2	–	–	–	–	–	–
42.4	1	114	4-1/2	–	–	–	–	–	–
53.5	1/0	127	5-1/2	127	5-1/2	178	7	–	–
67.4	2/0	152	6	152	6	191	7-1/2	–	–
85	3/0	165 (12.7)	6-1/2 (1/2)	165 (12.7)	6-1/2 (1/2)	203	8	–	–
107	4/0	178 (25.4)	7 (1)	191 (38.1)	7-1/2 (1-1/2)	216 (12.7)	8-1/2 (1/2)	–	–
127	250	216 (50.8)	8-1/2 (2)	216 (50.8)	8-1/2 (2)	229 (25.4)	9 (1)	254	10
152	300	254 (76.2)	10 (3)	254 (50.8)	10 (2)	279 (25.4)	11 (1)	305	12
177	350	305 (76.2)	12 (3)	305 (76.2)	12 (3)	330 (76.2)	13 (3)	356 (50.8)	14 (2)
203	400	330 (76.2)	13 (3)	330 (76.2)	13 (3)	356 (76.2)	14 (3)	381 (76.2)	15 (3)
253	500	356 (76.2)	14 (3)	356 (76.2)	14 (3)	381 (76.2)	15 (3)	406 (76.2)	16 (3)
304	600	381 (76.2)	15 (3)	406 (76.2)	16 (3)	457 (76.2)	18 (3)	483 (76.2)	19 (3)

Table 10 Continued on Next Page

Table 10 Continued

Wire size		Wires per terminal (pole)[b]							
mm²	AWG or kcmil	1		2		3		4 or more	
		mm	in	mm	in	mm	in	mm	in
355	700	406 (76.2)	16 (3)	457 (76.2)	18 (3)	508 (76.2)	20 (3)	559 (76.2)	22 (3)
380	750	432 (76.2)	17 (3)	483 (76.2)	19 (3)	559 (76.2)	22 (3)	610 (76.2)	24 (3)
405	800	457	18	508	20	559	22	610	24
456	900	483	19	559	22	610	24	610	24
507	1000	508	20	–	–	–	–	–	–
633	1250	559	22	–	–	–	–	–	–
760	1500	610	24	–	–	–	–	–	–
887	1750	610	24	–	–	–	–	–	–
1010	2000	610	24	–	–	–	–	–	–

[a] Alternatively, for a product identified for use only in Canada, the use of the values in Annex A, Ref. No. 14, shall be permitted.

[b] Wire-bending space may be reduced by the number 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), and

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.

Table 11
Minimum width of gutter and wire-bending space in mm (inches)[a]

Wire size		Wires per terminal (pole)									
mm²	AWG or kcmil	1		2		3		4		5	
		mm	(in)	mm	(in)	mm	(in)	mm	(in)	mm	(in)
2.1 – 5.3	14 – 10	–	–	–	–	–	–	–	–	–	–
8.4 – 13.3	8 – 6	38.1	(1-1/2)	–	–	–	–	–	–	–	–
21.1 – 26.7	4 – 3	50.8	(2)	–	–	–	–	–	–	–	–
33.6	2	63.5	(2-1/2)	–	–	–	–	–	–	–	–
42.4	1	76.2	(3)	–	–	–	–	–	–	–	–
53.5 – 67.4	1/0 – 2/0	88.9	(3-1/2)	127	(5)	178	(7)	–	–	–	–
85.0 – 107	3/0 – 4/0	102	(4)	152	(6)	203	(8)	–	–	–	–
127	250	112	(4-1/2)	152	(6)	203	(8)	254	(10)	–	–
152 – 177	300 – 350	127	(5)	203	(8)	254	(10)	305	(12)	–	–
203 – 253	400 – 500	152	(6)	203	(8)	254	(10)	305	(12)	356	(14)
304 – 355	600 – 700	203	(8)	254	(10)	305	(12)	356	(14)	406	(16)
380 – 456	750 – 900	203	(8)	305	(12)	356	(14)	406	(16)	457	(18)
507 – 633	1000 – 1250	254	(10)	–	–	–	–	–	–	–	–
760 – 1010	1500 – 2000	305	(12)	–	–	–	–	–	–	–	–

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

6.15.5 Provision for the connection required by 6.15.4 is not required for a neutral with a permanent, non-removable bond when:

a) The switch is rated at 100 A or less and a suitable pressure-type wire connector (attached to the neutral) is provided that will accept a folded, unbroken, 8 AWG grounding conductor, or

b) The switch is provided with a lay-in type solderless connector attached to the enclosure.

6.15.6 Terminals shall be provided on the neutral assembly for both the grounded service conductor and the load conductor (grounded circuit conductor; see Annex D).

6.15.7 Service equipment for Canada shall comply with the requirements of Annex A, Item 16.

7 Test methods

7.1 General

7.1.1 To determine if a switch complies with the performance requirements, a representative device of each rating shall be subjected to the tests as required in Table 13. Fewer samples may be used by completing additional tests on any single sample.

Table 13
Test sequences[a]

Description	Clause number	Sample number
Heating	7.2	1
Overload	7.3	2
Endurance	7.4	2
Dielectric voltage	7.5	1 and 2
Close-open[b]	7.7	3
Short-circuit withstand	7.8	3
Low-level dielectric	7.9	3
Short-circuit closing	7.10	4
Strength of insulating bases	7.11	5
Mold stress relief	7.13	6
Insulating barriers	7.14	2
Electrically tripped switches		
Temperature	7.12.2	7
Operation	7.12.3	7
Contact opening	7.12.4	7
Endurance	7.12.5	2 or 8
Overload and endurance	7.12.6	2

[a] For variances to test sequence, refer to clause numbers.
[b] The close-open test is required for switches rated greater than 10 kAIC.

7.1.2 A switch marked with two or more ratings shall be tested at each rating unless a test at one rating is representative of a performance at the other ratings.

7.1.3 A switch intended for use in a metal enclosure shall be tested in a metal enclosure having no paint, enamel, or other coating of insulating material.

7.1.4 A deadfront switch shall be tested on a representative panelboard chassis or the equivalent unless specified otherwise in this Standard.

7.1.5 Test circuits for the close-open, short-circuit withstand, and short-circuit closing tests shall be calibrated as described in Annex E.

7.1.6 Table 14 for ac ratings and Table 15 for dc ratings indicate representative tests. An overload and endurance test at any voltage rating in a row with a xx designation in a given column is representative of an overload and endurance test in a row below it with an entry (xx or x) in the same column, where the same or lesser current is involved.

7.1.7 Overload and endurance tests at 600 V ac or above are representative for ratings of 250 V dc or below, where the same or lesser dc current is involved.

7.1.8 Table 14 applies to devices having an interrupting means for each phase of the circuit. A single-throw switch is not considered to be representative of a double-throw switch of the same rating.

Table 14
Representative overload and endurance tests, ac

	Switch rating in volts, ac	Number of phases	Power factor of test	Representative tests					
				A	B	C	D	E	F
1	1000	3	0.40 – 0.50	0.40 – 0.50	xx *	–	–	–	
2	1000	1	0.40 – 0.50	0.40 – 0.50	x	xx *	–	–	
3	1000	3	0.75 – 0.80	0.75 – 0.80	x	–	xx *	–	
4	1000	1	0.75 – 0.80	0.75 – 0.80	x	x	x	xx *	
5	600	3	0.40 – 0.50	xx *					
6	600	1	0.40 – 0.50	x	xx *				
7	600	3	0.75 – 0.80	x		xx *			
8	600	1	0.75 – 0.80	x	x	x	xx *		
9	480	3	0.40 – 0.50	xx					
10	480	1	0.40 – 0.50	x	xx				
11	480	3	0.75 – 0.80	x		x		xx	
12	480	1	0.75 – 0.80	x	x	x	xx	x	
13	240	3	0.40 – 0.50	xx		xx			
14	240	1	0.40 – 0.50	xx	xx	xx			
15	240	3	0.75 – 0.80	xx		xx		xx	
16	240	1	0.75 – 0.80	xx	xx	xx	xx	xx	
17	120/240	1	0.75 – 0.80	x	x	x	x	x	xx
18	120	1	0.40 – 0.50	xx	xx	xx	xx	xx	
19	120	1	0.75 – 0.80	x	x	x	x	x	x

NOTES

xx – denotes test that covers any row below with entry (x or xx) in same column.

* – tests at 600 V ac or above cover ratings at 250 V dc and below.

Table 15
Representative overload and endurance tests, dc

	Switch rating in volts, dc	Representative tests
1	1000	xx
2	600	xx
3	250	xx *
4	125/250	xx *
5	125	x *

NOTES

xx – denotes test that covers any row below with entry (x or xx) in same column.

* – tests at 600 V ac or above cover ratings at 250 V dc and below.

7.1.9 If a general-use switch has the same horsepower or kilowatt rating of 100 hp or 74.6 kW or less at more than one voltage, an overload or endurance test at the highest voltage shall be considered to be representative of performance at any lower voltage. A motor-circuit switch or any switch having a horsepower or kilowatt rating greater than 100 hp or 74.6 kW shall be tested at the maximum voltage and also at the maximum current. An overload or endurance test on a 3-phase circuit is considered to be representative of performance on a 2-phase circuit of the same voltage for the same horsepower or kilowatt rating.

7.1.10 A switch shall not be adjusted, lubricated, or otherwise conditioned during the overload test, the endurance test with current, or the endurance test without current; however, switch blades and break jaws that are readily accessible may be put in good operating condition before starting each of these tests. Parts other than switch blades and break jaws shall not be adjusted. A switch shall not be conditioned between the endurance and dielectric voltage-withstand tests.

7.2 Heating test

7.2.1 Parts of a switch shall not exceed the temperature rise values in Table 16, and if fuses are used, no fuse element shall melt, when the switch is caused to carry continuously, until constant temperatures are attained, a 60 Hz essentially sinusoidal current as follows:

a) General-use switch without a horsepower or kilowatt rating: rated current.

b) General-use switch with a horsepower or kilowatt rating: rated current, or 115 percent of current (from Table 20 or Table 21) corresponding to the horsepower or kilowatt rating, whichever is greater.

c) Fused motor-circuit switch: 115 percent of the maximum full-load current rating. See also 8.2.2.

Table 16
Maximum acceptable temperature rises

Material and components	°C
A. Terminals for field-installed conductors:	
1. Unfused switches	50
2. Fused switches for use with 60°C wire and tested with dummy fuses	30
3. Fused switches for use with 75°C wire and tested with dummy fuses[a]	45
4. Class CA, CB, G, and T fused switches rated 100 A or less for use with 60°C wire	50
5. Class CA, CB, G, and T fused switches rated 100 A or less for use with 75°C wire[a]	65
6. Class J (rated more than 200 A), Class T (rated more than 100 A), Class L and Class C fused switches	60
B. All other current-carrying parts:	
1. Unfused switches	50
2. Fused switches for use with 60°C wire and tested with dummy fuses	30
3. Fused switches for use with 75°C wire and tested with dummy fuses[a]	50
4. Class J (rated more than 200 A), Class T, Class L, and Class C fused switches	85
C. Other materials and components:	
1. Wire insulation or insulating tubing	35
2. Electrical tape	55
3. Varnished cloth insulation	60
4. Fiber used as electrical insulation	65
5. Sealing compound	50
6. Phenolic composition used as electrical insulation or as a part whose failure would result in an undesired condition	125
7. Other insulating materials	b

[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.

[b] Rated temperature limit of material minus test ambient temperature.

7.2.2 Temperatures shall 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).

7.2.3 A thermocouple junction and adjacent thermocouple lead wire shall be securely held in good thermal contact with the surface of the material whose temperature is being measured.

7.2.4 A new switch shall be mounted as in actual service, with the door and other openings closed. The switch shall be connected with not less than 1.2 m (4 ft) of Type THHN, THWN, RH, TW, TW75, or THW copper wire per terminal, the wire size corresponding to the current rating of the switch. For a switch rated 30, 60, or 100 A, the wire size shall be based on the temperature rating of the wire as indicated by the marking on the switch (see 9.2.58). Where a dual temperature rating is marked 60/75°C wire, the test shall be conducted with 75°C wire. The test shall be made at any convenient voltage. A temperature shall be considered to be constant when three successive readings taken at 15-minute intervals do not indicate any change.

Note: The Canadian equivalent of THHN is T90.

Note: The Canadian equivalent of THWN is TWN75.

7.2.5 Except as stated in 7.2.6 and 7.2.7, a deadfront switch shall be tested in an enclosed panelboard or the equivalent having main bus bars with a maximum rating of two times the ampere rating of the switch under test.

7.2.6 A 30 A deadfront switch may be tested in a 100 A panelboard and a 60 A deadfront switch may be tested in a 150 A panelboard. Alternatively, a 30 or 60 A deadfront switch may be tested in the smallest current rated panelboard for which it is intended to be used.

7.2.7 If a deadfront switch can be used as a main switch, the bus bars shall be rated equal to the ampere rating of the switch.

7.2.8 In the test of 7.2.5, the switch under test shall be mounted in the top position. The main bus bars of the panelboard shall be loaded to their rating up to the points of connection to the switch under test. Additional switches, or cables, may be used to load the main bus bars so that the input to them is equal to their rating. Any unused positions in the panelboard shall be filled with additional switches or closed with filler plates.

7.2.9 Except as noted in 7.2.10, dummy fuses shall be used in place of regular fuses in clips or female screw-shells.

7.2.10 A switch employing fuse Classes as identified below shall be tested with fuses in place and when carrying 80 percent of its rated current continuously:

a) C, CA, CB, G, L, or T, and

b) Class J rated 400 or 600 A.

7.2.11 If a deadfront switch has a magnetic steel shell that completely encircles the ungrounded conductors in the switch, the switch shall additionally be tested in accordance with 7.2.13 – 7.2.16 if the grounded circuit conductor does not pass through the switch.

7.2.12 A three-pole sample of an individual deadfront switch of the maximum ampere rating of each line of deadfront switches that is constructed to form a complete steel shell shall be tested.

7.2.13 The deadfront switch being tested shall be mounted in the open, not in a panelboard, with the front in a vertical plane and the load terminals at one side. Connections shall be made with cables in accordance with 7.2.4, and loading shall be in accordance with 7.2.1 or 7.2.10 as appropriate. Where wire cannot be connected to the line end of the switch, copper bus bars shall be connected to the line terminals. The bus bars shall have an ampacity not more than the rating of the switch based on a current density not less than 1.55 A/mm^2(1 000 A/in^2), shall extend approximately 76 mm (3 inches) beyond the switch enclosure, and shall terminate in wire connectors appropriate for the rating of the switch. Bus bars of cross-section other than specified above may be used if agreeable to the submitter and the testing agency.

7.2.14 Temperatures shall be recorded for the top two load terminals, on the top front corner of the wire connectors farthest from the center of the switch.

7.2.15 The same sample used in the test of 7.2.13 shall be tested in the same manner, except that the conductors to the lower switch pole shall be disconnected from the switch and reconnected together outside and below the switch enclosure or shell. Results shall be considered acceptable if the temperature rises on the top two load terminals are not higher than those observed in the test of 7.2.13.

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7.2.16 A two-pole deadfront switch marked for multi-phase application having a steel shell as described in 7.2.12, and that has an enclosure smaller than the equivalent three-pole switch of the same voltage and ampere rating, shall be subjected to the test described in 7.2.13 except that

a) Dummy fuses shall be used in the two poles,

b) A 3-phase current shall be adjusted to 100 percent of the switch rating, and

c) The third-phase conductor shall be connected outside and below the enclosure or shell.

Results shall be considered acceptable if the temperature rises at the load terminals do not exceed 30°C. A switch employing Class L, C, or T fuses or 400 or 600 A Class J fuses shall be tested with fuses in place and when carrying 80 percent of its rated current. Results shall be considered acceptable if temperatures at the load terminals comply with Table 16.

7.3 Overload test

7.3.1 General

7.3.1.1 A general-use switch shall perform successfully when operated:

a) For 50 cycles,

b) Making and breaking 150 percent of its rated current, except as noted in 7.3.1.3 and 7.3.2.10,

c) With the rate of speed being the number of cycles per minute given in Table 19,

d) At the test voltage described in 7.3.2.4,

e) With a power factor (for an ac switch) of 0.75 – 0.80 maximum.

There shall not be any electrical or mechanical malfunction of the device or welding of the contacts. The ground fuse shall not have opened. Burning or pitting of the contacts shall be considered to be acceptable, but line-to-line breakdown shall be considered to be unacceptable.

7.3.1.2 A horsepower- or kilowatt-rated switch shall perform successfully when operated:

a) For 50 cycles of operation for switches rated 74.6 kW or 100 horsepower or kilowatt and less, or 10 cycles of operations for switches rated over 74.6 kW or 100 horsepower or kilowatt,

b) Making and breaking current given in Table 17 and Table 18,

c) With the rate of speed being the number of cycles per minute given in Table 19 (operations with current); the switch rating in amperes shall be assumed to be equal to 60 percent of the required overload test current. A switch rated in excess of 74.6 kW or 100 hp need not be operated faster than 1 cycle per minute,

d) A test voltage as described in 7.3.2.4, and

e) With power factor (for an ac switch) of 0.45 – 0.50 maximum.

There shall not be any electrical or mechanical malfunction of the device or welding of the contacts. The ground fuse shall not have opened. Burning or pitting of the contacts shall be considered to be acceptable, but line-to-line breakdown shall be considered to be unacceptable.

Table 17
Overload-test currents in amperes for alternating-current switches

Switch in rating		120 V			240 V			480 V			600 V		
kW	hp	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ
0.125	1/6	26.4	–	–	13.2	–	–	–	–	–	–	–	–
0.187	1/4	34.8	–	–	17.4	–	–	–	–	–	–	–	–
0.248	1/3	43.2	–	–	21.6	–	–	–	–	–	–	–	–
0.373	1/2	58.8	–	40	29.4	–	20	–	–	10	–	–	8
0.56	3/4	82.8	28.8	50	41.4	14.4	25	21	7.2	12.5	16.8	6	10
0.746	1	96	38.4	60	48	19.2	30	24	9.6	15	19.2	7.8	12
1.119	1-1/2	120	54	80	60	27	40	30	13.8	20	24	10.8	16
1.492	2	144	70.8	100	72	35.4	50	36	18	25	28.8	14.4	20
2.238	3	204	99.6		102	49.8	64	51	25.2	32	40.8	19.8	25.6
3.73	5	336	158		168	79.2	92	84	39.6	46	67.2	31.8	36.8
5.6	7-1/2	480	228		240	114	127	126	54	63.5	96	48	50.8
7.46	10	600	288		300	144	162	156	72	81	120	60	64.8
11.19	15		432			216	232		108	116		84	93
14.92	20		564			282	290		138	145		114	116
18.65	25		708			354	365		174	183		144	146
22.38	30		828			414	435		210	218		168	174
29.84	40		1 080			540	580		270	290		216	232
37.3	50		1 360			678	725		336	363		270	290
44.76	60						870			435			348
55.95	75						1 085			543			434
74.6	100						1 450			725			580
93.25	125						1 815			908			726
111.9	150						2 170			1 085			868
149.2	200						2 900			1 450			1 160
186.5	250									1 825			1 460
223.8	300									2 200			1 760
261.1	350									2 550			2 040
298.4	400									2 900			2 320
335.7	450									3 250			2 600
373.0	500									3 625			2 900

Table 18
Overload test currents in amperes for direct-current switches

Rating		125 V	250 V	600 V
kW	hp			
0.373	1/2	32.4	16.2	–
0.56	3/4	45.6	22.8	–
0.746	1	38	19	7
1.119	1-1/2	53	26	10
1.492	2	68	34	14
2.238	3	100	49	20
3.730	5	160	80	33
5.600	7-1/2	232	116	48
7.460	10	304	152	64
11.19	15	448	220	92
14.92	20	592	288	124
18.65	25	–	356	152
22.38	30	–	424	184
29.84	40	–	560	244
37.30	50	–	692	300

7.3.1.3 A general-use switch that also has a horsepower or kilowatt rating greater than 74.6 kW or 100 hp shall be subjected to the overload tests required in 7.3.1.1 and 7.3.1.2. If both tests are performed on the same sample, the number of operations required in 7.3.1.1 may be reduced to 40.

7.3.1.4 A double-throw switch shall be subjected to four overload tests, as follows:

a) With the line connected to the hinge jaws and the load connected to one set of contact jaws,

b) With the line connected to the hinge jaws and the load connected to the other set of contact jaws,

c) With the line connected to one set of contact jaws and the load connected to the hinge jaws, and

d) With the line connected to the other set of contact jaws and the load connected to the hinge jaws.

7.3.1.5 A double-throw switch for use as optional standby systems in accordance with Annex A, Ref. No. 1, shall be tested according to one of the following methods:

a) Subjected to the overload test using both sets of contacts simultaneously. During the test, the source of one set of contacts shall be displaced 120 electrical degrees from the source of the other set of contacts for a 3-phase supply or 180 electrical degrees for a single-phase supply.

b) If the double-throw switch is provided with a mechanical means to reduce the likelihood of the load switching from the normal source of supply to an alternate source of supply in one continuous motion, testing in accordance with 7.3.1.4 shall be permitted.

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Table 19
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 and less	6	6 000	4 000	10 000
200	5	6 000	2 000	8 000
400	4	1 000	5 000	6 000
600	3	1 000	4 000	5 000
800	2	500[b]	3 000	3 500
1 200	1	500[b]	2 000	2 500
1 600 – 2 500	1	500	2 000	2 500[c]
3 000 – 4 000	1[d]	400	1 100	1 500[c]

[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.

[b] For a switch marked "For isolating use only" (see 9.2.12) the switch is not operated with current in the endurance test.

[c] For switches rated over 1 200 A at 250 V or less and marked in accordance with 9.2.12, the total number of operations is 1000 without current.

[d] Rate of operation: 1 cycle per minute for first ten operations; thereafter in groups of five (at 1 cycle per minute) with an interval between groups that is agreeable to all concerned.

7.4.3 For horsepower- or kilowatt-rated switches, the endurance test shall be made with whichever is greater – the rated current of the device or the current selected from the appropriate full-load motor-running currents stated in Table 20 and 21. A fused motor-circuit switch shall be tested at 125 percent of the current given in Table 20 and Table 21. See also 9.2.4.

7.4.4 The current for the common wire of a 2-phase, 3-wire system is 1.414 times the value in Table 20 for a 2-phase, 4-wire system.

7.4.5 The endurance test of a double-throw switch shall be made with the connections that are shown by the overload test to be the most severe (see 7.3.1.4).

7.4.6 In determining if a switch complies with the requirements in 7.4, test conditions shall be as described in 7.3.2.

Table 20
Endurance-test currents in amperes for alternating-current switches

Switch rating in		120 V[a]			240 V			480 V			600 V		
kW	hp	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ
0.125	1/6	4.4	–	–	2.2	–	–	–	–	–	–	–	–
0.187	1/4	5.8	–	–	2.9	–	–	–	–	–	–	–	–
0.248	1/3	7.2	–	–	3.6	–	–	–	–	–	–	–	–
0.373	1/2	9.8	4.0	4.4	4.9	2.0	2.2	–	1.0	1.1	–	0.8	0.9
0.560	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
0.746	1	16	6.4	8.4	8	3.2	4.2	4.0	1.6	2.1	3.2	1.3	1.7
1.119	1-1/2	20	9.0	12	10	4.5	6	5.0	2.3	3	4.0	1.8	2.4
1.492	2	24	11.8	13.6	12	5.9	6.8	6.0	3.0	3.4	4.8	2.4	2.7
2.238	3	34	16.6	19.2	17	8.3	9.6	8.5	4.2	4.8	6.8	3.3	3.9
3.73	5	56	26.4	30.4	28	13.2	15.2	14.	6.6	7.6	11.2	5.3	6.1
5.60	7-1/2	80	38	44	40	19	22	21	9	11	16	8	9

Table 20 Continued on Next Page

Table 20 Continued

Switch rating in		120 V[a]			240 V			480 V			600 V		
kW	hp	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ
7.46	10	100	48	56	50	24	28	26	12	14	20	10	11
11.19	15	135	72	84	68	36	42	34	18	21	27	14	17
14.92	20	–	94	108	88	47	54	44	23	27	25	19	22
18.65	25	–	118	136	110	59	68	55	29	34	44	24	27
22.38	30	–	138	160	136	69	80	68	35	40	54	28	32
22.84	40	–	180	208	176	90	104	88	45	52	70	36	41
37.30	50	–	226	260	216	113	130	108	56	65	86	45	52
44.76	60	–	–	–	–	–	154	–	–	77	–	–	62
55.95	75	–	–	–	–	–	192	–	–	96	–	–	77
74.60	100	–	–	–	–	–	248	–	–	124	–	–	99
93.25	125	–	–	–	–	–	312	–	–	156	–	–	125
111.9	150	–	–	–	–	–	360	–	–	180	–	–	144
149.2	200	–	–	–	–	–	480	–	–	240	–	–	192
186.5	250	–	–	–	–	–	–	–	–	302	–	–	242
223.8	300	–	–	–	–	–	–	–	–	361	–	–	289
261.1	350	–	–	–	–	–	–	–	–	414	–	–	336
298.4	400	–	–	–	–	–	–	–	–	477	–	–	382
335.7	450	–	–	–	–	–	–	–	–	515	–	–	412
373.0	500	–	–	–	–	–	–	–	–	590	–	–	472

[a] For 127 V ratings, the test is conducted at rated voltage with the currents in this column.

Table 21
Endurance-test currents in amperes for direct-current switches

Switch rating		125 V	250 V	600 V
kW	hp			
0.373	1/2	5.4	2.7	–
0.56	3/4	7.6	3.8	–
0.746	1	9.4	4.7	1.8
1.119	1-1/2	13.2	6.6	2.6
1.462	2	17	8.5	3.4
2.238	3	25	12.2	5.0
3.73	5	40	20	8.3
5.60	7-1/2	58	29	12
7.46	10	76	38	16
11.19	15	112	55	23
14.92	20	148	72	31
18.65	25	–	89	89
22.38	30	–	106	46
29.84	40	–	140	61
37.30	50	–	173	75

made to the load side of the limiting impedance by a 10 AWG (5.3 mm^2) copper wire having a length of 1.22 to 1.83 m (4 to 6 ft). The fuse may be connected to the grounded conductor if the switch is intended for use on a grounded system.

7.8.7 The overcurrent protection devices specified in 7.8.5 shall be one of the following:

a) For ac rated fused or unfused switches rated 10 kA AIC and less, externally connected Class H fuses (maximum rating for the case size of the rating specified),

b) For ac rated fused switches rated higher than 10 kA AIC, fuses as described in 7.8.12,

c) For ac rated unfused switches rated higher than 10 kA AIC, externally connected fuses as described in 7.8.12, or circuit breakers as marked on the switch, or

d) For dc rated switches, see 7.8.2.

7.8.8 Performing the test specified in 7.8.5 without overcurrent protective devices shall be permitted 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.

7.8.9 For the performance of the test, the line and load terminals of the switch shall be connected to the corresponding test-circuit terminals by short copper wire leads, maximum 1.22 m (4 ft) per terminal, each of which has an ampacity not less than the current rating of the switch. Leads more than 1.22 m (4 ft) in length may be used if the excess length over 1.22 m (4 ft) is included in the test circuit when it is calibrated.

7.8.10 For a switch rated greater than 10 kA AIC that employs 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 shall 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 shall be conducted with the bolts in place if the bar or tube would not otherwise remain in position. Otherwise, the test shall be performed with the bolts omitted.

7.8.11 A deadfront switch shall be tested when installed in a representative panelboard, or on a representative chassis, in accordance with 7.2.8, except that the cross-section of the main bus bars need not be larger than the bus bars in the panelboard in which the switch is intended to be used. The switch shall be mounted in the top position and any unused positions in the panelboard may be filled with additional switches or closed with filler plates. The line terminals of the panelboard and the load terminals of the switch shall be connected to the corresponding test-circuit terminals as specified in 7.8.9, except the ampacity of the line leads shall be not less than the ampere rating of the main bus bars of the panelboard used in the test.

7.8.12 Fuses used in tests for ac ratings shall have characteristics representing the peak let-through current (I_p) and clearing I^2t values associated with the maximum rated fuses that the device accepts, or by which the device is to be externally protected. For an unfused switch, it shall be assumed that protection will be provided by the maximum fuse in the case size of the indicated fuse. Each of these fuses shall 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. The use of special test fuses having the required characteristics shall be permitted (see Table 22). The use of special test fuses of the same physical dimensions as a fuse the enclosed 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 that the switch accommodates and of a different class.

7.8.13 The fuse referred to in 7.8.12 may be any Class L fuse without regard to its peak let-through current and clearing I^2t, if the test current is below the point (threshold value of the fuse) where the fuse is considered to be current-limiting.

7.8.14 Fuses used for ac tests shall be selected from a lot from which two samples have been selected and calibrated to determine that their I^2t and I_p characteristics comply with the prescribed values called for in 7.8.12. Two samples from the lot shall be calibrated if the fuses are of Class G, J, RK5, C, or T, and one sample if the fuse is Class L.

7.8.15 Switches designed for use with special purpose fuses are to be tested using requirements in this standard for that Class fuse for which the special purpose fuse is marked as having the same performance specifications.

7.8.16 With the device in the fully closed position, the test circuit shall be closed on the device. For devices tested on a single-phase alternating current 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.

Table 22
Peak-let-through currents and clearing I^2t for fuses

Fuse rating, amperes	Between threshold and 50 kA		100 kA		200 kA		300 kA	
	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$
Class C Fuses								
0 – 30	–	–	–	–	12	15		
31 – 60	–	–	–	–	20	60		
61 – 100	–	–	–	–	30	200		
101 – 200	–	–	–	–	40	750		
201 – 400	–	–	–	–	70	4000		
401 – 600	–	–	–	–	100	10000		
601 – 800	–	–	–	–	115	25000		
801 – 1200	–	–	–	–	125	40000		
Class CA Fuses								
0 – 30	–	–	–	–	8	6		
Class CB Fuses								
0 – 30	–	–	–	–	10	10		
31 – 60	–	–	–	–	15	60		
Class CC Fuses								
0 – 15	3	2	3	2	4	3		
16 – 20	3	2	4	3	5	3		
21 – 30	6	7	7.5	7	12	7		
Class CF Fuses								

Table 22 Continued on Next Page

Table 22 Continued

Fuse rating, amperes	Between threshold and 50 kA		100 kA		200 kA		300 kA	
	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$
0 – 30	6	7	7.5	7	12	7	18.5	8.4
31 – 60	8	30	10	30	16	30	24.4	36
61 – 100	12	60	14	80	20	80	28.4	96
Class G Fuses								
0– 15	–	–	4	3.8	–	–		
16 – 20	–	–	5	5	–	–		
21 – 30	–	–	7	7	–	–		
31 – 60	–	–	10.5	25	–	–		
300-Volt Class T Fuses								
0 – 30	5	3.5	7	3.5	9	3.5		
31 – 60	7	15	9	15	12	15		
61 – 100	9	40	12	40	15	40		
101 – 200	13	150	16	150	20	150		
201 – 400	22	550	28	550	35	550		
401 – 600	29	1000	37	1000	46	1000		
601 – 800	37	1500	50	1500	65	1500		
801 – 1200	50	3500	65	3500	80	4000		
Class J and 600-Volt Class T Fuses								
0 – 30	6	7	7.5	7	12	7	18.5	8.4
31 – 60	8	30	10	30	16	30	24.4	36
61 – 100	12	60	14	80	20	80	28.4	96
101 – 200	16	200	20	300	30	300	42.4	360
201 – 400	25	1000	30	1100	45	1100	66.4	1320
401 – 600	35	2500	45	2500	70	2500	101.4	3000
601 – 800	50	4000	55	4000	75	4000		
Class L Fuses								
601 – 800	80	10000	80	10000	80	10000	79.2	12000
801 – 1200	80	12000	80	12000	120	15000	107.8	18000
1201 – 1600	100	22000	100	22000	150	30000	143	36000
1601 – 2000	110	35000	120	35000	165	40000	158.4	48000
2001 – 2500	–	–	165	75000	180	75000	170.5	90000
2501 – 3000	–	–	175	100000	200	100000	225.5	120000
3001 – 4000	–	–	220	150000	250	150000	286	180000
4001 – 5000	–	–	–	350000	300	350000	286	420000
5001 – 6000	–	–	–	350000	350	500000	399.3	600000
Class RK5 Fuses[a]								
0 – 30	11	50	11	50	14	50	21	60
31 – 60	20	200	21	200	26	200	35	240
61 – 100	22	500	25	500	32	500	40	600
101 – 200	32	1600	40	1600	50	2000	62	2400
201 – 400	50	5200	60	5000	75	6000	90	7200

Table 22 Continued on Next Page

Table 22 Continued

Fuse rating, amperes	Between threshold and 50 kA		100 kA		200 kA		300 kA	
	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$
401 – 600	65	10000	80	10000	100	12000	124	14400
[a] The value for a Class RK5 fuse is to be used when a Class RK1 fuse is specified for overcurrent protection.								

7.9 Low-level dielectric voltage-withstand test

7.9.1 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 7.5, except that the test voltage shall be twice the rated voltage of the switch but not less than 900 V.

7.10 Short-circuit closing test

7.10.1 A switch shall be closed on a circuit capable of providing the maximum short-circuit current for which the switch is rated. After the circuit has cleared, the switch shall comply with the requirements of 7.8.5(a) – 7.8.5(f).

7.10.2 The sample for this test shall be either that used for the short-circuit withstand test or a previously untested sample. The conditions of the closing test shall be the same as for the short-circuit withstand test, see 7.8. Complete physical closure of the switch contacts need not be established.

7.10.3 The dielectric voltage-withstand test described in 7.9 shall be performed following the closing test.

7.11 Strength of insulating base and support test

7.11.1 The insulating base of a 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.

7.11.2 Damage is considered to have occurred if the base insulating material cracks or rotates; if bosses, recesses, or other means to prevent turning do not perform their intended function; if straps or bus bars bend or twist; or if 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.

7.12.6 Other tests

7.12.6.1 If an electrical tripping mechanism affects the parts involving the mechanical or arcing characteristics of an enclosed switch because of its proximity to such parts, the switch with the electrical tripping mechanism installed shall be subjected to the overload and endurance tests.

7.13 Mold stress relief test

7.13.1 Except for rigid thermosetting materials, conditioning of the equipment as described in 7.13.2 shall not cause softening of the material as determined by handling immediately after the conditioning, nor shall there be any shrinkage, warpage, or other distortion as judged after cooling to room temperature, that results in any of the following:

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

b) Making uninsulated live parts or internal wiring accessible to contact, or defeating the integrity of the enclosure so that unacceptable mechanical protection is not afforded to internal parts of the equipment, and

c) Causing interference with the intended operation or servicing of the equipment.

7.13.2 One complete switch shall be placed in a full-draft circulating-air oven maintained at a uniform temperature at least 10°C higher than the maximum temperature of the material measured during the temperature test, but not less than 70°C in any case. The sample shall remain in the oven for 7 hours. After its removal from the oven and return to room temperature, the sample shall be investigated for compliance with 7.13.1.

7.14 Insulating barriers test

7.14.1 With regard to the 6.6.2.5, 6.6.2.7, and 6.6.2.8(b), the barrier material shall be placed between two metal electrodes. The electrodes shall be cylindrical brass or stainless steel rods 6.4 mm (1/4 inch) in diameter with edges rounded to a 0.8 mm (1/32 inch) radius. The test potential shall be increased to the test value and shall be maintained for 1 second. The result shall be acceptable if there is no dielectric breakdown.

8 Ratings

8.1 General

8.1.1 A general-use switch shall be rated in amperes and volts and may, in addition, be rated in horsepower or kilowatts. A fused motor-circuit switch shall be rated in horsepower or kilowatts and volts and also in maximum full-load amperes. A short-circuit-current rating of a switch shall be in accordance with 9.2.14 – 9.2.25.

8.1.2 A double-throw switch intended for use as optional standby systems in accordance with Annex A, Ref. No. 1, shall be rated in full load ampere and volts, and may be additionally rated in horsepower.

8.2 Current

8.2.1 The current rating of a general-use switch shall be 15, 20, 30, 60, 100, 200, 400, 600, 800, 1 200, 1 600, 2 000, 2 500, 3 000, 3 500, or 4 000 A.

8.2.2 The maximum full-load current rating (see 8.1.1) of a fused motor-circuit switch shall be the whole number nearest to 125 percent of the appropriate value selected from Table 20 or Table 21, but the horsepower or kilowatt rating shall be such that the maximum full-load current rating will not be more than 87 percent of the current rating of the fuseholder.

8.3 Voltage

8.3.1 A switch shall have one or more of the following voltage ratings;

a) DC: 125, 125/250, 160, 200, 200/400, 250, 400, 500, 600, and 650 to 1000 volts in 50 volt increments;

b) AC: 120, 127, 120/240, 208, 208Y/120, 240, 277, 347, 480Y/277, 480, 600Y/347, 600, 650, 690; and 700 to 1000 volts in 50 volt increments. In addition, any wye connected system voltage with the above mentioned values is also acceptable.

8.3.2 Table 25 provides various voltage ratings for a given type of switch. To indicate its use on circuits where all of the poles of the switch will not be used, a switch may have, in addition to the standard rating, one or more of the applicable ratings shown for a switch having fewer poles. The rating or ratings applicable depend upon the fusing, spacings, and test performance of the switch. Except as noted in 8.3.3, the 120/240 V ac and the 125/250 V dc rating is applicable only to a switch intended for use on a 3-wire ac or dc system having a grounded neutral.

8.3.3 A 3-wire switch having three blades and three fuses may have an additional voltage rating of 120/240 V ac, or 125/250 V dc, under the following conditions:

a) The switch nameplate carries the applicable standard voltage rating,

b) If the switch nameplate carrying the standard voltage rating appears on the outside of the switch enclosure, the nameplate shall be marked ″For special water-heater applications, see rating inside.″

c) The additional voltage rating appears on a wiring diagram showing the use of the switch on a 2-wire 240 V (or 250 V) water-heater circuit derived from an Edison 3-wire system having a grounded neutral, with auxiliary equipment to provide off-peak service to a dual element water heater, and

d) The switch performs acceptably when subjected to the tests appropriate for the additional rating.

Table 25
Permissible voltage ratings of enclosed and deadfront switches

	Switch configuration			Voltage rating	
	Number of wires	Number of blades	Number of fuses	Direct current	Alternating current
A	1	1	1 or none	125	120 127
B	2	1 with solid neutral	1 or none	125 250[a]	120 127 240[a] 347
C	2	2	1	125 250[a]	120 127 240[a]
D	2 2 2	2 2 2	1, 2, or none 1 or none 2 or none	 125 125/250 250[a] 600[a] 750[a] 1000[a]	120 127 120/240 240[a] 480[a] 600[a] – 1000[a]
E	3	2 with solid neutral	2 or none	125/250	120 127 120/240 220Y/127 240[a]
F	3	3	2	125/250	120 127 120/240 220Y/127 240[a]
G	3	3	None	125/250	120 120/240 240[a] 480[a] 600[a] 1000[a]
H	3	3	3		120 240[a] 480[a] 600[a]
I	4	3 with solid neutral	3 or none		240[a] 480[a] 600[a] 1000[a]
J	4	4	3		240[a] 480[a]

Table 25 Continued on Next Page

Table 25 Continued

	Switch configuration			Voltage rating	
	Number of wires	Number of blades	Number of fuses	Direct current	Alternating current
					600[a] 1000[a]
K	4	4	4 or none none		120 240[a] 480[a] 600[a] 1000[a]
L	5	4 with solid neutral	4 or none		120/240

[a] These ratings are not applicable to switches having plug fuses.

8.4 Horsepower or kilowatts

8.4.1 The horsepower or kilowatts rating of a switch shall be one of values indicated in Table 20 or Table 21.

8.4.2 The horsepower or kilowatts rating of a switch incorporating fuseholders shall not be higher than as indicated in Table 26.

Table 26
Power ratings of fused switches

Fuse-holder, amps	Switch rating in volts	Power ratings, kilowatts (horsepower)							
		2-pole single-phase		2-pole DC		3-pole, 3-phase		4-pole, 2-phase	
		Standard	Maximum[a]	Standard	Maximum[a]	Standard	Maximum[a]	Standard	Maximum[a]
15	120 – 127 AC	0.124 (1/6)	0.249 (1/3)	–	–	0.373 (1/2)	0.56 (3/4)	0.56 (3/4)	1.119 (1-1/2)
20	120 – 127 AC	0.186 (1/4)	0.373 (1/2)	–	–	0.56 (3/4)	0.746 (1)	0.746 (1)	1.492 (2)
30	120 AC 127 AC	0.373 (1/2)	1.492 (2)			1.119 (1-1/2)	2.238 (3)	1.492 (2)	2.238 (3)
60	120 AC 127 AC	1.119 (1-1/2)	2.238 (3)			2.238 (3)	5.60 (7-1/2)	2.238 (3)	7.46 (10)
15	125 DC	–	–	0.746 (1)	0.746 (1)	–	–	–	–
30	120 – 127 AC	0.373 (1/2)	1.492 (2)	–	–	0.56 (3/4)	0.746 (1)	0.746 (1)	1.492 (2)
30	125 DC			1.492 (2)	2.238 (3)				
60	125 DC			3.73 (5)					
15	240 AC	0.373 (1/2)	0.746 (1)	–	–	0.746 (1)	1.492 (2)	1.119 (1-1/2)	2.238 (3)

Table 26 Continued on Next Page

Table 26 Continued

Fuse-holder, amps	Switch rating in volts	Power ratings, kilowatts (horsepower)							
		2-pole single-phase		2-pole DC		3-pole, 3-phase		4-pole, 2-phase	
		Standard	Maximum[a]	Standard	Maximum[a]	Standard	Maximum[a]	Standard	Maximum[a]
20	240 AC	0.56 (3/4)	1.119 (1-1/2)	–	–	1.119 (1-1/2)	2.238 (3)	1.462 (2)	3.73 (5)
30	240 AC	1.119 (1-1/2)	2.238 (3)			2.238 (3)	5.60 (7-1/2)	2.238 (3)	7.46 (10)
60	240 AC	2.238 (3)	7.46 (10)			5.60 (7-1/2)	11.19 (15)	5.60 (7-1/2)	14.92 (20)
100	240 AC	5.60 (7-1/2)	11.19 (15)			11.19 (15)	22.38 (30)	11.19 (15)	22.38 (30)
200	240 AC	11.19 (15)				18.65 (25)	44.76 (60)	22.38 (30)	37.30 (50)
400	240 AC					37.30 (50)	93.25 (125)	37.30 (50)	
600	240 AC					55.95 (75)	149.2 (200)		
800	240 AC					74.60 (100)	186.5 (250)		
15	250 DC	–	–	1.462 (2)	1.462 (2)		–	–	–
20	250 DC	–	–	2.238 (3)	2.238 (3)	–	–	–	–
30	250 DC			3.73 (5)					
60	250 DC			7.46 (10)					
100	250 DC			14.92 (20)					
200	250 DC			29.84 (40)					
400	250 DC			37.30 (50)					
15	480 AC	1.119 (1-1/2)	2.238 (3)	–	–	2.238 (3)	3.73 (5)	2.238 (3)	5.60 (7-1/2)
20	480 AC	1.462 (2)	3.73 (5)	–	–	2.238 (3)	5.60 (7-1/2)	3.73 (5)	7.46 (10)
30	480 AC	2.238 (3)	5.60 (7-1/2)			3.73 (5)	11.19 (15)	5.60 (7-1/2)	14.92 (20)
60	480 AC	3.73 (5)	14.92 (20)			11.19 (15)	22.38 (30)	11.19 (15)	29.84 (40)
100	480 AC	7.46 (10)	22.38 (30)			18.65 (25)	44.76 (60)	18.65 (25)	37.30 (50)
200	480 AC	18.65 (25)	37.30 (50)			37.30 (50)	93.25 (125)	37.30 (50)	
400	480 AC					74.66 (100)	186.5 (250)		
600	480 AC					111.9 (150)	298.4 (400)		
800	480 AC					149.2 (200)	373 (500)		
15	600 AC	–	–	–	–	2.238 (3)	5.60 (7-1/2)	2.238 (3)	5.60 (7-1/2)
20	600 AC	–	–	–	–	3.73 (5)	7.46 (10)	3.73 (5)	7.46 (10)
30	600 AC	2.238 (3)	7.46 (10)			5.60 (7-1/2)	14.92 (20)	7.46 (10)	18.65 (25)
60	600 AC	7.466 (10)	18.65 (25)			11.19 (15)	37.30 (50)	14.92 (20)	37.30 (50)

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Table 26 Continued

Fuse-holder, amps	Switch rating in volts	Power ratings, kilowatts (horsepower)							
		2-pole single-phase		2-pole DC		3-pole, 3-phase		4-pole, 2-phase	
		Standard	Maximum[a]	Standard	Maximum[a]	Standard	Maximum[a]	Standard	Maximum[a]
100	600 AC	11.19 (15)	29.84 (40)			22.38 (30)	55.95 (75)	22.38 (30)	37.30 (50)
200	600 AC	22.38 (30)	37.30 (50)			44.76 (60)	111.9 (150)	37.30 (50)	
400	600 AC					93.25 (125)	261.1 (350)		
600	600 AC					149.2 (200)	373 (500)		
800	600 AC					186.5 (250)	373 (500)		
15	600 DC	–	–	3.73 (5)	3.73 (5)	–	–	–	–
20	600 DC	–	–	5.60 (7-1/2)	5.60 (7-1/2)	–	–	–	–
30	600 DC			7.466 (10)	11.19 (15)				
60	600 DC			18.65 (25)	22.38 (30)				
100	600 DC			29.84 (40)	37.30 (50)				
200	600 DC			37.30 (50)					

[a] See 9.2.8 and 9.2.9.

8.4.3 In addition to the horsepower or kilowatt ratings corresponding to the number of poles provided, as shown in Table 26, a switch may have a horsepower or kilowatt rating or ratings applicable to a switch having the same size fuseholders but fewer poles if, upon investigation, the switch is found to be acceptable for the assigned rating.

8.4.4 The horsepower or kilowatt ratings of fused motor-circuit switches shall be related to the voltage and fuseholder ratings on the same basis as the ratings of fused switches, in accordance with Table 26.

No Text on This Page

8.5 Short-circuit current

8.5.1 The short-circuit current rating of a switch shall be one or more of the values shown in Table 27 or 28. The short-circuit current rating of a switch shall not be greater than the interrupting rating of the specified overcurrent protective devices. The rating shall be 10 000 A for plug, Class H, and Class K fuses. An alternating current rating shall not be less than 50 000 A for Class CC, CF, G, J, L, R, C, or T fuses.

Table 27
Alternating current short-circuit current rating, rms

Symmetrical amperes		
5000[a]	25000[a]	85000[a]
7500[a]	30000[a]	100000[a]
10000	35000[a]	125000
14000[a]	42000[a]	150000[a]
18000[a]	50000	200000[a]
22000[a]	65000[a]	300000[b]

[a] These short-circuit current ratings shall only be employed when circuit breakers are specified.
[b] This short-circuit current rating is not applicable in Canada and Mexico.

Table 28
Direct current short-circuit current ratings

Direct current amperes	
5000[a]	20000
7500[a]	50000
10000	100000

[a] These short-circuit current ratings shall only be employed when circuit breakers are specified.

9 Marking

9.1 General

9.1.1 All markings shall be in the appropriate language for the country in which the switch will be installed. A manufacturer shall be permitted to choose to utilize multiple languages on a switch.

Note: In Canada, there are two official languages, English and French. Annex C lists acceptable French translations of the markings specified in this Standard. All markings required by this Standard may have to be in other languages to conform with the language requirements where the product is to be used.

9.2.36 The marking ″Service disconnect″, which identifies the service disconnecting switch, required by 9.2.35, shall appear on or adjacent to the switch handle.

9.2.37 Enclosed switches constructed in accordance with 9.2.34 shall be provided with a tag, instruction sheet, or the equivalent indicating how the bond is to be removed when required by the electrical inspection authorities (for example, Where electrical inspection authorities require the neutral assembly to be disconnected from the enclosure...*).

Note: *Each manufacturer should add specific instructions applicable to the particular construction.

9.2.38 An enclosed switch that is intended for use as service equipment and does not have the neutral bonded to the enclosure at the factory shall be marked, ″Suitable for use as service equipment″.

9.2.39 An enclosed switch marked ″Suitable for use as service equipment″ shall be provided with a marking, ″Service Disconnect″ in the form of a pressure-sensitive label in an envelope or on a card, with instructions to apply near the disconnect handle if the equipment is used as service equipment.

9.2.40 The marking mentioned in 9.2.34 – 9.2.38 shall be an integral part of the marking containing the manufacturer's name, or equivalent, unless it is an integral part of another required marking of the enclosed switch.

9.2.41 If the electrical safety features, including performance and spacing to grounded metal parts of a switch, are dependent upon the proper connection of line and load conductors, the marking shall indicate plainly the proper connections, except that a double-throw switch need not be so marked.

9.2.42 The words ″line″ and ″load″ are usually employed to indicate the proper connections. If it is impracticable to place such markings at terminals because connections vary for different systems, a wiring diagram attached to the inside of the enclosure shall be acceptable if it indicates clearly the proper connections.

9.2.43 A double-throw switch having fuses in series with one or both sets of stationary jaws shall be marked to indicate that when installed as a transfer device between two sources of power and a common load, the fuses may be energized even if the switch is in the middle (off) position.

9.2.44 Fixed terminal parts of a 30 A switch shall be marked for identification unless the terminal parts intended for the connection of the grounded conductor are clearly evident. The terminals intended for the grounded conductor shall be identified by means of a metal-plated coating substantially white in color, or the terminals may be of a material substantially white in color. The other terminals shall be of a readily distinguishable different color.

9.2.45 If pressure terminal connectors are not provided on the equipment as shipped, the equipment shall be marked stating which pressure terminal connector or component terminal assemblies are for use with the equipment. A wire connector of the type or types mentioned may be installed on the equipment at the factory with instructions, if necessary, to effect proper connection of the conductor or conductors. The terminal assembly packages shall carry an identifying marking, wire size, and manufacturer's name or trademark.

9.2.46 If a terminal is omitted in accordance with 6.7.2.14, the switch and the equipment intended to be connected to it shall each be marked to indicate that one is to be used with the other. Both pieces of equipment shall also identify, by a marking or the equivalent, the means by which connections between them should be made.

9.2.47 If, in accordance with 6.1.3 or 6.1.7, an accessory is shipped from the factory separately from or included with the switch for which it is intended to be used:

a) The accessory or kit shall be marked with its own catalog number or the equivalent and with the name or trademark of the manufacturer and, except for neutral assemblies, with the electrical rating.

b) The switch shall be marked to indicate the catalog number or the equivalent of each of the accessories or kit(s) that are for use with it. In the case of neutral assemblies, the switch shall also be marked with an indication of the voltage ratings for which the neutral assembly must be used.

c) Installation instructions shall be furnished with the accessory or kit. Instructions for wiring of an accessory or kit and installation of barriers and/or jumpers shall be permanently attached to the enclosed switch or to the accessory so as to be visible after installation. Also, see 6.1.7(e).

9.2.48 If the terminals mentioned in 6.12.3 and 6.12.4 are required but are not supplied with the enclosed switch, the enclosed switch shall be marked with a catalog number of a kit including the terminals, or information stating the wire size of terminals required, and instructions for assembly in the enclosure.

9.2.49 If a terminal is acceptable for the connection of more than one conductor and is intended for such use, the marking shall indicate the proper connection.

9.2.50 If any terminal of a switch is marked to indicate that aluminum wire may be used at that terminal, such as by being marked with the symbol ″Al″, and if such marking is visible, the switch shall be marked in accordance with 9.2.52, 9.2.53, or 9.2.54, whichever applies.

9.2.51 The term ″visible″ signifies a marking that will be visible when a front, trim, or a hinged cover has been opened or removed. A marking on a separately supplied connector or a connector or part thereof that is likely to be removed or displaced during the wiring operation is considered to be visible.

9.2.52 If, because of wiring space or other factors, a terminal is not for use with aluminum wire, the switch shall be marked, ″Use copper wire only″.

9.2.53 If the wiring space and other factors are such that all terminals of the switch are for use with aluminum and copper wire, the enclosed switch shall be marked, ″Use copper or aluminum wire″.

9.2.54 If the wiring space and other factors are such that some terminals of the switch are for use with aluminum and copper wire and the remainder of the terminals are for use with copper wire only, the switch shall be marked ″Use copper wire only except at terminals _____″. The marking shall positively identify the terminals that are for use with aluminum wire.

ANNEX A (normative)

Referenced Standards

Where reference is made to other organization's standards, such reference shall be considered to refer to the latest edition and all amendments published to that edition up to the time when this standard was approved.

Ref. No.	United States	Canada	Mexico
1	ANSI/NFPA 70, National Electrical Code	CSA C22.1, Canadian Electrical Code, Part I	NOM-001-SEDE, Electrical installations (utility)
2	ASTM D3638, Standard Test Method for Comparative Tracking Index of Electrical Insulating Materials	CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials	No equivalent
3	ASTM D3874, Standard Test Method for Ignition of Materials by Hot Wire Sources	CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials	No equivalent
4	UL 50, Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations	CSA C22.2, No. 94-1 – Enclosures for Electrical Equipment, Non-Environmental Considerations	NMX-J-235/1-ANCE, Enclosures for electrical equipment – Part 1 General requirements NMX-J-235/2-ANCE, Enclosures for electrical equipment – Part 2 Specific requirements
5	UL 94, Standard for Test for Flammability of Plastic Materials for Parts in Devices and Appliances	CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials	No equivalent
6	UL 486A-486B, Standard for Wire Connectors	CSA C22.2 No. 65, Wire Connectors	No equivalent
7	UL 969, Standard for Marking and Labeling Systems	CSA C22.2 No. 0.15, Adhesive Labels	No equivalent

Table Continued on Next Page

Table Continued

Ref. No.	United States	Canada	Mexico
8	UL 4248-1, Standard for Fuseholders – Part 1: General Requirements	CSA C22.2 No. 39, Fuseholder Assemblies, or as applicable CSA C22.2 No. 4248.1, Fuseholders, General Requirements	NMX-J-098/4248/1-ANCE,
	UL 4248-4, Standard for Fuseholders – Part 4: Class CC	CSA C22.2 No. 4248.4, Fuseholders, Class CC	NMX-J-098/4248/4-ANCE
	UL 4248-5, Standard for Fuseholders – Part 5: Class G	CSA C22.2 No. 4248.5, Fuseholders, Class C	NMX-J-098/4248/5-ANCE
	UL 4248-6, Standard for Fuseholders – Part 6: Class H	CSA C22.2 No. 4248.6, Fuseholders, Class H	NMX-J-098/4248/6-ANCE
	UL 4248-8, Standard for Fuseholders – Part 8: Class J	CSA C22.2 No. 4248.8, Fuseholders, Class J	NMX-J-098/4248/8-ANCE
	UL 4248-9, Standard for Fuseholders – Part 9: Class K	CSA C22.2 No. 4248.9, Fuseholders, Class K	NMX-J-098/4248/9-ANCE
	UL 4248-11, Standard for Fuseholders – Part 11: Type C (Edison Base) and Type 2 Plug Fuse	CSA C22.2 No. 4248.11, Fuseholders, Type C and Type 2	No equivalent
	UL 4248-12, Standard for Fuseholders – Part 12: Class R	CSA C22.2 No. 4248.12, Fuseholders, Class R	NMX-J-098/4248/12-ANCE
	UL 4248-15, Standard for Fuseholders – Part 15: Class T	CSA C22.2 No. 4248.15, Fuseholders, Class T	NMX-J-098/4248/15-ANCE
9	UL 746C, Standard for Polymeric Materials – Used in Electrical Equipment Evaluations	CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials	No equivalent
10	UL 746A, Standard for Polymeric Materials – Short Term Property Evaluations	CSA C22.2 No. 0.17, Evaluation of Properties of Polymeric Materials	No equivalent
11	ASTM E28-67(1982), Test Method for Softening Point by Ring-and-Ball Apparatus	No equivalent	No equivalent
12	No equivalent	CSA C22.2 No. 0, General Requirements – Canadian Electrical Code, Part II	No equivalent
13	No equivalent	CSA C22.2 No. 0.4, Bonding of electrical equipment	No equivalent
14	No equivalent	CSA C22.2 No. 0.12, Wiring Space and Wire Bending Space in Enclosures for Equipment Rated 750 Volts or Less	No equivalent
15	No equivalent	CSA C22.2 No. 0.19, Requirements for Service Entrance Equipment	No equivalent
16	UL 83 , Thermoplastic-Insulated Wires and Cables	CSA C22.2 No. 75, Thermoplastic-Insulated Wires and Cables	NMX-J-010-ANCE, Thermoplastic-Insulated Wires and Cables

Standards Update Service

CSA C22.2 No. 4:16
February 2016

Title: *Enclosed and dead-front switches*

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Association of Standardization and Certification
NMX-J-162-ANCE-2016
Fourth Edition

CSA Group
CSA-C22.2 No. 4-16
Eighth Edition

Underwriters Laboratories Inc.
UL 98
Fourteenth Edition

Enclosed and Dead-Front Switches

February 12, 2016

ANSI/UL 98-2016

Commitment for Amendments

This standard is issued jointly by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (operating as "CSA Group"), and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to ANCE, CSA Group, or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of ANCE, CSA Group, and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue. ANCE will incorporate the same revisions into a new edition of the standard bearing the same date of issue as the CSA Group and UL pages.

ISBN 978-1-77139-928-9 © 2016 CSA Group

This Standard is subject to review five years from the date of publication, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquires@csagroup.org and include ″Proposal for change″ in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

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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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Preface

This is the harmonized ANCE, CSA Group, and UL standard for *Enclosed and Dead-Front Switches*. It is the Fourth edition of NMX-J-162-ANCE, the Eighth edition of CSA C22.2 No. 4, and the Fourteenth edition of UL 98. This harmonized standard has been jointly issued February 12, 2016.

This harmonized standard was prepared by the Association of Standardization and Certification (ANCE), CSA Group, and Underwriters Laboratories Inc., (UL). The efforts and support of the Technical Harmonization Committee for Enclosed Switches, of the Council on the Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA), are gratefully acknowledged.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

This standard was reviewed by the CSA Subcommittee on Enclosed and Dead-Front Switches, under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee.

This standard has been approved by the American National Standards Institute (ANSI) as an American National Standard.

Where reference is made to a specific number of samples to be tested, the specified number shall be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of harmonization

This standard uses the IEC format but is not based on, nor is it considered equivalent to, an IEC standard. This standard is published as an equivalent standard for ANCE, CSA Group, and UL.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

Reasons for differences from IEC

The THC determined the safe use of enclosed and dead-front switches is dependent on the design and performance of the products in relation to the North American Electrical Codes with which they are intended to be installed.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

1 Scope

1.1 These requirements cover individually enclosed air switches, rated 4000 A or less at 600 V or less, having all current-carrying parts enclosed, manually operable by means of external handles, and intended to be employed in accordance with the national installation codes listed in Annex A, Ref. No. 1.

1.2 As used in this Standard, the term switch is intended to mean an enclosed switch or deadfront switch unless specifically stated otherwise.

1.3 These requirements also cover deadfront switches that have all current-carrying parts enclosed when mounted in an enclosed panelboard, deadfront switchboard, or the like. These switches are manually operable by means of external handles and are intended to be employed in accordance with the national installation codes listed in Annex A, Ref. No. 1.

1.4 These requirements cover enclosed switches with or without provision for fuses suitable for use as branch circuit, feeder, and service overcurrent protection.

1.5 The following fuses are deemed suitable for use as branch circuit, feeder, and service overcurrent protection:

a) Cartridge Fuses (Ref. Annex B, Low-Voltage Fuses – Parts 1 – 10, 12 and 15),

b) Plug Fuses (Ref. Annex B, Low-Voltage Fuses – Parts 1 and 11), and

c) Special Purposes Fuses marked as meeting the performance specifications of a specific Class Fuse.

1.6 These requirements cover enclosed switches intended for general use and having ampere ratings, with or without horsepower or kilowatt ratings, and enclosed switches intended for motor-circuit use only and having horsepower or kilowatt ratings but no general-use ampere ratings.

1.7 These requirements cover double-throw switches intended for use in optional standby systems (see Annex A, Ref. No. 1).

1.8 These requirements cover fused electrically tripped switches rated over 600 A and rated 600 A or less employing Class J, R or T fuses.

1.9 These requirements also cover electrically tripped switches that have been investigated to determine their acceptability for ground-fault protection when combined with ground-fault sensing and relaying equipment as follows:

a) Switches for use with Class I ground-fault sensing and relaying equipment include those that are capable of interrupting 12 times their rated current or that have integral means to prevent disconnecting as levels of fault current exceeding the contact interrupting capability of the switch.

b) Switches for use with Class II ground-fault sensing and relaying equipment are capable of interrupting 10 times their rated current and are for use in ground-fault protection systems in which means to prevent disconnecting at levels of fault current exceeding the contact interrupting capability of the switch are incorporated within the ground-fault sensing and relaying equipment when combined with Class I and II ground-fault sensing and relaying equipment.

1.10 These requirements do not cover:

a) Common forms of snap switches,

b) Switches having features intended primarily for the starting and protection of motors, including the switches arranged to shunt out fuses during the starting of motors,

c) Switches provided with automatic trips for opening them and constructed to afford overload protection without other circuit breakers or fuses,

d) Devices in which the pulling of fuses or the removal of a detachable pullout member is designed to accomplish a switching operation, or

e) Circuit breakers, molded-case switches, magnetic-only circuit interrupters, instantaneous-only circuit breakers, and supplementary protectors.

2 Normative References

2.1 Where reference is made to any Standards, such reference shall be considered to refer to the latest editions and revisions thereto available at the time of printing, unless otherwise specified. See Annex A.

2.2 Products covered by this standard shall comply with the referenced installation codes and standards noted in this clause as appropriate for the country where the product is to be used. When the product is intended for use in more than one country, the product shall comply with the installation codes and standards for all countries where it is intended to be used.

2.3 In Canada, general requirements are as indicated in Annex A, Ref. Item No. 12, and grounding and bonding requirements are as indicated in Annex A, Ref. Item No. 13.

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this standard shall comply with the requirements for that component. See Annex B for a list of standards covering components generally used in the products covered by this standard. A component shall comply with the ANCE, CSA Group, or UL standards as appropriate for the country where the product is to be used.

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

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

b) Is superseded by a requirement in this standard.

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

3.4 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.

4 Units of Measurement

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

5 Definitions

5.1 ACCESSORY – a device that performs a secondary or minor duty as an adjunct or refinement to the primary or major duty of a unit of equipment.

5.2 AIR SWITCH – a switching device designed to close and open one or more electric circuits by means of guided separable contacts that separate in air.

5.3 AMBIENT TEMPERATURE – the temperature of the surrounding medium that comes in contact with the exterior of the switch enclosure.

5.4 AUXILIARY SWITCH – a switch mechanically operated by the main switching device for switching, signaling, interlocking, or other purposes.

5.5 AUXILIARY SWITCH contacts may be designated as ″a″ or ″b″ as indicated below, but other contact arrangements may be used:

> ″a″ – Contacts that are open when the switch contacts are open and closed when the switch contacts are closed.
>
> ″b″ – Contacts that are closed when the switch contacts are open and open when the switch contacts are closed.

5.6 AVAILABLE FAULT CURRENT – the maximum current that the power system can deliver through a given circuit point to any negligible impedance short-circuit applied at that point.

5.7 CARTRIDGE FUSE – a fuse consisting of a current-responsive element inside a fuse body with contacts on both ends.

5.8 CLEARING I^2t (AMPERE-SQUARED SECONDS) – the measure of heat energy developed as a result of current flow between the time that current begins to flow and until the fuse clears the circuit. I^2 stands for the square of the effective (rms) let-through current and t stands for the time of current flow in seconds.

5.9 CLEARING I^2t (OF A FUSE) – the amount of ampere-squared seconds passed by a fuse during total clearing time under specified conditions.

5.10 CURRENT-LIMITING FUSE (AC) – a fuse that safely interrupts all available currents within its interrupting rating and, within its current-limiting range, limits the clearing time at rated voltage to an interval equal to or less than the first major or symmetrical current loop duration and limits peak let-through current to a value less than the peak current that would be possible with the fuse replaced by a solid conductor of the same impedance.

5.11 CURRENT-LIMITING FUSE RATING – a rating expressed in terms of three characteristics that measure the degree by which the fuse limits current. These are threshold ratio, maximum peak let-through current, and maximum clearing I^2t.

5.12 CURRENT RATING – the designated maximum direct or alternating operating current in rms amperes at rated frequency for which the switch qualifies under specified test conditions.

5.13 DEADFRONT SWITCH – a switch that has all current-carrying parts enclosed when it is mounted in an enclosed panelboard, deadfront switchboard, or the like.

5.14 DETACHABLE PULLOUT – a type of pullout switch that is operated by physical removal and reinsertion of a detachable pullout member.

5.15 DIELECTRIC TESTS – tests made to determine the ability of insulating materials and spacings used to withstand specified overvoltages.

5.16 DOUBLE-THROW SWITCH – a switch by means of which a change in circuit connections can be obtained by operating the switch into either of two closed positions or into an open position.

5.17 DUMMY FUSE – a current-carrying part made of copper and having dimensions such that it will fit its fuse mounting means with the same conditions of pressure, contact, and cross-section area as are obtained on terminals of the fuse that it is intended to replace. A dummy fuse is not a protective device.

5.18 ELECTRICALLY TRIPPED SWITCH – a switch whose closing is performed manually, but whose contact opening may be performed by a release which is energized by a voltage source in addition to the manual operating means.

5.19 ENCLOSED PULLOUT SWITCH – a pullout switch, with or without fuseholders, having all current-carrying parts completely enclosed when the hinged cover is in the closed position (in the case of hinged pullouts) or when the detachable member is in the installed position (in the case of detachable pullouts).

5.20 ENCLOSED SWITCH – a switch, with or without fuseholders, having all current-carrying parts completely enclosed, that is operable without opening the enclosure.

5.21 ENCLOSURE – a surrounding case constructed to provide a degree of protection to personnel against incidental contact with the enclosed equipment and to provide a degree of protection to the enclosed equipment against specified environmental conditions.

5.22 FUSE – a protective device that opens by the melting of a current-sensitive element during specified overcurrent conditions.

5.23 FUSE CLIPS – the contacts of the fuseholder that support the fuse and connect the fuse terminals with the circuit.

5.24 FUSED MOTOR-CIRCUIT SWITCH – a switch rated in horsepower (or kilowatts) capable of interrupting the maximum operating overload current of a motor of the same horsepower (or kilowatts) rating as the switch at the rated voltage.

5.25 FUSEHOLDER – an assembly of base, fuse clips, and necessary insulation for the mounting or connecting of a fuse into a circuit.

5.26 FUSED SWITCH – a switch in which one or more poles have a fuse in series in a composite unit. These switches should not be confused with switches in which the fuse forms the moving contact.

5.27 GROUND (EARTH) (ELECTRIC SYSTEM) – a conducting connection, whether intentional or accidental, by which an electric circuit or equipment is connected to the earth or to some conducting body of relatively large extent that serves in place of the earth. A ground is used for establishing and maintaining the potential of the earth (or of the conducting body), or approximately that potential, on conductors connected to it, and for conducting ground current to and from the earth (or the conducting body).

5.28 ISOLATING SWITCH – a switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means.

5.29 KNOCKOUT – a portion of the wall of an enclosure so fashioned that it can be removed readily by a hammer, screwdriver, and pliers at the time of installation in order to provide a hole for the attachment of an auxiliary device or raceway, cable, or fitting.

5.30 LIVE PARTS – parts that are designed to operate at a voltage different from that of the earth.

5.31 NORMAL-FREQUENCY RECOVERY VOLTAGE – the normal-frequency-root-mean-square voltage that occurs across the terminals of an ac circuit-interrupting device after the interruption of the current and after the high-frequency transients have subsided.

5.32 OPERATING MECHANISM OF A SWITCH – the mechanism by which the contacts of a switch are actuated to open or close the circuit.

5.33 OVERLOAD TESTS – tests to which a switch is subjected to determine the ability of the switch, under specified conditions, to make and break currents greater than the current rating of the switch.

5.34 PEAK LET-THROUGH CURRENT, Ip – the highest instantaneous current passed by the over-current protection device during the interruption of the current.

5.35 PEAK LET-THROUGH CURRENT, Ip (aC) – the maximum instantaneous current during the total clearing time.

5.36 PLUG FUSE – fuse consisting of a current-responsive element inside a housing with coaxial terminals on one end, one terminal being a threaded metal ring or shell on the outside of the housing.

5.37 POLE OF A SWITCHING DEVICE – the portion of a switching device associated exclusively with one electrically separated conducting path of its main circuit and excluding those portions which provide a means for mounting and operating all poles together.

5.38 PRESSURE WIRE CONNECTOR – a reusable connector into which the conductor (wire) is secured by mechanical pressure applied by integral screw, cone, or other mechanical parts.

5.39 RATING – a designated limit of operating characteristics based on specified conditions of current, voltage, frequency, and such.

5.40 SERVICE EQUIPMENT – the necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply.

5.41 SHORT-CIRCUIT CURRENT RATING – the maximum available rms symmetrical ac current or maximum available dc current (which is marked on the switch) to which the (fused or unfused) switch is intended to be connected when protected by the specified overcurrent protective device or devices.

5.42 SINGLE-THROW SWITCH – a switch which has an open and a closed circuit position only.

5.43 SWITCH – a device, manually operated, unless otherwise designated, for opening and closing or for changing the connection of a circuit.

5.44 SWITCHING DEVICE – called ″single-pole″ if it has only one pole. If it has more than one pole, it is called ″multipole″ (two-pole, three-pole, and so on) provided the poles are coupled in such a manner as to operate together.

5.45 TYPE TESTS – tests made to determine the adequacy of the design of a particular type, style, or model of equipment or its component parts to meet its assigned ratings and to operate satisfactorily under usual service conditions. Type tests should be made only on representative equipment to substantiate the ratings assigned to all other apparatus of basically the same design. These tests are not intended to be used as a part of normal production. The applicable portion of these type tests may also be used to evaluate modifications of a previous design and to assure that performance has not been adversely affected. Test data from previous similar designs may be used for current designs, where appropriate.

6 Construction

6.1 General

6.1.1 A switch shall employ materials throughout that are acceptable for the particular use, and shall be made and finished with the degree of uniformity and quality of work practicable in a well-equipped factory.

6.1.2 All parts of a switch shall be assembled in place when the switch is shipped from the factory, except as noted in 6.1.3.

6.1.3 A switch may have provision for factory- or field-installed accessories such as neutral assemblies or auxiliary switches provided that:

a) The switch is for use with and 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. Cutting, splicing of existing wires, or resoldering of connections shall not be permitted, and

f) The accessory and switch are marked in accordance with 9.2.47.

6.1.4 With reference to 6.1.3, screws for mounting the neutral assembly shall be furnished with that assembly but need not be assembled in place.

6.1.5 A switch (including all of its parts) shall be strong and rigid enough for the intended application.

6.1.6 All ferrous metal parts other than enclosures, unless of corrosion-resistant material, shall be galvanized, painted, enameled, plated, or otherwise acceptably treated to provide protection against corrosion.

6.2 Enclosure

6.2.1 An overall enclosure shall comply with the requirements in Annex A, Ref. No. 4, except for modifications and additional requirements as specially described in this Standard.

6.2.2 A deadfront switch shall comply with the requirements in Annex A, Ref. No. 4, only with regard to those parts of its enclosure that will be exposed when the switch is installed behind the deadfront of a panelboard or the like.

6.2.3 The entire enclosure of a switch intended for surface mounting and the box proper of a switch intended for flush mounting shall be permitted to be formed of steel not less than 1.07 mm (0.042 inch) thick (base metal thickness not including a coating thickness) if:

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

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

c) The thickness of a cover, front, door, trim, and similar parts, provided as part of an enclosure intended for flush mounting, is as specified in Annex A, Ref. No. 4.

6.2.4 An opening for a closely fitting operating handle shall be permitted if the opening is substantially closed when the switch handle is in any operating position. The clearance between the edge of the hole and the handle shall not exceed 2.4 mm (3/32 inch) on either side (one side only) and 3.2 mm (1/8 inch) total (both sides). The clearances shall be measured with the handle in the full on and off positions. The handle and its supporting member shall be assembled in the position resulting in the largest clearance that can result from ordinary factory assembly.

6.2.5 A single door may be provided regardless of the width of a door.

6.2.6 A door or cover intended to give access to fuses shall be hinged, sliding, or similarly attached so as to prevent its removal.

6.2.7 Switches shall be provided with a means for locking the door closed. Switches marked as suitable for use as service equipment shall be provided with a means for sealing.

6.2.8 The enclosure shall be constructed so that all doors can be opened to a minimum of 90 degrees from the closed position.

6.2.9 When knockouts are provided in the enclosure of a switch, they shall be located so that the installation of conduit bushings will not result in electrical spacings less than the minimum requirements of this Standard. In measuring electrical spacings it shall be assumed that the bushings are of suitable size for the largest conduit that can be used.

6.2.10 An external operating means, such as one for a disconnect, a pilot device, or a resetting operation, mounted on or through an enclosure shall withstand the environmental tests specified in Annex A, Ref. No. 4, for the marked enclosure type.

6.3 Operating mechanism

6.3.1 The operating mechanism shall be designed and 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 prevent loosening under the jars of continued use. Stops shall be provided so as to remove undue strain from switch parts.

6.3.2 A handle shall be provided for convenient operation of a switch and shall be constructed so as not to present a risk of fire, electric shock, or injury to persons. An operating handle and door of conducting material shall be in electrical connection with the enclosure.

6.3.3 A metal rod using the wall of the box as a bearing shall be considered to be in electrical connection with the enclosure.

6.3.4 If the position of a switch is indicated by the position of the operating handle, there shall be definite off and on positions for the handle, and the construction of the operating mechanism shall be such that the handle cannot be left readily at or near the off position when the switch is on. See also 9.2.13.

6.3.5 If a switch is operated such that movement of the operating handle is vertical between the on and off positions resulting in one position being above the other position, then the upper position shall be the on position. A switching device having more than one on position, such as a double-throw switch, need not comply with this requirement.

6.3.6 A handle or other member that indicates the position of the switch contacts (closed or open) shall be so constructed that the door, front, or cover cannot be secured in place in the intended manner so that the handle or member indicates off with the switch contacts in the closed position.

6.3.7 There shall be provision for locking an enclosed switch in the off position without opening the enclosure.

6.3.8 An isolating switch shall have provision for locking the switch in the on position. A current-interrupting switch may have provision for locking the switch in the on position.

6.3.9 A switch so constructed that it will tend to close by gravity shall be provided with means for holding the operating mechanism in the off position.

6.3.10 Switches rated greater than 250 V, 30 A shall have the design of the operating mechanism in conjunction with the contact structure, such that in normal operation, the operator of the switch cannot restrain the operation of the contacts after they have initially touched or parted when closing or opening the switch. Isolating switches complying with 6.3.8 and 9.2.12 are exempt from this requirement.

6.4 Accessibility of live parts

6.4.1 Openings in enclosures that provide access to live parts shall be evaluated in accordance with Annex A, Ref. No. 14.

6.5 Electrical insulation material

6.5.1 Insulation material in contact with live parts shall have at least the minimum values specified in Table 1 and additionally be subjected to the mold stress relief test in 7.13.

6.5.2 An insulation material having values below those contained in Table 1 may be accepted based on acceptable end-product performance tests. See Annex A, Ref. No. 9.

Note: This requirement does not apply in Canada.

6.5.3 The mold stress relief test is not required for rigid thermosetting materials.

Table 1
Minimum values for insulating materials

	Flammability rating of material			
Test specified	**V-0**	**V-1**	**V-2**	**HB**
Hot wire ignition (HWI)[e], ignition time in sec. (Annex A, Ref. No. 3)	7	15	30	30
High current arc ignition (HAI)[d], number of arcs (Annex A, Ref. No. 10)	15	30	30	60
Comparative tracking index (CTI) under moist conditions[c], volts (Annex A, Ref. No. 2)	175[a,b]	175[a,b]	175[a,b]	175[a,b]

a) A material having a minimum comparative tracking value of 100 may be used if the voltage involved is 250 volts or less.

b) Not applicable if the over-surface spacing is greater than or equal to 12.7 mm (1/2 inch).

c) Material surface is in contact with or in close proximity [within 0.8 mm (1/32 inch)] to:

1) uninsulated live parts of opposite polarity, or

2) uninsulated live parts and either

i) metal parts that may be grounded in service, or

ii) any surface exposed to contact.

d) Material is in contact with or in close proximity to uninsulated live parts 0.8 mm (1/32 inch) for nonarcing parts or 12.7 mm (1/2 inch) for arcing parts.

e) Material is in contact with or close proximity to uninsulated live parts [within 0.8 mm (1/32 inch)].

6.5.4 The overall thickness of switch bases shall not be less than 12.5 mm (1/2 inch) if made of porcelain.

6.5.5 Vulcanized fiber, impregnated hard wood, and molded composition are acceptable as materials for crossbars. Cold-molded and phenolic compositions are acceptable generally, but ordinary fiber, rubber, and so-called hot-molded shellac and tar compositions shall not be used for the mounting of uninsulated live parts.

6.6 Spacings

6.6.1 General

6.6.1.1 Except as noted in 6.6.1.4 – 6.6.1.6, the spacings in a switch shall be as indicated in Table 2. Grounded metal includes the enclosure and any metal that may be in electrical connection with the enclosure.

Table 2
Minimum spacings[a]

Voltage between parts involved	Minimum spacings in mm (inches)							
	Between uninsulated live parts of opposite polarity				Between uninsulated live parts and any grounded metal			
	Over surface		Through air		Over surface		Through air	
0 – 130	19	(3/4)	12.5	(1/2)	12.5	(1/2)	12.5	(1/2)
131 – 250	31	(1-1/4)	19	(3/4)	12.5	(1/2)	12.5	(1/2)
251 – 600	50	(2)	25	(1)	25	(1)	12.5	(1/2)

[a] The SI units are minimum values and are not a direct conversion from the corresponding values in inches.

6.6.1.2 Terminals and other live parts intended to be connected to the grounded conductor of a circuit shall be considered to be uninsulated live parts unless such parts are mounted directly on or in permanent electrical connection with the enclosure.

6.6.1.3 If the connection mentioned in 6.6.1.2 is solely by means of a screw, strap, or other bonding device that can be readily removed and is not depended upon to perform a mechanical function, the switch shall:

a) Comply with the requirement in 6.6.1.1 when the bonding device is removed, or

b) Be marked as described in 9.2.33.

6.6.1.4 The spacings between screw-shells of plug fuseholders that are protected by surrounding walls of insulating material, and between such screw-shells and a metal cover plate, may be less than those indicated in Table 2 but not less than 6.4 mm (1/4 inch) in any case, if the depth of the receptacle, as measured from the top of the wall to the plane of the center contact, is not less than 19.1 mm (3/4 inch).

6.6.1.5 The distance between a door or cover over a fuseholder and:

a) The center contact of an Edison-base plug fuseholder shall not be less than 39.7 mm (1-9/16 inches).

b) The center contact of a Type S plug fuseholder shall not be less than 33.3 mm (1-5/16 inches).

6.6.1.6 The spacings given in Table 2 are not required to be maintained between switch blades and the enclosure cover when the switch is in the off position and the blades are deenergized, but such spacings shall not be less than 3.2 mm (1/8 inches).

6.6.1.7 In measuring between an uninsulated live part and a conduit bushing installed at a knockout, it shall be assumed that a conduit bushing having the dimensions specified in Table 3 is in place.

Table 3
Conduit bushings

Trade size designators	Overall diameter,		Height,	
	mm	(inches)	mm	(inches)
1/2	25.4	(1)	9.5	(3/8)
3/4	31.4	(1-15/64)	10.7	(27/64)
1	40.5	(1-19/32)	13.1	(33/64)
1-1/4	49.2	(1-15/16)	14.3	(9/16)
1-1/2	56.0	(2-13/64)	15.1	(19/32)
2	68.7	(2-45/64)	15.9	(5/8)
2-1/2	81.8	(3-7/32)	19.1	(3/4)
3	98.4	(3-7/8)	20.6	(13/16)
3-1/2	112.7	(4-7/16)	23.8	(15/16)
4	126.2	(4-31/32)	25.4	(1)
4-1/2	140.9	(5-35/64)	27.0	(1-1/16)
5	158.0	(6-7/32)	30.2	(1-3/16)
6	183.4	(7-7/32)	31.8	(1-1/4)

6.6.1.8 There shall be a spacing of not less than 3.2 mm (1/8 inch) between line and load terminals of the same polarity.

6.6.1.9 Wire connectors shall be kept from turning to the extent that spacings would be reduced to less than those required in 6.6.1.1; however, if such minimum or greater spacings are maintained when wire connectors are turned 30 degrees toward each other or toward other uninsulated live or grounded parts, no means to prevent turning need be provided.

6.6.1.10 Spacings at the wiring terminals of a 30 A switch shall be measured with the device wired in accordance with Table 4.

Table 4
AWG size (mm^2) of wire to be used in spacings evaluation of 30 A switches

Terminal acceptable for use with	For use as service equipment		Not for use as service equipment	
	AWG	mm^2	AWG	mm^2
Copper only	8	8.367	10	5.260
Copper/aluminum	6	13.30	8	8.367

6.6.1.11 The spacings at wiring terminals employing wire connectors shall be measured with the device wired with conductors having an ampacity not less than the current rating of the switch (see 6.10.2).

6.6.1.12 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 shall be considered as reducing the spacing by an amount equal to the dimension of the metal part in the direction of the measurement.

6.6.1.13 The requirements in 6.6.1.1 and 6.6.1.8 do not apply

a) Between uninsulated live parts of opposite polarity within a component of the switch (such as an auxiliary switch),

b) Between uninsulated live parts of the component and deenergized metal that is part of the component, or

c) Between uninsulated live parts of the component and that part of the deenergized metal surface of the switch on which the component is mounted in the intended manner.

6.6.1.14 The requirements in 6.6.1.1 and 6.6.1.8 shall apply:

a) between uninsulated live parts in different components, and

b) between uninsulated live parts of a component and a live part or the deenergized metal of the switch, other than the dead metal surface on which the component is mounted.

6.6.1.15 Live screw heads or nuts on the underside of a base intended for surface mounting shall be countersunk not less than 3.2 mm (1/8 inch) in the clear, and then covered with a waterproof, insulating, sealing compound that will not soften at a temperature 15°C higher than the temperature observed at the point where it is used, but not lower than 65°C in any case; however, if such parts are staked, upset, or otherwise kept from loosening, insulation 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 12.7 mm (1/2 inch) shall be permitted.

6.6.1.16 A lock washer, properly applied, is acceptable as a means of keeping a screw or nut from loosening as required in 6.6.1.15.

6.6.1.17 A determination of the softening point of a sealing compound shall be made in accordance with the Test for Softening Point by Ring and Ball Apparatus, Annex A, Ref. No. 11.

6.6.1.18 Spacings shall be measured through cracks unless a clamped joint has passed the test covered in Clamped joint test, Clause 7.6, 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 5. Adhesive cements, and the like, if used to effect a seal in lieu of a tightly mated joint, shall comply with the requirements in Annex A, Reference Item No. 9.

6.6.2 Insulating barriers

6.6.2.1 In 6.6.2.2 – 6.6.2.12, the barrier referred to is an insulating material that separates uninsulated live parts of opposite polarity or separates an uninsulated live part from a grounded metal part (including the enclosure) where the through-air spacing between the parts would otherwise be less than the minimum values specified in Table 2.

6.6.2.2 A barrier that constitutes the sole separation or is used in conjunction with an air space less than 0.33 mm (0.013 inch) shall be:

a) Of insulation material as specified in 6.5.1. However, with regard to the flammability rating in Table 1, the rating may be VTM-0, VTM-1, or VTM-2 rather than V-0, V-1, or V-2, respectively,

b) Of such strength to withstand the stress associated with normal handling, installation, and use of the equipment,

c) Secured in place,

d) Located so that it will not be adversely affected by operation of the equipment in service, and

e) Of a minimum thickness of 0.71 mm (0.028 inch).

6.6.2.3 A barrier located between the enclosure and an uninsulated live part electrically connected to a grounded circuit conductor (neutral) may be of vulcanized fiber.

6.6.2.4 A barrier material having values below those contained in Table 1 may be accepted based on acceptable end-product performance tests.

6.6.2.5 A barrier of insulating material other than vulcanized fiber may have a thickness less than 0.71 mm (0.028 inch) if it withstands a 60 Hz dielectric-withstand voltage of 5 000 V applied in accordance with 7.14.

6.6.2.6 A barrier used in conjunction with a minimum air space of 0.33 mm (0.013 inch) shall be:

a) Of material that has insulating properties as specified in 6.5.1 or, other than vulcanized fiber, complying with Table 5,

b) Of such strength to withstand the stress associated with normal handling, installation, and use of the equipment,

c) Secured in place,

d) Located so that it will not be adversely affected by operation of the equipment in service, and

e) Of a minimum thickness of 0.71 mm (0.028 inch).

6.6.2.7 Vulcanized fiber with a minimum thickness of 0.71 mm (0.028 inch) and used in conjunction with a minimum 0.71 mm (0.028 inch) air space need not comply with 6.5.1.

6.6.2.8 Material other than vulcanized fiber used in conjunction with an air space of 50% or more of the required through air spacing may have a thickness:

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

b) Less than 0.33 mm (0.013 inch) if it withstands a 60 Hz dielectric-withstand voltage of 2 500 V applied in accordance with the requirements in 7.14.

6.6.2.9 A barrier material having values below those contained in Table 5 may be accepted based on acceptable end-product performance tests.

Table 5
Minimum values for insulating barriers used in place of spacing in conjunction with minimum air space of 0.33 mm (0.013 inch)

Test specified[f]	Flammability rating of material[e]			
	V-0 or VTM-0	V-1 or VTM-1	V-2 or VTM-2	HB
Hot wire ignition (HWI)[d], ignition time in sec. (Annex A, Ref. No. 3)	7	15	30	30
High current arc ignition (HAI)[c], number of arcs (Annex A, Ref. No. 10)	15	30	30	60
Comparative tracking index (CTI)[a] under moist conditions[b], Volts (Annex A, Ref. No. 2)	100	100	100	100

[a] Not applicable if the over-surface spacing is greater than or equal to 12.7 mm (1/2 inch).

[b] Material surface is in contact with or in close proximity (within 0.8 mm (1/32 inch)) to:

1) uninsulated live parts of opposite polarity, or

2) uninsulated live parts and either

i) metal parts that may be grounded in service, or

ii) any surface exposed to contact.

[c] Material is in contact with or in close proximity to uninsulated live parts 0.8 mm (1/32 inch) for nonarcing parts or 12.7 mm (1/2 inch) for arcing parts.

[d] Material is in contact with or close proximity to uninsulated live parts [within 0.8 mm (1/32 inch)].

[e] These flammability ratings are derived from Annex A, Ref. No. 5.

[f] See Annex A, Ref. No. 10, for these specified tests.

6.6.2.10 The barrier shall also be subjected to the mold stress relief test in 7.13.

6.6.2.11 A wrap of thermoplastic tape, acceptable for use as sole insulation, may be employed if all of the following conditions are met:

a) At a point where the spacing prior to the application of the tape is not less than half the required through-air spacing, the wrap is not less than 0.33 mm (0.013 inch) thick and is 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, the wrap is not less than 0.71 mm (0.028 inch) thick,

c) The tape is not subject to compression,

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

e) The temperature rating of the tape is not less than the temperature rise observed during the temperature test plus 40°C. If a temperature test is not required, the temperature rating shall be 105°C minimum.

6.6.2.12 If spacings would otherwise be less than the minimum values specified in Table 2, thermoplastic tubing may be used if all of the following conditions are met:

a) It is not subjected to compression, repeated flexure, or sharp bends,

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

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

d) Its wall thickness (after assembly) is not less than 0.56 mm (0.022 inch) for tubing 12.7 mm (1/2 inch) or less in diameter, not less than 0.69 mm (0.027 inches) for tubing 14.3 or 15.9 mm (9/16 or 5/8 inch) in diameter, and not less than 0.71 mm (0.028 inch) for larger diameter tubing, and

e) Its temperature marking is not less than the temperature rise observed during the temperature test plus 40°C. If a temperature test is not required, the temperature marking shall be 105°C minimum.

6.7 Current-carrying parts

6.7.1 General

6.7.1.1 The only iron or steel parts that are depended upon to carry current shall be No. 10 or larger binding head screws, machine screws, bolts, studs, nuts, and washers used for terminal parts. These iron or steel parts shall be suitably protected with a plating of zinc having a thickness of not less than 0.005 mm (0.0002 inch) and the conductor or terminal to be secured shall be clamped against a surface of nonferrous metal that will carry the greater part of the current.

6.7.1.2 Copper and brass shall not be used for the plating of steel wire-binding screws, nuts, and stud terminals; a plating of zinc shall be permitted.

6.7.1.3 Bolts, washers, and nuts at the hinges of knife switches shall be considered to be parts that are not depended upon to carry current.

6.7.1.4 A metal other than silver, a silver alloy, copper, or a copper alloy, if used for current-carrying parts, shall be suitable for the particular application.

6.7.1.5 Uninsulated live parts, other than soldering lugs or pressure wire connectors as mentioned in 6.6.1.9, shall be so secured to the mounting surface that they will be kept from turning or loosening.

6.7.1.6 Friction between surfaces shall not be used as a means to keep uninsulated live parts from turning.

Note: 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.

6.7.1.7 Where parts are held together by screws, a threaded part shall not have less than two full, clean-cut threads, not finer than the threads given in Table 6, 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 6
Machine-screw threads

American screws		Metric screws	
American National Standard size	Maximum number of threads per inch (per 25.4 mm)	Size (diameter, mm)	Minimum thread pitch (mm)
1/4	20	M8	1.25
12	24	M6	1.00
10	32	M5	0.80
8	32	M4	0.70
6	36	M3.5	0.60

6.7.1.8 If a break jaw, hinge 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 Table 7.

Table 7
Securing of jaws and contacts

Construction		Rating in amperes	Means of securing
Slots (See Figure 1)		100 or less	Pinning required, soldering not acceptable
		over 100	Pinning and soldering required
Holes (See Figure 1)	Jaw or contact securely swaged on the under-side of the mounting piece	100 or less	Pinning and soldering are both acceptable but neither is required
		over 100	Soldering required, additional pinning is acceptable but not required
	Jaw or contact not securely swaged on the under-side	Any	Pinning and soldering required

6.7.1.9 Hinge jaws, when used to carry current, shall be equipped with spring washers held by locknuts or pins, or some approved equivalent, so arranged that a firm and secure connection will be maintained at all positions of the switch blades. Two spring washers per hinge shall be used for currents of 100 A and over, unless a single washer is shown by investigation to be fully effective.

6.7.1.10 Spring washers shall have sufficient strength to take up wear in the hinge jaw and still maintain good contact.

6.7.1.11 A switch of the knife-blade type shall be so arranged that the blades will be deenergized when the switch is open, unless the blades will not be exposed to inadvertent contact during the replacement or inspection of fuses.

6.7.1.12 Notwithstanding 6.7.1.11, the blades in a double-throw switch are permitted to be energized even if the switch is in the off position.

6.7.2 Wiring terminals

6.7.2.1 Except as noted in 6.7.2.13 and 6.7.2.14:

a) A 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

b) The terminals of a switch having a horsepower or kilowatt rating shall be capable of accommodating conductors having an ampacity equal to 125% of the motor-running current corresponding to the horsepower or kilowatt rating.

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

6.7.2.3 A wire binding screw shall be permitted at a wiring terminal intended for the connection of a 10 AWG (5.3 mm^2) or smaller copper conductor. Upturned edges or the equivalent shall be provided to retain the conductor under the head of the screw when the screw is loosened enough to enable shifting of the conductor.

6.7.2.4 The binding screw shall not be smaller than an M5 with a minimum pitch of 0.80 mm or a No. 10 with not more than 32 threads.

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

6.7.2.6 Extrusion of a terminal plate for a wire binding screw at the tapped hole so as to give the thickness necessary for at least two full threads shall be permitted, provided that the thickness of the unextruded metal is not less than the pitch of the thread.

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

6.7.2.8 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 to prevent any reduction of required spacings.

6.7.2.9 A wiring terminal provided for the connection of a service conductor to an enclosed switch marked for service equipment use and rated 30 A 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.

6.7.2.10 Sizes of field-installed conductors shall be determined as follows for current as specified in Table 8:

a) Conductors rated at 75°C in the 1/0 AWG (53.5 mm^2) and larger sizes.

b) Conductors rated at 60°C in the 1 AWG (42.4 mm^2) and smaller sizes, except 75°C conductors if the switch is marked for 75°C conductors in accordance with 9.2.58.

6.7.2.11 Aluminum conductors may be used at any terminal identified on a wiring diagram or the like as being acceptable for use with such conductors, whether or not that terminal is also identified as being acceptable for use with copper conductors. See 9.2.49 – 9.2.59.

6.7.2.12 Multiple wire connectors shall not be provided at the terminals of enclosed switches rated 100 A or less unless at least one of the wire connectors is sized for the current rating of the switch.

Table 8
Ampacity of insulated conductors[a,b]

Wire size		60°C		75°C	
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	80	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	107.2			230	180
kcmil					
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 connector at a terminal, the value shall 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 shall be 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.

6.7.2.13 Pressure terminal connectors for field connection (line or load) need not be provided if all of 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, 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. The means for securing the terminal connector shall be readily accessible for tightening before and after installation of conductors.

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 package 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 9.2.45.

6.7.2.14 A terminal may be omitted if:

a) The switch is specifically intended to be used with such other equipment that the terminal is unnecessary,

b) A means, such as bus-bar link or the equivalent, is provided to connect the two pieces together, and

c) Both pieces of equipment are marked in accordance with 9.2.46.

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

6.7.2.16 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.

6.7.2.17 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.

6.7.2.18 With reference to the requirement in 6.7.2.17, the range of wire sizes with which an ampere-rated switch may be used shall be considered to correspond to the range of fuse sizes accommodated by the switch. For a switch having both ampere and horsepower or kilowatt ratings, the range of wire sizes shall be considered to include those acceptable for the ampere rating and also the wire sizes acceptable for the horsepower or kilowatt ratings at which the switch can be used; however, a connector need not be acceptable for all the horsepower or kilowatt ratings less than the maximum if acceptable markings show the range of acceptable wire sizes.

6.7.2.19 A pressure wire connector provided with or specified for use with a switch shall comply with the applicable requirements for wire connectors and soldering lugs, as outlined in Annex A, Ref. No. 6.

6.7.2.20 Switches that are marked for use with aluminum conductors shall have means for terminating aluminum grounding conductors separate from copper grounding conductors.

6.7.2.21 The tightening torque for a field-wiring terminal shall be as specified by the switch manufacturer and shall be marked as required by 9.2.57. The specified tightening torque shall not be less than 90 percent of the value employed in the static heating test as specified in the requirements in Annex A, Ref. No. 6.

6.7.2.22 A torque value of less than 90 percent shall be permitted if the connector is investigated in accordance with the requirements in Annex A, Ref. No. 6, using the lesser assigned torque value.

6.7.3 Neutral

6.7.3.1 A neutral need not be insulated from grounded metal parts when the switch is marked in accordance with 9.2.34.

6.7.3.2 A switched neutral shall be permitted only if the switch mechanism disconnects all ungrounded conductors simultaneously or previously.

6.8 Fusing

6.8.1 Fuseholders and fuse terminals shall be of either the cartridge-enclosed, plug-fuse, or special purpose fuse type and shall comply with the requirements in Annex A, Ref. No. 8, except as modified by this Standard. Fuseholders of the special purpose fuse type shall also comply with the requirements in 6.8.6.

6.8.2 The construction of a switch and the location of fuses shall be such that fuses will be readily accessible when the switch is open, so that they may be replaced without a person touching any live part. The electrical arrangement of a single-throw switch shall be such that, if properly connected, fuse terminals will be deenergized when the switch is open. See also 9.2.41 and 9.2.42.

6.8.3 A plug fuse shall be considered to be accessible if, when the switch is in the full off position, the test gauge described in 6.8.5 can be inserted and bottomed in each plug fuseholder by using the fingers of one hand and without causing a reduction in the break distance between the stationary and moving switch contacts to less than 12.7 mm (1/2 inch).

6.8.4 A neutral need not be insulated from grounded metal parts when the switch is marked in accordance with 9.2.34.

6.8.5 The test gauge mentioned in 6.8.3 shall be in the form of a plug fuse having the dimensions specified for plug fuses and having an overall height of 44.5 mm (1-3/4 inches) and a diameter of 31.8 mm (1-1/4 inches) at the section above the male screw-shell.

6.8.6 Special purpose fuseholders may be used if evaluated for use with specific special purpose fuses, which are suitably rated for use as branch circuit, feeder, or service overcurrent protection. When used, special purpose fuseholders shall:

a) Be non-interchangeable with fuses of incompatible ratings. This requires that the fuseholder be of a design so that it will be difficult to install a fuse of any given class into a fuseholder that is designed for a current lower, or voltage higher, than that of the fuse intended for use with the fuseholder; and

b) Be marked for use with the specific special purpose fuses for which it is intended to be used.

6.9 Field conversion

6.9.1 A switch constructed to accommodate Class ″H″ type fuses and for field conversion to accept Class ″J,″ ″R,″ ″T,″ or ″C″ fuses shall be marked in accordance with 9.2.25 – 9.2.30 and shall comply with 6.9.2 – 6.9.12.

6.9.2 A switch shipped from the factory with complete fuseholders shall have them positioned to accept Class ″H″ fuses.

6.9.3 A switch intended to accept Class ″J″ fuses by repositioning the load base or fuseholder may have the fuseholders in the ″J″ fuse position when the known use is for ″J″ fuses.

6.9.4 A switch may be shipped by the factory without load fuse clips or without the complete load fuse base.

6.9.5 A switch shipped without load fuse clips or complete load fuse base shall be provided with explicit instructions for ordering the necessary components to complete the switch to accept either Class ″H″, ″J″, or ″R″ type fuses.

6.9.6 The intended repositioning of a load side fuseholder assembly (common or individual pole construction) or the individual fuse clips to accommodate ″J″ fuses shall have factory-provided mounting holes. The repositioning shall be by the use of common tools by front access to the switch.

6.9.7 A load side fuseholder assembly (common or individual pole construction) or individual fuse clips that are intended to be installed to permit the acceptance of Class ″R″ fuses only shall be installed by the use of common tools by front access to the switch.

6.9.8 Fuse clips that are intended to be added or replaced shall be capable of being added or replaced 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.

6.9.9 The field installation of a fuse clip shall not require the spreading of the fuse clip or adversely affect the fuse clip in any manner.

6.9.10 Replacement of the line-side fuse clips and the load-side fuseholder assembly to accommodate ″T″ fuses that are mounted in the fuse clips and the replacement or adding of bus bars for Class ″T″ or ″C″ fuses that are bolted in place shall be by the use of common tools by front access.

6.9.11 A rejection means for Class ″R″ fuses intended to be installed in a load fuse base containing a Class ″H″ fuseholder shall be permitted provided:

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

b) The fuse rejection means is 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 and rendering it unusable.

d) The fuse rejection means has the mechanical strength to comply with the requirements for Class ″R″ fuseholders in Annex A, Ref. No. 8.

6.9.12 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.

6.9.13 Spacing as required by 6.6 and fuse alignment as required by 6.8.1 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 spacing; however, the moving of barriers that are part of the load side fuseholder assembly shall be permitted.

6.9.14 A switch constructed for Class ″L″ or ″C″ fuses and for field conversion to accept Class ″T″ fuses shall be marked in accordance with 9.2.14 and 9.2.27 – 9.2.30 and shall comply with 6.9.12, 6.9.13, 6.9.15, and 6.9.16.

6.9.15 Replacement or adding of bus bars for Class ″T″ fuses shall be by the use of common tools by front access only.

6.9.16 If the switch leaves the factory with complete fuseholders, they shall be arranged to accept Class ″L″ or ″C″ fuses. Supplying the switch without the complete load fuse base, as an alternate to complete fuseholders, shall be permitted.

6.10 Enclosed switch wiring and bending space

6.10.1 There shall be adequate space within an enclosed switch for the installation and termination of all wires.

6.10.2 The adequacy of wiring spaces shall be judged using the size and conductor material of a wire used at a terminal in accordance with 6.7.2.10, except for ampacities of 100 A or less, the size shall be based on 60°C insulated conductors if the markings specify both 60°C and 75°C wire.

6.10.3 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 6.7.2.10, the combination necessitating the largest wiring space shall be used, unless the enclosed switch is marked in accordance with 9.2.59.

6.10.4 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.

6.10.5 The clear wiring space at any point, independent of all projections, obstructions, and interference from moving parts of the switching mechanism, shall not be less in width or in depth than the values given in Table 9.

6.10.6 If knockouts are provided in a side wiring space, the width of such a space shall be enough to accommodate (with respect to bending) the maximum size of wiring for the particular application; however, side wiring spaces of less width may be provided if knockouts of an acceptable size are located elsewhere and if they can be used to wire the device in the intended manner. For wire sizes 8 AWG (8.4 mm^2) or larger, reference shall be made to Table 10 and Table 11.

6.10.7 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-section area of the maximum number of the wires that may be used in such space. The minimum areas of some of the more common multiple-wire conditions are given in Table 9.

6.10.8 With reference to the requirements of 6.10.7, the number of wires for which wiring space is to be provided shall be 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 shall be considered as being run in the side or back wiring space. In the case of a double-throw switch, provision shall also be made for the wires connected to the center terminals, unless the construction is such that they are obviously not to be run in the regular wiring spaces. The provision of barriers riveted or welded in position so as to prevent the running of wires from end to end shall be permitted in place of the wiring space otherwise required.

Table 9
Enclosed switch wiring space

Maximum size of wire or cable involved	Minimum width and depth of wiring space		Minimum areas in mm² (square inches) required for multiple wires based on factor of 250 percent											
			Two wires		Three wires		Four wires		Five wires		Six wires		Seven wires	
	mm	(in)	mm²	(in²)	mm²	(in²)	mm²	(in²)	mm²	(in²)	mm²	(in²)	mm²	(in²)
10 AWG	9.5	(3/8[a])	148	(0.23)	219	(0.34)	297	0.46	368	0.57	439	0.68	516	0.80
8	12.7	(1/2)	277	(0.43)	413	(0.64)	548	(0.85)	690	(1.07)	826	(1.28)	968	(1.50)
6	15.9	(5/8)	400	(0.62)	600	(0.93)	800	(1.24)	1000	(1.55)	1200	(1.86)	1400	(2.17)
4	19.1	(3/4)	516	(0.80)	774	(1.20)	1032	(1.60)	1290	(2.00)	1548	(2.40)	1806	(2.80)
3	19.1	(3/4)	587	(0.91)	877	(1.36)	1174	(1.82)	1465	(2.27)	1755	(2.72)	2052	(3.18)
2	22.2	(7/8)	665	(1.03)	1000	(1.55)	1329	(2.06)	1665	(2.58)	2000	(3.10)	2329	(3.61)
1	25.4	(1)	877	(1.36)	1316	(2.04)	1755	(2.72)	2194	(3.40)	2632	(4.08)	3071	(4.76)
1/0	25.4	(1)	1000	(1.55)	1503	(2.33)	2000	(3.10)	2503	(3.88)	3006	(4.66)	3503	(5.43)
2/0	25.4	(1)	1155	(1.79)	1729	(2.68)	2310	(3.58)	2884	(4.47)	3458	(5.36)	4039	(6.26)
3/0	28.6	(1-1/8)	1342	(2.08)	2006	(3.11)	2684	(4.16)	3348	(5.19)	4013	(6.22)	4690	(7.27)
4/0	31.8	(1-1/4)	1561	(2.42)	2342	(3.63)	3123	(4.84)	3903	(6.05)	4684	(7.26)	5465	(8.47)
250 kcmil	34.9	(1-3/8)	1910	(2.96)	2865	(4.44)	3819	(5.92)	4774	(7.40)	5729	(8.88)	6684	(10.36)
300	38.1	(1-1/2)	2206	(3.42)	3310	(5.13)	4413	(6.84)	5516	(8.55)	6619	(10.26)	7716	(11.96)
350	38.1	(1-1/2)	2458	(3.81)	3690	(5.72)	4916	(7.62)	6148	(9.53)	7381	(11.44)	8606	(13.34)
400	41.3	(1-5/8)	2697	(4.18)	4045	(6.27)	5394	(8.36)	6742	(10.45)	8090	(12.54)	9439	(14.63)
500	44.5	(1-3/4)	3174	(4.92)	4761	(7.38)	6348	(9.84)	7935	(12.30)	9523	(14.76)	11110	(17.22)
600	47.6	(1-7/8)	3852	(5.97)	5781	(8.96)	7703	(11.94)	9632	(14.93)	11561	(17.92)	13484	(20.90)
700	50.8	(2)	4310	(6.68)	6465	(10.02)	8619	(13.36)	10774	(16.70)	12929	(20.04)	15083	(23.38)
750	50.8	(2)	4542	(7.04)	6813	(10.56)	9084	(14.08)	11355	(17.60)	13626	(21.12)	15896	(24.64)
800	54.0	(2-1/8)	4768	(7.39)	7155	(11.09)	9535	(14.78)	11923	(18.48)	14310	(22.18)	16690	(25.87)
900	57.2	(2-1/4)	5219	(8.09)	7826	(12.13)	10439	(16.18)	13045	(20.22)	15652	(24.26)	18264	(28.31)
1000	57.2	(2-1/4)	5658	(8.77)	8484	(13.15)	11316	(17.54)	14142	(21.92)	16968	(26.30)	19800	(30.69)
1250	63.5	(2-1/2)	7116	(11.03)	10677	(16.55)	14232	(22.06)	17794	(27.58)	21355	(33.10)	24910	(38.61)
1500	69.9	(2-3/4)	8219	(12.74)	12329	(19.11)	16439	(25.48)	20548	(31.85)	24658	(38.22)	28768	(44.59)
1750	73.0	(2-7/8)	9323	(14.45)	13981	(21.67)	18645	(28.90)	23303	(36.12)	27961	(43.34)	32626	(50.57)
2000	79.4	(3-1/8)	10348	(16.04)	15523	(24.06)	20697	(32.08)	25871	(40.10)	31045	(48.12)	36219	(56.14)

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

6.10.9 In determining if a wiring space complies with the requirements in 6.10.7 and 6.10.8, consideration shall be given to the actual size of wires that will be used in the space, but it shall be assumed that wires smaller than those indicated in Table 9 will not be used. In computing the actual area of a wiring space, consideration shall be given to all the available space that may be used for the placement of wires, and no consideration shall be given to space in which the presence of wires would render neutral terminals inaccessible. See also 6.7.2.16.

6.10.10 For an enclosed switch, the wire-bending space at the line and load terminals shall be as specified in Table 10 for the conductor size that corresponds with the maximum ampere (full-load amperes) rating of the enclosed switch. See 6.10.2.

6.10.11 The wire-bending space from a connector to any barrier or other obstruction that is part of an enclosed switch shall be as specified in Table 11.

6.10.12 A separate neutral block shall be permitted in a wiring gutter if it does not obstruct the required wiring space.

6.10.13 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 shall be measured from the end of the barrier or other obstruction.

6.10.14 The distance mentioned in 6.10.10 and 6.10.11 shall 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 terminal 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 shall be disregarded when the measurement is being made if it does not reduce the radius to which wire must be bent. If a terminal is provided with one or more connectors for the connection of conductors in multiple, the distance shall be measured from the wire opening closest to the wall of the enclosure. Side wire-bending space, such as at a neutral in side gutter, may be measured in a straight line from the center of the wire opening in the direction the wire leaves the terminal.

6.10.15 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.

6.10.16 The construction and arrangement of the operating mechanism and its relation to the wiring space shall be such that it will not cause damage to wires with which it may come in contact during switch operation.

Table 10
Minimum wire-bending space at terminals[a]

Wire size		Wires per terminal (pole)[b]							
mm²	AWG or kcmil	1		2		3		4 or more	
		mm	in	mm	in	mm	in	mm	in
2.1 – 5.3	14 – 10	Not specified		–	–	–	–	–	–
8.4	8	38.1	1-1/2	–	–	–	–	–	–
13.3	6	50.8	2	–	–	–	–	–	–
21.2	4	76.2	3	–	–	–	–	–	–
26.7	3	76.2	3	–	–	–	–	–	–
33.6	2	88.9	3-1/2	–	–	–	–	–	–
42.4	1	114	4-1/2	–	–	–	–	–	–
53.5	1/0	127	5-1/2	127	5-1/2	178	7	–	–
67.4	2/0	152	6	152	6	191	7-1/2	–	–
85	3/0	165 (12.7)	6-1/2 (1/2)	165 (12.7)	6-1/2 (1/2)	203	8	–	–
107	4/0	178 (25.4)	7 (1)	191 (38.1)	7-1/2 (1-1/2)	216 (12.7)	8-1/2 (1/2)	–	–
127	250	216 (50.8)	8-1/2 (2)	216 (50.8)	8-1/2 (2)	229 (25.4)	9 (1)	254	10
152	300	254 (76.2)	10 (3)	254 (50.8)	10 (2)	279 (25.4)	11 (1)	305	12
177	350	305 (76.2)	12 (3)	305 (76.2)	12 (3)	330 (76.2)	13 (3)	356 (50.8)	14 (2)
203	400	330 (76.2)	13 (3)	330 (76.2)	13 (3)	356 (76.2)	14 (3)	381 (76.2)	15 (3)
253	500	356 (76.2)	14 (3)	356 (76.2)	14 (3)	381 (76.2)	15 (3)	406 (76.2)	16 (3)
304	600	381 (76.2)	15 (3)	406 (76.2)	16 (3)	457 (76.2)	18 (3)	483 (76.2)	19 (3)

Table 10 Continued on Next Page

Table 10 Continued

Wire size		Wires per terminal (pole)[b]							
mm²	AWG or kcmil	1		2		3		4 or more	
		mm	in	mm	in	mm	in	mm	in
355	700	406 (76.2)	16 (3)	457 (76.2)	18 (3)	508 (76.2)	20 (3)	559 (76.2)	22 (3)
380	750	432 (76.2)	17 (3)	483 (76.2)	19 (3)	559 (76.2)	22 (3)	610 (76.2)	24 (3)
405	800	457	18	508	20	559	22	610	24
456	900	483	19	559	22	610	24	610	24
507	1000	508	20	–	–	–	–	–	–
633	1250	559	22	–	–	–	–	–	–
760	1500	610	24	–	–	–	–	–	–
887	1750	610	24	–	–	–	–	–	–
1010	2000	610	24	–	–	–	–	–	–

[a] Alternatively, for a product identified for use only in Canada, the use of the values in Annex A, Ref. No. 15, shall be permitted.

[b] Wire-bending space may be reduced by the number 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), and

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.

Table 11
Minimum width of gutter and wire-bending space in mm (inches)[a]

Wire size		Wires per terminal (pole)									
mm²	AWG or kcmil	1		2		3		4		5	
		mm	(in)	mm	(in)	mm	(in)	mm	(in)	mm	(in)
2.1 – 5.3	14 – 10	–	–	–	–	–	–	–	–	–	–
8.4 – 13.3	8 – 6	38.1	(1-1/2)	–	–	–	–	–	–	–	–
21.1 – 26.7	4 – 3	50.8	(2)	–	–	–	–	–	–	–	–
33.6	2	63.5	(2-1/2)	–	–	–	–	–	–	–	–
42.4	1	76.2	(3)	–	–	–	–	–	–	–	–
53.5 – 67.4	1/0 – 2/0	88.9	(3-1/2)	127	(5)	178	(7)	–	–	–	–
85.0 – 107	3/0 – 4/0	102	(4)	152	(6)	203	(8)	–	–	–	–
127	250	112	(4-1/2)	152	(6)	203	(8)	254	(10)	–	–
152 – 177	300 – 350	127	(5)	203	(8)	254	(10)	305	(12)	–	–
203 – 253	400 – 500	152	(6)	203	(8)	254	(10)	305	(12)	356	(14)
304 – 355	600 – 700	203	(8)	254	(10)	305	(12)	356	(14)	406	(16)
380 – 456	750 – 900	203	(8)	305	(12)	356	(14)	406	(16)	457	(18)
507 – 633	1000 – 1250	254	(10)	–	–	–	–	–	–	–	–
760 – 1010	1500 – 2000	305	(12)	–	–	–	–	–	–	–	–

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

6.11 Disconnecting means of the grounded service conductor

6.11.1 An enclosed switch shall be provided with a means for disconnecting the grounded service conductor from the load conductors provided that it is acceptable for use as service equipment and that it has provisions for the connection of a grounded service conductor.

6.11.2 The required disconnecting means may be:

a) A link, screw, or similar conducting piece intended to make connection between two terminals,

b) 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,

c) A single stud provided with wire connectors or lugs, or with nuts and cupped washers for clamping a 10 AWG (5.3 mm^2) or smaller wire,

d) A wire connector that is intended for the connection of a single conductor and also for the connection of two conductors, or

e) A single wire connector 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.

6.11.3 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.

6.12 Provision for grounding

Note: *The grounding and bonding terms used in this section are in accordance with the UL column in Annex D. The corresponding Canadian Electrical Code, Part I and ANCE terms are also provided.*

6.12.1 An enclosed switch acceptable for use as service equipment shall have provision for connection of the grounding electrode conductor to the grounded service conductor terminal. The size of the grounding electrode conductor shall be in accordance with Table 12. A soldering lug or other connection means that depends upon solder shall not be used.

Table 12
Size of grounding electrode conductors and main bonding jumper

Ampere rating not exceeding	Size of bonding jumper (minimum)[d,f]						Minimum size of grounding electrode conductor terminal			
	Copper			Aluminum			Copper		Aluminum[g]	
	AWG or kcmil	Cross section mm^2	Cross section (in^2)	AWG or kcmil	Cross section mm^2	Cross section (in^2)	AWG or kcmil	mm^2	AWG or kcmil	mm^2
90	8	8.4[a]	(0.013)[a]	6	13.3[a]	(0.021)[a]	8	8.4	6	13.3
150	6	13.3[a]	(0.021)[a]	4	21.1[a]	(0.033)[a]	4	21.1	4	21.1
200	4	21.1[b]	(0.033)[b]	2	33.6[b]	(0.052)[b]	3	26.7	2	33.6
400	1/0[e]	53.5[c,e]	(0.083)[c,e]	3/0[e]	85.0[c,e]	(0.132)[c,e]	2/0[e]	67.4	3/0[e]	85.0
600	2/0	67.4	(0.105)	4/0	107	(0.166)	3/0	85.0	4/0	107
800	2/0	67.4	(0.105)	4/0	107	(0.166)	3/0	85.0	4/0	107
1000	3/0	85.0	(0.132)	250	127	(0.196)	3/0	85.0	250	127
1200	250	127	(0.196)	250	127	(0.196)	3/0	85.0	250	127
1600	300	152	(0.236)	400	203	(0.314)	3/0	85.0	250	127
2000	400	203	(0.314)	500	253	(0.393)	3/0	85.0	250	127
2500	500	253	(0.393)	700	355	(0.550)	3/0	85.0	250	127
3000	600	304	(0.471)	750	380	(0.589)	3/0	85.0	250	127
4000	750	380	(0.589)	1000	507	(0.785)	3/0	85.0	250	127

[a] A No. 8 or M4 or larger brass or No. 10 or M5 or larger plated or corrosion resistant steel screw may be used.

[b] A No. 10 or M5 or larger brass or plated or corrosion resistant steel screw may be used.

[c] A 1/4 inch diameter or M8 or larger brass or plated or corrosion resistant steel screw may be used.

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

[e] 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 kcmil aluminum conductor but will not accept a 600 kcmil conductor, these values may be reduced to 2 AWG copper or 1/0 AWG aluminum.

[f] For equipment rated 1200 A or more and that has wiring connectors intended to connect service conductor wire sized larger than 600 kcmil copper or 750 kcmil 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 or conductors of the same material (copper or aluminum) for any phase.

[g]Aluminum grounding electrode conductors are not used in Canada.

6.12.2 The provision for connection of the grounding electrode conductor mentioned in 6.12.1 shall be:

a) On the neutral, if a neutral is provided, or

b) In Mexico and the United States, 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.

6.12.3 In Mexico and the United States, the following applies. An enclosed switch that is suitable for use as service equipment shall have a wire connector for a grounded service conductor, regardless of whether there is provision for a load conductor to be connected to the grounded service conductor, or be marked as covered in 9.2.48.

6.12.4 In Mexico and the United States, the following applies. If there is no provision for the load conductor mentioned in 6.12.3, the grounded service conductor wire connector shall:

a) Accommodate a conductor of the same size as the main bonding jumper specified in Table 12,

b) Be bonded to the enclosure, and

c) Be directly connected to the grounding electrode conductor wire connector.

6.13 Provision for bonding

Note: *The grounding and bonding terms used in this section are in accordance with the UL column in Annex D. The corresponding Canadian Electrical Code, Part I and ANCE terms are also provided.*

6.13.1 The bond between the installed equipment grounding conductor and the conductive parts of the frame or enclosure shall comply with the requirements of 6.13.2 – 6.13.8.

6.13.2 When an insulated neutral is provided for an enclosed switch that is acceptable for use as service equipment, a main bonding jumper shall be provided to bond the enclosure to the insulated grounded circuit conductor (the insulated neutral) of an ac circuit.

6.13.3 The bonding jumper shall have a cross-section area as indicated in Table 12.

6.13.4 If an insulated neutral is provided, the construction shall be such that when the bonding means is not used, the spacings given in Table 2 will be obtained.

6.13.5 Unless the intended use and method of installation of the bonding means are obvious, such means shall be accompanied by instructions for installing.

6.13.6 If the main bonding jumper is a screw, the screw shall have a green-colored head. The screw shall be visible without disassembly or removal of devices inside the enclosed switch.

6.13.7 Screws located in the backs of enclosures and used to secure grounding conductors of nonmetallic sheathed cables shall not project past the back of the enclosure by more than 1.6 mm (0.063 inch) when a 16 AWG conductor is in place under the head of the screw. With the maximum intended size of wire in place, the screw shall engage at least two full threads.

6.13.8 If enamels or other nonconducting protective coatings are applied to switch enclosures, means shall be provided for securing an effective electrical bond between the grounding means and the metal enclosure.

Note: *Bolts or screws provided with corrosion-resisting lockwashers that pierce or remove the enamel while being tightened are recognized as means for bonding.*

6.13.9 Provision for bonding conductor terminations shall be provided in one of the following ways:

a) Terminations in enclosures in accordance with 6.13.10, or

b) Field-installable grounding and bonding kits.

6.13.10 Bonding conductor terminations shall be provided for at least the following:

a) One for each incoming and each outgoing power circuit (based on one circuit for three poles or less and one circuit for each additional three poles or less), and

b) One for the control circuit, where applicable.

6.13.11 In Canada, the following applies. The bonding means for enclosed switches shall also comply with Annex A, Ref. No. 13.

6.14 Electrically tripped switches

6.14.1 The electrical tripping mechanism shall be such that the tripping operation shall be completed should loss of power occur during any portion of opening operation in which the switch blades have started to move.

6.14.2 An electrically tripped switch intended and marked for use as a disconnecting device in conjunction with Class I ground-fault sensing and relaying equipment shall have means to prevent automatic opening (lockout) if the current in any phase exceeds 850 percent of the switch ampere rating, unless tested in accordance with item 4 in Table 24.

6.14.3 A control circuit for an electrical tripping mechanism for use with ground-fault sensing and relaying equipment that is located wholly within the switch enclosure and that derives its power from the load side of the disconnecting switch is not required to have overcurrent protection devices.

6.14.4 The operating mechanism of an electrically tripped switch shall be such that when the switch contacts are closed, the mechanism shall immediately be in a condition to open by the electrical tripping means without further operation, manual or otherwise.

6.15 Additional service equipment requirements for Canada

6.15.1 In Canada, the service equipment requirements contained in 6.15.2 – 6.15.7 apply, in addition to the other requirements of this Standard. Annex F contains a complete list of requirements concerning service equipment.

6.15.2 Switches marked for use as service equipment shall have a single, load-rated, manually operable service-disconnecting fused switch that opens all ungrounded supply conductors. The service-disconnecting means and its associated components only shall be located in a separate compartment.

6.15.3 Incoming service conductors shall be capable of being connected to the line side of the switch without contacting conductors connected to the load side of the switch.

6.15.4 A terminal shall be provided on the neutral assembly to bond the service conduit (not shown in Annex D).

6.15.5 Provision for the connection required by 6.15.4 is not required for a neutral with a permanent, non-removable bond when:

a) The switch is rated at 100 A or less and a suitable pressure-type wire connector (attached to the neutral) is provided that will accept a folded, unbroken, 8 AWG grounding conductor, or

b) The switch is provided with a lay-in type solderless connector attached to the enclosure.

6.15.6 Terminals shall be provided on the neutral assembly for both the grounded service conductor and the load conductor (grounded circuit conductor; see Annex D).

6.15.7 Service equipment for Canada shall comply with the requirements of Annex A, Item 16.

7 Test methods

7.1 General

7.1.1 To determine if a switch complies with the performance requirements, a representative device of each rating shall be subjected to the tests as required in Table 13. Fewer samples may be used by completing additional tests on any single sample.

Table 13
Test sequences[a]

Description	Clause number	Sample number
Heating	7.2	1
Overload	7.3	2
Endurance	7.4	2
Dielectric voltage	7.5	1 and 2
Close-open[b]	7.7	3
Short-circuit withstand	7.8	3
Low-level dielectric	7.9	3
Short-circuit closing	7.10	4
Strength of insulating bases	7.11	5
Mold stress relief	7.13	6
Insulating barriers	7.14	2
Electrically tripped switches		
Temperature	7.12.2	7
Operation	7.12.3	7
Contact opening	7.12.4	7
Endurance	7.12.5	2 or 8
Overload and endurance	7.12.6	2

[a] For variances to test sequence, refer to clause numbers.
[b] The close-open test is required for switches rated greater than 10 kAIC.

7.1.2 A switch marked with two or more ratings shall be tested at each rating unless a test at one rating is representative of a performance at the other ratings.

7.1.3 A switch intended for use in a metal enclosure shall be tested in a metal enclosure having no paint, enamel, or other coating of insulating material.

7.1.4 A deadfront switch shall be tested on a representative panelboard chassis or the equivalent unless specified otherwise in this Standard.

7.1.5 Test circuits for the close-open, short-circuit withstand, and short-circuit closing tests shall be calibrated as described in Annex E.

7.1.6 Table 14 for ac ratings and Table 15 for dc ratings indicate representative tests. An overload and endurance test at any voltage rating in a row with a xx designation in a given column is representative of an overload and endurance test in a row below it with an entry (xx or x) in the same column, where the same or lesser current is involved.

7.1.7 Overload and endurance tests at 600 V ac are representative for ratings of 250 V dc or below, where the same or lesser dc current is involved.

7.1.8 Table 14 applies to devices having an interrupting means for each phase of the circuit. A single-throw switch is not considered to be representative of a double-throw switch of the same rating.

Table 14
Representative overload and endurance tests, ac

	Switch rating in volts, ac	Number of phases	Power factor of test	Representative tests					
				A	B	C	D	E	F
1	600	3	0.40 – 0.50	xx *					
2	600	1	0.40 – 0.50	x	xx *				
3	600	3	0.75 – 0.80	x		xx *			
4	600	1	0.75 – 0.80	x	x	x	xx *		
5	480	3	0.40 – 0.50	xx					
6	480	1	0.40 – 0.50	x	xx				
7	480	3	0.75 – 0.80	x		x		xx	
8	480	1	0.75 – 0.80	x	x	x	xx	x	
9	240	3	0.40 – 0.50	xx		xx			
10	240	1	0.40 – 0.50	xx	xx	xx			
11	240	3	0.75 – 0.80	xx		xx		xx	
12	240	1	0.75 – 0.80	xx	xx	xx	xx	xx	
13	120/240	1	0.75 – 0.80	x	x	x	x	x	xx
14	120	1	0.40 – 0.50	xx	xx	xx	xx	xx	
15	120	1	0.75 – 0.80	x	x	x	x	x	x

NOTES

xx – denotes test that covers any row below with entry (x or xx) in same column.

* – tests at 600 V ac cover ratings at 250 V dc and below.

Table 15
Representative overload and endurance tests, dc

	Switch rating in volts, dc	Representative tests
1	600	xx
2	250	xx *
3	125/250	xx *
4	125	x *
NOTES xx – denotes test that covers any row below with entry (x or xx) in same column. * – tests at 600 V ac cover ratings at 250 V dc and below.		

7.1.9 If a general-use switch has the same horsepower or kilowatt rating of 100 hp or 74.6 kW or less at more than one voltage, an overload or endurance test at the highest voltage shall be considered to be representative of performance at any lower voltage. A motor-circuit switch or any switch having a horsepower or kilowatt rating greater than 100 hp or 74.6 kW shall be tested at the maximum voltage and also at the maximum current. An overload or endurance test on a 3-phase circuit is considered to be representative of performance on a 2-phase circuit of the same voltage for the same horsepower or kilowatt rating.

7.1.10 A switch shall not be adjusted, lubricated, or otherwise conditioned during the overload test, the endurance test with current, or the endurance test without current; however, switch blades and break jaws that are readily accessible may be put in good operating condition before starting each of these tests. Parts other than switch blades and break jaws shall not be adjusted. A switch shall not be conditioned between the endurance and dielectric voltage-withstand tests.

7.2 Heating test

7.2.1 Parts of a switch shall not exceed the temperature rise values in Table 16, and if fuses are used, no fuse element shall melt, when the switch is caused to carry continuously, until constant temperatures are attained, a 60 Hz essentially sinusoidal current as follows:

a) General-use switch without a horsepower or kilowatt rating: rated current.

b) General-use switch with a horsepower or kilowatt rating: rated current, or 115 percent of current (from Table 20 or Table 21) corresponding to the horsepower or kilowatt rating, whichever is greater.

c) Fused motor-circuit switch: 115 percent of the maximum full-load current rating. See also 8.2.2.

Table 16
Maximum acceptable temperature rises

Material and components	°C
A. Terminals for field-installed conductors:	
1. Unfused switches	50
2. Fused switches for use with 60°C wire and tested with dummy fuses	30
3. Fused switches for use with 75°C wire and tested with dummy fuses[a]	45
4. Class T fused switches rated 100 A or less for use with 60°C wire	50
5. Class T fused switches rated 100 A or less for use with 75°C wire[a]	65
6. Class J (rated more than 200 A), Class T (rated more than 100 A), Class L and Class C fused switches	60
B. All other current-carrying parts:	
1. Unfused switches	50
2. Fused switches for use with 60°C wire and tested with dummy fuses	30
3. Fused switches for use with 75°C wire and tested with dummy fuses[a]	50
4. Class J (rated more than 200 A), Class T, Class L, and Class C fused switches	85
C. Other materials and components:	
1. Wire insulation or insulating tubing	35
2. Electrical tape	55
3. Varnished cloth insulation	60
4. Fiber used as electrical insulation	65
5. Sealing compound	50
6. Phenolic composition used as electrical insulation or as a part whose failure would result in an undesired condition	125
7. Other insulating materials	b

[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.

[b] Rated temperature limit of material minus test ambient temperature.

7.2.2 Temperatures shall 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).

7.2.3 A thermocouple junction and adjacent thermocouple lead wire shall be securely held in good thermal contact with the surface of the material whose temperature is being measured.

7.2.4 A new switch shall be mounted as in actual service, with the door and other openings closed. The switch shall be connected with not less than 1.2 m (4 ft) of Type THHN, THWN, RH, TW, TW75, or THW copper wire per terminal, the wire size corresponding to the current rating of the switch. For a switch rated 30, 60, or 100 A, the wire size shall be based on the temperature rating of the wire as indicated by the marking on the switch (see 9.2.58). Where a dual temperature rating is marked 60/75°C wire, the test shall be conducted with 75°C wire. The test shall be made at any convenient voltage. A temperature shall be considered to be constant when three successive readings taken at 15-minute intervals do not indicate any change.

Note: The Canadian equivalent of THHN is T90.

Note: The Canadian equivalent of THWN is TWN75.

7.2.5 Except as stated in 7.2.6 and 7.2.7, a deadfront switch shall be tested in an enclosed panelboard or the equivalent having main bus bars with a maximum rating of two times the ampere rating of the switch under test.

7.2.6 A 30 A deadfront switch may be tested in a 100 A panelboard and a 60 A deadfront switch may be tested in a 150 A panelboard. Alternatively, a 30 or 60 A deadfront switch may be tested in the smallest current rated panelboard for which it is intended to be used.

7.2.7 If a deadfront switch can be used as a main switch, the bus bars shall be rated equal to the ampere rating of the switch.

7.2.8 In the test of 7.2.5, the switch under test shall be mounted in the top position. The main bus bars of the panelboard shall be loaded to their rating up to the points of connection to the switch under test. Additional switches, or cables, may be used to load the main bus bars so that the input to them is equal to their rating. Any unused positions in the panelboard shall be filled with additional switches or closed with filler plates.

7.2.9 Except as noted in 7.2.10, dummy fuses shall be used in place of regular fuses in clips or female screw-shells.

7.2.10 A switch employing Class L, T, or C fuses or 400 or 600 A Class J fuses shall be tested with fuses in place and when carrying 80 percent of its rated current continuously.

7.2.11 If a deadfront switch has a magnetic steel shell that completely encircles the ungrounded conductors in the switch, the switch shall additionally be tested in accordance with 7.2.13 – 7.2.16 if the grounded circuit conductor does not pass through the switch.

7.2.12 A three-pole sample of an individual deadfront switch of the maximum ampere rating of each line of deadfront switches that is constructed to form a complete steel shell shall be tested.

7.2.13 The deadfront switch being tested shall be mounted in the open, not in a panelboard, with the front in a vertical plane and the load terminals at one side. Connections shall be made with cables in accordance with 7.2.4, and loading shall be in accordance with 7.2.1 or 7.2.10 as appropriate. Where wire cannot be connected to the line end of the switch, copper bus bars shall be connected to the line terminals. The bus bars shall have an ampacity not more than the rating of the switch based on a current density not less than 1.55 A/mm^2 (1 000 A/in^2), shall extend approximately 76 mm (3 inches) beyond the switch enclosure, and shall terminate in wire connectors appropriate for the rating of the switch. Bus bars of cross-section other than specified above may be used if agreeable to the submitter and the testing agency.

7.2.14 Temperatures shall be recorded for the top two load terminals, on the top front corner of the wire connectors farthest from the center of the switch.

7.2.15 The same sample used in the test of 7.2.13 shall be tested in the same manner, except that the conductors to the lower switch pole shall be disconnected from the switch and reconnected together outside and below the switch enclosure or shell. Results shall be considered acceptable if the temperature rises on the top two load terminals are not higher than those observed in the test of 7.2.13.

7.2.16 A two-pole deadfront switch marked for multi-phase application having a steel shell as described in 7.2.12, and that has an enclosure smaller than the equivalent three-pole switch of the same voltage and ampere rating, shall be subjected to the test described in 7.2.13 except that

a) Dummy fuses shall be used in the two poles,

b) A 3-phase current shall be adjusted to 100 percent of the switch rating, and

c) The third-phase conductor shall be connected outside and below the enclosure or shell.

Results shall be considered acceptable if the temperature rises at the load terminals do not exceed 30°C. A switch employing Class L, C, or T fuses or 400 or 600 A Class J fuses shall be tested with fuses in place and when carrying 80 percent of its rated current. Results shall be considered acceptable if temperatures at the load terminals comply with Table 16.

7.3 Overload test

7.3.1 General

7.3.1.1 A general-use switch shall perform successfully when operated:

a) For 50 cycles,

b) Making and breaking 150 percent of its rated current, except as noted in 7.3.1.3 and 7.3.2.10,

c) With the rate of speed being the number of cycles per minute given in Table 19,

d) At the test voltage described in 7.3.2.4,

e) With a power factor (for an ac switch) of 0.75 – 0.80 maximum.

There shall not be any electrical or mechanical malfunction of the device or welding of the contacts. The ground fuse shall not have opened. Burning or pitting of the contacts shall be considered to be acceptable, but line-to-line breakdown shall be considered to be unacceptable.

7.3.1.2 A horsepower- or kilowatt-rated switch shall perform successfully when operated:

a) For 50 cycles of operation for switches rated 74.6 kW or 100 horsepower or kilowatt and less, or 10 cycles of operations for switches rated over 74.6 kW or 100 horsepower or kilowatt,

b) Making and breaking current given in Table 17 and Table 18,

c) With the rate of speed being the number of cycles per minute given in Table 19 (operations with current); the switch rating in amperes shall be assumed to be equal to 60 percent of the required overload test current. A switch rated in excess of 74.6 kW or 100 hp need not be operated faster than 1 cycle per minute,

d) A test voltage as described in 7.3.2.4, and

e) With power factor (for an ac switch) of 0.45 – 0.50 maximum.

There shall not be any electrical or mechanical malfunction of the device or welding of the contacts. The ground fuse shall not have opened. Burning or pitting of the contacts shall be considered to be acceptable, but line-to-line breakdown shall be considered to be unacceptable.

Table 17
Overload-test currents in amperes for alternating-current switches

Switch in rating		120 V			240 V			480 V			600 V		
kW	hp	1ϕ	2ϕ	3ϕ	1ϕ	2ϕ	3ϕ	1ϕ	2ϕ	3ϕ	1ϕ	2ϕ	3ϕ
			4-Wire			4-Wire			4-Wire			4-Wire	
0.373	1/2	58.8	–	40	29.4	–	20	–	–	10	–	–	8
0.56	3/4	82.8	28.8	50	41.4	14.4	25	21	7.2	12.5	16.8	6	10
0.746	1	96	38.4	60	48	19.2	30	24	9.6	15	19.2	7.8	12
1.119	1-1/2	120	54	80	60	27	40	30	13.8	20	24	10.8	16
1.492	2	144	70.8	100	72	35.4	50	36	18	25	28.8	14.4	20
2.238	3	204	99.6		102	49.8	64	51	25.2	32	40.8	19.8	25.6
3.73	5	336	158		168	79.2	92	84	39.6	46	67.2	31.8	36.8
5.6	7-1/2	480	228		240	114	127	126	54	63.5	96	48	50.8
7.46	10	600	288		300	144	162	156	72	81	120	60	64.8
11.19	15		432			216	232		108	116		84	93
14.92	20		564			282	290		138	145		114	116
18.65	25		708			354	365		174	183		144	146
22.38	30		828			414	435		210	218		168	174
29.84	40		1 080			540	580		270	290		216	232
37.3	50		1 360			678	725		336	363		270	290
44.76	60						870			435			348
55.95	75						1 085			543			434
74.6	100						1 450			725			580
93.25	125						1 815			908			726
111.9	150						2 170			1 085			868
149.2	200						2 900			1 450			1 160
186.5	250									1 825			1 460
223.8	300									2 200			1 760
261.1	350									2 550			2 040
298.4	400									2 900			2 320
335.7	450									3 250			2 600
373.0	500									3 625			2 900

Table 18
Overload test currents in amperes for direct-current switches

Rating		125 V	250 V	600 V
kW	hp			
0.746	1	38	19	7
1.119	1-1/2	53	26	10
1.492	2	68	34	14
2.238	3	100	49	20
3.730	5	160	80	33
5.600	7-1/2	232	116	48
7.460	10	304	152	64
11.19	15	448	220	92
14.92	20	592	288	124
18.65	25	–	356	152
22.38	30	–	424	184
29.84	40	–	560	244
37.30	50	–	692	300

7.3.1.3 A general-use switch that also has a horsepower or kilowatt rating greater than 74.6 kW or 100 hp shall be subjected to the overload tests required in 7.3.1.1 and 7.3.1.2. If both tests are performed on the same sample, the number of operations required in 7.3.1.1 may be reduced to 40.

7.3.1.4 A double-throw switch shall be subjected to four overload tests, as follows:

a) With the line connected to the hinge jaws and the load connected to one set of contact jaws,

b) With the line connected to the hinge jaws and the load connected to the other set of contact jaws,

c) With the line connected to one set of contact jaws and the load connected to the hinge jaws, and

d) With the line connected to the other set of contact jaws and the load connected to the hinge jaws.

7.3.1.5 A double-throw switch for use as optional standby systems in accordance with Annex A, Ref. No. 1, shall be tested according to one of the following methods:

a) Subjected to the overload test using both sets of contacts simultaneously. During the test, the source of one set of contacts shall be displaced 120 electrical degrees from the source of the other set of contacts for a 3-phase supply or 180 electrical degrees for a single-phase supply.

b) If the double-throw switch is provided with a mechanical means to reduce the likelihood of the load switching from the normal source of supply to an alternate source of supply in one continuous motion, testing in accordance with 7.3.1.4 shall be permitted.

c) If the double-throw switch is constructed such that the movable contact of the normal supply is not in motion at the same time as the movable contact of the alternate supply, testing in accordance with 7.3.1.4 shall be permitted.

7.3.1.6 A cycle for a double throw-switch for use as optional standby systems in accordance Annex A, Ref. No. 1, is defined as making and breaking the required test current on both sets of contacts.

7.3.2 Test conditions

7.3.2.1 A switch shall be mounted as in actual service with the door or cover and any other openings closed. The line terminals shall be connected to a supply circuit, and the load terminals shall be connected to the necessary resistance or impedance.

7.3.2.2 A deadfront switch shall be mounted in a panelboard or on a representative chassis, provided spacings from live parts in the switch to the main bus structure and to grounded chassis metal are representative of those in the complete panelboard.

7.3.2.3 A switch intended for use on dc circuits and a switch not specially 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.

7.3.2.4 The open-circuit voltage shall not be less than 100 percent of the rated voltage of the switch, and the closed-circuit voltage shall not be less than 90 percent of the rated voltage of the switch or the normal-frequency recovery voltage shall be equal to the rated voltage of the device.

7.3.2.5 A switch intended for ac circuits only shall be tested with alternating current with an inductive load. The test shall be made on a circuit having a maximum frequency of 60 Hz. 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 following formula:

$$R_{SH} = 100[(1/PF) - PF]E/I$$

in which PF is the power factor, E is the closed-circuit phase voltage, and I is the phase current.

7.3.2.6 A switch intended for use on circuits having one conductor grounded shall be tested with the enclosure connected through a 30 ampere non-delay, non-renewable-type 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 to ground.

7.3.2.7 A 2-wire and a 3-wire switch intended for use on either 3-wire dc or single-phase ac circuits with grounded neutral shall be tested on a 3-wire dc circuit with grounded neutral, with the switch connected to the outside conductors of the circuit, and with the enclosure grounded as indicated in 7.3.2.6. If the switch is intended for use with alternating current only, it shall be tested with alternating current in a similar manner and in accordance with 7.3.2.5.

7.3.2.8 A 3-wire switch without a solid neutral intended for use on ac circuits other than that described in 7.3.2.7 and a 4-wire switch having a solid neutral shall be tested on a 3-phase circuit with a 3-phase balanced load.

7.3.2.9 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.

7.3.2.10 A switch marked for isolating use only and rated at more than 1 200 A at 250 V or less shall be subjected to the overload test with a current of 1 800 A. A switch marked for isolation use only and rated at more than 600 A at more than 250 V shall be subjected to the overload test with current 900 A. See 9.2.12.

7.4 Endurance test

7.4.1 The same switch previously subjected to the overload test shall perform successfully when operated:

a) For the number of cycles and rate of speed indicated in Table 19,

b) Making and breaking 100 percent of its rated current. Switches for isolating use only, rated at more than 1 200 A at 250 V or less, and switches rated at more than 600 A at more than 250 V may be operated without current, if the switch is marked in accordance with 9.2.12,

c) With the test potential as described in 7.3.2.4 for an ac switch and within 5 percent of the rated voltage of the switch if direct current is used, and

d) With a power (factor for an ac switch) of 0.75 – 0.80 maximum.

There shall not be any electrical or mechanical malfunction of the device or welding of the contacts. The ground fuse shall not have opened. Burning or pitting of the contacts shall be considered to be acceptable, but line-to-line breakdown shall be considered to be unacceptable.

7.4.2 For a switch having both ampere and horsepower or kilowatt horsepower ratings, the endurance test for the horsepower- or kilowatt-rated sample need not be conducted if represented by the endurance test for the general-use rating.

Table 19
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
30 – 100	6	6 000	4 000	10 000
200	5	6 000	2 000	8 000
400	4	1 000	5 000	6 000
600	3	1 000	4 000	5 000
800	2	500[b]	3 000	3 500
1 200	1	500[b]	2 000	2 500
1 600 – 2 500	1	500	2 000	2 500[c]
3 000 – 4 000	1[d]	400	1 100	1 500[c]

[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.

[b] For a switch marked "For isolating use only" (see 9.2.12) the switch is not operated with current in the endurance test.

[c] For switches rated over 1 200 A at 250 V or less and marked in accordance with 9.2.12, the total number of operations is 1000 without current.

[d] Rate of operation: 1 cycle per minute for first ten operations; thereafter in groups of five (at 1 cycle per minute) with an interval between groups that is agreeable to all concerned.

7.4.3 For horsepower- or kilowatt-rated switches, the endurance test shall be made with whichever is greater – the rated current of the device or the current selected from the appropriate full-load motor-running currents stated in Table 20 and 21. A fused motor-circuit switch shall be tested at 125 percent of the current given in Table 20 and Table 21. See also 9.2.4.

7.4.4 The current for the common wire of a 2-phase, 3-wire system is 1.414 times the value in Table 20 for a 2-phase, 4-wire system.

7.4.5 The endurance test of a double-throw switch shall be made with the connections that are shown by the overload test to be the most severe (see 7.3.1.4).

7.4.6 In determining if a switch complies with the requirements in 7.4, test conditions shall be as described in 7.3.2.

Table 20
Endurance-test currents in amperes for alternating-current switches

Switch rating in		120 V[a]			240 V			480 V			600 V		
kW	hp	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ
0.373	1/2	9.8	–	4.4	–	–	2.2	–	–	1.1	–	–	0.9
0.560	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
0.746	1	16	6.4	8.4	8	3.2	4.2	4.0	1.6	2.1	3.2	1.3	1.7
1.119	1-1/2	20	9.0	12	10	4.5	6	5.0	2.3	3	4.0	1.8	2.4
1.492	2	24	11.8	13.6	12	5.9	6.8	6.0	3.0	3.4	4.8	2.4	2.7
2.238	3	34	16.6	19.2	17	8.3	9.6	8.5	4.2	4.8	6.8	3.3	3.9
3.73	5	56	26.4	30.4	28	13.2	15.2	14.	6.6	7.6	11.2	5.3	6.1
5.60	7-1/2	80	38	44	40	19	22	21	9	11	16	8	9
7.46	10	100	48	56	50	24	28	26	12	14	20	10	11
11.19	15	135	72	84	68	36	42	34	18	21	27	14	17

Table 20 Continued on Next Page

Table 20 Continued

Switch rating in		120 V[a]			240 V			480 V			600 V		
kW	hp	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ	1ϕ	2ϕ 4-Wire	3ϕ
14.92	20	–	94	108	88	47	54	44	23	27	25	19	22
18.65	25	–	118	136	110	59	68	55	29	34	44	24	27
22.38	30	–	138	160	136	69	80	68	35	40	54	28	32
22.84	40	–	180	208	176	90	104	88	45	52	70	36	41
37.30	50	–	226	260	216	113	130	108	56	65	86	45	52
44.76	60	–	–	–	–	–	154	–	–	77	–	–	62
55.95	75	–	–	–	–	–	192	–	–	96	–	–	77
74.60	100	–	–	–	–	–	248	–	–	124	–	–	99
93.25	125	–	–	–	–	–	312	–	–	156	–	–	125
111.9	150	–	–	–	–	–	360	–	–	180	–	–	144
149.2	200	–	–	–	–	–	480	–	–	240	–	–	192
186.5	250	–	–	–	–	–	–	–	–	302	–	–	242
223.8	300	–	–	–	–	–	–	–	–	361	–	–	289
261.1	350	–	–	–	–	–	–	–	–	414	–	–	336
298.4	400	–	–	–	–	–	–	–	–	477	–	–	382
335.7	450	–	–	–	–	–	–	–	–	515	–	–	412
373.0	500	–	–	–	–	–	–	–	–	590	–	–	472

[a] For 127 V ratings, the test is conducted at rated voltage with the currents in this column.

Table 21
Endurance-test currents in amperes for direct-current switches

Switch rating		125 V	250 V	600 V
kW	hp			
0.746	1	9.4	4.7	1.8
1.119	1-1/2	13.2	6.6	2.6
1.462	2	17	8.5	3.4
2.238	3	25	12.2	5.0
3.73	5	40	20	8.3
5.60	7-1/2	58	29	12
7.46	10	76	38	16
11.19	15	112	55	23
14.92	20	148	72	31
18.65	25	–	89	89
22.38	30	–	106	46
29.84	40	–	140	61
37.30	50	–	173	75

7.5 Dielectric voltage-withstand test

7.5.1 A single-throw switch (with fuses, if any, in place) shall withstand for 1 minute without breakdown the application of a 60 Hz essentially sinusoidal voltage of 1 000 V plus twice the maximum rated voltage:

a) Between live parts and the enclosure with the switch closed,

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

c) Between the line and load terminals with the switch open.

7.5.2 A double-throw switch for use in optional standby systems in accordance with Annex A, Ref. No. 1, shall have the potential voltage applied:

a) Between live parts and the enclosure with the contact alternately closed to each supply source,

b) Between terminals of opposite polarity with the contacts closed,

c) Between live parts of different circuits, and

d) Between terminals of the normal source and the alternate source with the switch in both normal and alternate positions.

7.5.3 To determine if a switch complies with the requirements in Clause 7.5, Dielectric voltage-withstand test, the device shall be stressed by means of a 500 VA or larger transformer, the output voltage of which can be varied. The applied voltage shall be increased from zero until the required test value is reached and held at that value for 1 minute. The increase in the applied voltage shall be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by the voltmeter. A transformer less than 500 VA shall be permitted if the output voltage is measured directly.

7.6 Clamped joint test

7.6.1 A clamped joint between two insulators (reference 6.6.1.18) shall be tested using two samples:

a) The clamped joint on the first sample shall be opened up to produce a space 3.2 mm (1/8 inch) wide. This may be accomplished by loosening the clamping means or by drilling a 3.2 mm (1/8 inch) diameter hole at the joint between the insulators at a point of minimum spacing between the metal parts on the opposite sides of the joint. The drilled hole shall not decrease spacings between the opposite polarity parts as measured through the crack between the insulators. The 60 Hz dielectric breakdown voltage through this hole shall then be determined by applying a gradually increasing voltage (500 V per second) until breakdown occurs.

b) The second sample, with the clamped joint intact, shall be subjected to a gradually increasing 60 Hz voltage until 110 percent of the breakdown voltage of item (a) has been reached. If the breakdown voltage of item (a) is less than 4 600 V rms, the voltage to be applied to the second sample shall be further increased to 5 000 V rms and held for 1 second. There shall be no electrical breakdown of the second sample.

7.7 Close-open test

7.7.1 Switches rated higher than 10 000 amperes short-circuit current shall comply with the Close-open test requirements in 7.7.2 – 7.7.6.

7.7.2 A deadfront switch shall be mounted and connected to the test circuit in the same manner as for the overload test as specified in 7.3.2.2.

7.7.3 The test conditions shall be as follows:

a) A previously untested sample shall be used.

b) The line terminals of an ac rated switch shall be connected to the power supply circuit and the load terminals of the switch to an inductive load. The connections for a dc rated switch shall be as specified in 7.3.2.3.

c) The test circuit shall be as follows:

i) For ac rated switches, the power factor of the load shall be 0.45 – 0.50.

ii) For dc rated switches, testing shall be on a dc circuit with a time constant not less than 0.003 s. The time constant shall be measured on the oscillogram of the test current where the value is 63.2% of the maximum current.

d) The current shall be 600% of the rated current of the device.

e) A shunting resistance as described in 7.3.2.5 shall be permitted.

f) The open-circuit test voltage shall not be less than 100% of the rated voltage of the device.

g) The closed-circuit test voltage shall not be less than 90% of the rated voltage of the device, or the normal-frequency recovery voltage shall be equal to the rated voltage of the device.

h) A ground fuse as described in 7.3.2.6 shall be used.

i) A polyphase switch or a dc rated switch shall be subjected to 3 operations. A switch intended for use on single-phase ac circuits only shall be subjected to 5 operations.

j) The time between operations is not specified.

k) Servicing the blades and jaws before each operation shall be permitted. Servicing is considered to be filing, lubricating, deburring, and the like. There shall not be any disassembly of the device to accomplish the servicing. Servicing shall not include replacement of any part.

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

7.7.5 Upon completion of the test, the test sample shall not be serviced in any manner before conducting the dielectric voltage-withstand test. After completion of the dielectric voltage-withstand test, servicing the switch prior to the short-circuit withstand test shall be permitted.

7.7.6 The dielectric voltage-withstand test described in 7.5 shall be conducted following the close-open test.

7.8 Short-circuit withstand test

7.8.1 The following switches shall be subjected to the tests outlined in 7.8 – 7.9:

a) Switches rated higher than 10 000 A short circuit current rating,

b) Unfused switches, having a 5 000, 7 500, or a 10 000 A short-circuit current rating and marked for use with overcurrent protective devices having a continuous current rating greater than that of the switch,

c) Fused motor-circuit switches incorporating fuseholders of a current rating greater than that of the switch, and

d) Switches with design technologies other than the knife-blade design and a short-circuit current rating of 10 kA or less.

Note: *The 5 000 and 7 500 A levels are applicable only to combinations of the switch and a circuit breaker.*

7.8.2 Switches that have dc short-circuit current ratings greater than 10 000 A shall be evaluated as follows:

a) The switch shall be subjected to short-circuit withstand, short-circuit closing and low-level dielectric withstand tests described in 7.7 through 7.10 as required for an ac rating of 600 V at the short-circuit current value of the dc rating to be applied. The ac test circuit current level shall be at least the value of the dc short-circuit current rating to be applied. If the dc rating is 250 V or lower and at the same or lower short-circuit current rating, no dc short-circuit test is required provided that the ac testing is conducted with fuses with suitable current limiting capability and marked in accordance with 9.2.17.

b) If the dc rating is greater than 250 V, an additional set of short-circuit withstand and short-circuit closing tests shall be conducted at the dc voltage and dc short-circuit current rating. The fuses used in these tests shall be commercially available fuses having appropriate dc voltage, current and interrupting ratings.

Note: *The fuses are not required to have specific characteristics of peak current and I^2t let through. The samples used for the additional dc short-circuit tests may be previously untested samples.*

7.8.3 For switches rated for 10 000 A and below available fault current a previously untested sample shall be permitted.

7.8.4 For a double-throw switch, the tests specified in 7.8.1 shall be performed on both sets of contacts. If the construction of both sets of contacts are representative of each other, the test need only be conducted on one set.

7.8.5 A circuit capable of providing the maximum short-circuit current for which the switch is rated shall be closed on the sample. The switch shall withstand the designated current until the overcurrent protective device or devices specified in 7.8.7 opens, or, for a switch not marked as requiring a specific overcurrent protective device, for 0.050 s. After the circuit is opened:

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

b) There shall not be any 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 operating handle, and

e) Fuses (neither end of a bar or tube as described in 7.8.10) shall not be completely ejected from the fuse clips and no fuse (or line end of a bar or tube) shall bridge from a fuse clip to grounded metal.

f) Cracking or crazing of a viewing window is acceptable but a hole or opening of 6.4 mm or more in any dimension shall not occur.

7.8.6 For the test mentioned in 7.8.5:

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

b) The available rms symmetrical short-circuit current or prospective direct current in amperes shall not be less than the short-circuit current rating of the switch.

c) The circuit shall be as indicated in Figure 2, with any overcurrent protection device on the load side, and shall include the necessary measuring equipment and the fuse-mounting means. A circuit breaker shall be used if specified for use with an unfused switch. Connecting overcurrent protection means on the line side of an unfused switch shall be permitted if the switch is marked as indicated in 9.2.22.

d) The test circuit requirements shall be as follows:

i) For an ac circuit, the power factor of the circuit shall be 0.45 to 0.50 lagging for a circuit of 0 to 10 000 A, except the power factor shall be 0.85 to 0.95 lagging for fuses rated 100 A or less, 0.25 to 0.30 lagging for a circuit of 10 001 to 20 000 A, and 0.15 to 0.20 lagging for circuits over 20 000 A.

ii) For a dc circuit, the time constant shall not be less than 0.003 s for 10 000 A or less, and 0.008 s for circuits greater than 10 000 A.

e) The enclosure of the switch shall be connected through a 30 A nonrenewable, nondelay-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 shall be

made to the load side of the limiting impedance by a 10 AWG (5.3 mm^2) copper wire having a length of 1.22 to 1.83 m (4 to 6 ft). The fuse may be connected to the grounded conductor if the switch is intended for use on a grounded system.

7.8.7 The overcurrent protection devices specified in 7.8.5 shall be one of the following:

a) For ac rated fused or unfused switches rated 10 kA AIC and less, externally connected Class H fuses (maximum rating for the case size of the rating specified),

b) For ac rated fused switches rated higher than 10 kA AIC, fuses as described in 7.8.12,

c) For ac rated unfused switches rated higher than 10 kA AIC, externally connected fuses as described in 7.8.12, or circuit breakers as marked on the switch, or

d) For dc rated switches, see 7.8.2.

7.8.8 Performing the test specified in 7.8.5 without overcurrent protective devices shall be permitted 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.

7.8.9 For the performance of the test, the line and load terminals of the switch shall be connected to the corresponding test-circuit terminals by short copper wire leads, maximum 1.22 m (4 ft) per terminal, each of which has an ampacity not less than the current rating of the switch. Leads more than 1.22 m (4 ft) in length may be used if the excess length over 1.22 m (4 ft) is included in the test circuit when it is calibrated.

7.8.10 For a switch rated greater than 10 kA AIC that employs 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 shall 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 shall be conducted with the bolts in place if the bar or tube would not otherwise remain in position. Otherwise, the test shall be performed with the bolts omitted.

7.8.11 A deadfront switch shall be tested when installed in a representative panelboard, or on a representative chassis, in accordance with 7.2.8, except that the cross-section of the main bus bars need not be larger than the bus bars in the panelboard in which the switch is intended to be used. The switch shall be mounted in the top position and any unused positions in the panelboard may be filled with additional switches or closed with filler plates. The line terminals of the panelboard and the load terminals of the switch shall be connected to the corresponding test-circuit terminals as specified in 7.8.9, except the ampacity of the line leads shall be not less than the ampere rating of the main bus bars of the panelboard used in the test.

7.8.12 Fuses used in tests for ac ratings shall have characteristics representing the peak let-through current (I_p) and clearing I^2t values associated with the maximum rated fuses that the device accepts, or by which the device is to be externally protected. For an unfused switch, it shall be assumed that protection will be provided by the maximum fuse in the case size of the indicated fuse. Each of these fuses shall 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. The use of special test fuses having the required characteristics shall be permitted (see Table 22). The use of special test fuses of the same physical dimensions as a fuse the enclosed 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 that the switch accommodates and of a different class.

7.8.13 The fuse referred to in 7.8.12 may be any Class L fuse without regard to its peak let-through current and clearing I^2t, if the test current is below the point (threshold value of the fuse) where the fuse is considered to be current-limiting.

7.8.14 Fuses used for ac tests shall be selected from a lot from which two samples have been selected and calibrated to determine that their I^2t and I_p characteristics comply with the prescribed values called for in 7.8.12. Two samples from the lot shall be calibrated if the fuses are of Class G, J, RK5, C, or T, and one sample if the fuse is Class L.

7.8.15 Switches designed for use with special purpose fuses are to be tested using requirements in this standard for that Class fuse for which the special purpose fuse is marked as having the same performance specifications.

7.8.16 With the device in the fully closed position, the test circuit shall be closed on the device. For devices tested on a single-phase alternating current 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.

Table 22
Peak-let-through currents and clearing I^2t for fuses

Fuse rating, amperes	Between threshold and 50 kA		100 kA		200 kA		300 kA	
	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$
Class C Fuses								
0 – 30	–	–	–	–	12	15		
31 – 60	–	–	–	–	20	60		
61 – 100	–	–	–	–	30	200		
101 – 200	–	–	–	–	40	750		
201 – 400	–	–	–	–	70	4000		
401 – 600	–	–	–	–	100	10000		
601 – 800	–	–	–	–	115	25000		
801 – 1200	–	–	–	–	125	40000		
Class CC Fuses								
0 – 15	3	2	3	2	4	3		
16 – 20	3	2	4	3	5	3		
21 – 30	6	7	7.5	7	12	7		
Class CF Fuses								
0 – 30	6	7	7.5	7	12	7	18.5	8.4
31 – 60	8	30	10	30	16	30	24.4	36
61 – 100	12	60	14	80	20	80	28.4	96
Class G Fuses								
0 – 1	–	–	1	0.8	–	–		
2 – 3	–	–	1.5	1.2	–	–		

Table 22 Continued on Next Page

Table 22 Continued

Fuse rating, amperes	Between threshold and 50 kA		100 kA		200 kA		300 kA	
	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$
4 – 6	–	–	2	1.8	–	–		
7 – 10	–	–	3	2.8	–	–		
11 – 15	–	–	4	3.8	–	–		
16 – 20	–	–	5	5	–	–		
21 – 25	–	–	6	6	–	–		
26 – 30	–	–	7	7	–	–		
31 – 35	–	–	8	14	–	–		
36 – 40	–	–	8.5	17	–	–		
41 – 45	–	–	9	18.5	–	–		
46 – 50	–	–	9.5	21	–	–		
51 – 60	–	–	10.5	25	–	–		
300-Volt Class T Fuses								
0 – 30	5	3.5	7	3.5	9	3.5		
31 – 60	7	15	9	15	12	15		
61 – 100	9	40	12	40	15	40		
101 – 200	13	150	16	150	20	150		
201 – 400	22	550	28	550	35	550		
401 – 600	29	1000	37	1000	46	1000		
601 – 800	37	1500	50	1500	65	1500		
801 – 1200	50	3500	65	3500	80	4000		
Class J and 600-Volt Class T Fuses								
0 – 30	6	7	7.5	7	12	7	18.5	8.4
31 – 60	8	30	10	30	16	30	24.4	36
61 – 100	12	60	14	80	20	80	28.4	96
101 – 200	16	200	20	300	30	300	42.4	360
201 – 400	25	1000	30	1100	45	1100	66.4	1320
401 – 600	35	2500	45	2500	70	2500	101.4	3000
601 – 800	50	4000	55	4000	75	4000		
Class L Fuses								
601 – 800	80	10000	80	10000	80	10000	79.2	12000
801 – 1200	80	12000	80	12000	120	15000	107.8	18000
1201 – 1600	100	22000	100	22000	150	30000	143	36000
1601 – 2000	110	35000	120	35000	165	40000	158.4	48000
2001 – 2500	–	–	165	75000	180	75000	170.5	90000
2501 – 3000	–	–	175	100000	200	100000	225.5	120000
3001 – 4000	–	–	220	150000	250	150000	286	180000
4001 – 5000	–	–	–	350000	300	350000	286	420000
5001 – 6000	–	–	–	350000	350	500000	399.3	600000
Class RK5 Fuses[a]								
0 – 30	11	50	11	50	14	50	21	60
31 – 60	20	200	21	200	26	200	35	240
61 – 100	22	500	25	500	32	500	40	600
101 – 200	32	1600	40	1600	50	2000	62	2400
201 – 400	50	5200	60	5000	75	6000	90	7200

Table 22 Continued on Next Page

Table 22 Continued

Fuse rating, amperes	Between threshold and 50 kA		100 kA		200 kA		300 kA	
	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$	$I_p \times 10^3$	$I^2t \times 10^3$
401 – 600	65	10000	80	10000	100	12000	124	14400

[a] The value for a Class RK5 fuse is to be used when a Class RK1 fuse is specified for overcurrent protection.

7.9 Low-level dielectric voltage-withstand test

7.9.1 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 7.5, except that the test voltage shall be twice the rated voltage of the switch but not less than 900 V.

7.10 Short-circuit closing test

7.10.1 A switch shall be closed on a circuit capable of providing the maximum short-circuit current for which the switch is rated. After the circuit has cleared, the switch shall comply with the requirements of 7.8.5(a) – 7.8.5(f).

7.10.2 The sample for this test shall be either that used for the short-circuit withstand test or a previously untested sample. The conditions of the closing test shall be the same as for the short-circuit withstand test, see 7.8. Complete physical closure of the switch contacts need not be established.

7.10.3 The dielectric voltage-withstand test described in 7.9 shall be performed following the closing test.

7.11 Strength of insulating base and support test

7.11.1 The insulating base of a 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.

7.11.2 Damage is considered to have occurred if the base insulating material cracks or rotates; if bosses, recesses, or other means to prevent turning do not perform their intended function; if straps or bus bars bend or twist; or if 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.

7.12 Electrically tripped switches

7.12.1 General

7.12.1.1 An electrically tripped switch shall be investigated by subjecting representative devices to the tests described in 7.12.2 – 7.12.6. See 7.1.1 for samples requirements.

7.12.2 Temperature test

7.12.2.1 The maximum temperature rise on a coil or winding intended for continuous duty shall, when operated at rated voltage, not be greater than that indicated in Table 23.

Table 23
Maximum acceptable temperature rise on coils

Wire wound on coils	°C
A. Class 90 insulation systems:	
Thermocouple method	50
Resistance method	70
B. Class 105 insulation systems:	
Thermocouple method	65
Resistance method	85
C. Class 130 insulation systems:	
Thermocouple method	85
Resistance method	105
D. Class ″Over 220″ insulation systems	No limit specified

7.12.2.2 A coil or winding intended for continuous duty shall be capable of withstanding 110 percent of its rated voltage continuously.

7.12.3 Operation test

7.12.3.1 An electrically tripped mechanism shall operate successfully at 75 percent of its rated voltage to open the switch, except that an electrical trip device intended to function when a ground exists shall operate successfully at 55 percent of its rated voltage.

7.12.3.2 An electrically tripped mechanism intended to be powered by a source independent of the circuit controlled by the switch shall operate successfully at 85 percent of its rated voltage regardless of the intended switch function.

7.12.4 Contact opening test

7.12.4.1 An electrically tripped switch shall perform successfully when operated by the electrical tripping mechanism:

a) Breaking the levels of current as indicated in Table 24,

b) For five operations for a switch intended for use on a single-phase circuit only, and for three operations for all other switches,

c) At any rate of speed,

d) At a test potential as described in 7.3.2.4,

e) At a power factor of 45 – 50 percent for ac rated switches, and

f) For dc rated switches, a load with a time constant of not less than 0.003 seconds.

Table 24
Circuit-opening - current multiplier

Item	Type of switch	ac test current	dc test current
1	Electrically tripped	10 times rated	3 times rated
2	Electrically tripped – for use with Class II ground-fault sensing and relaying equipment	10 times rated	3 times rated
3	Electrically tripped – with integral lockout (6.14.2) – for use with Class I ground-fault sensing and relaying equipment	10 times rated	3 times rated
4	Electrically tripped – without integral lockout (6.14.2) – for use with Class I ground-fault sensing and relaying equipment	12 times rated	3 times rated

7.12.5 Endurance test

7.12.5.1 An electrical tripping mechanism, including any switch used to deenergize the tripping coil after tripping has occurred, shall be capable of performing successfully for 10 percent of the number of ″With Current″ operations, at the rate of operation shown in Table 19. The test may be performed in conjunction with the endurance test on the switch.

7.12.6 Other tests

7.12.6.1 If an electrical tripping mechanism affects the parts involving the mechanical or arcing characteristics of an enclosed switch because of its proximity to such parts, the switch with the electrical tripping mechanism installed shall be subjected to the overload and endurance tests.

7.13 Mold stress relief test

7.13.1 Except for rigid thermosetting materials, conditioning of the equipment as described in 7.13.2 shall not cause softening of the material as determined by handling immediately after the conditioning, nor shall there be any shrinkage, warpage, or other distortion as judged after cooling to room temperature, that results in any of the following:

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

b) Making uninsulated live parts or internal wiring accessible to contact, or defeating the integrity of the enclosure so that unacceptable mechanical protection is not afforded to internal parts of the equipment, and

c) Causing interference with the intended operation or servicing of the equipment.

7.13.2 One complete switch shall be placed in a full-draft circulating-air oven maintained at a uniform temperature at least 10°C higher than the maximum temperature of the material measured during the temperature test, but not less than 70°C in any case. The sample shall remain in the oven for 7 hours. After its removal from the oven and return to room temperature, the sample shall be investigated for compliance with 7.13.1.

7.14 Insulating barriers test

7.14.1 With regard to the 6.6.2.5, 6.6.2.7, and 6.6.2.8(b), the barrier material shall be placed between two metal electrodes. The electrodes shall be cylindrical brass or stainless steel rods 6.4 mm (1/4 inch) in diameter with edges rounded to a 0.8 mm (1/32 inch) radius. The test potential shall be increased to the test value and shall be maintained for 1 second. The result shall be acceptable if there is no dielectric breakdown.

8 Ratings

8.1 General

8.1.1 A general-use switch shall be rated in amperes and volts and may, in addition, be rated in horsepower or kilowatts. A fused motor-circuit switch shall be rated in horsepower or kilowatts and volts and also in maximum full-load amperes. A short-circuit-current rating of a switch shall be in accordance with 9.2.14 – 9.2.25.

8.1.2 A double-throw switch intended for use as optional standby systems in accordance with Annex A, Ref. No. 1, shall be rated in full load ampere and volts, and may be additionally rated in horsepower.

8.2 Current

8.2.1 The current rating of a general-use switch shall be 30, 60, 100, 200, 400, 600, 800, 1 200, 1 600, 2 000, 2 500, 3 000, 3 500, or 4 000 A.

8.2.2 The maximum full-load current rating (see 8.1.1) of a fused motor-circuit switch shall be the whole number nearest to 125 percent of the appropriate value selected from Table 20 or Table 21, but the horsepower or kilowatt rating shall be such that the maximum full-load current rating will not be more than 87 percent of the current rating of the fuseholder.

8.3 Voltage

8.3.1 The voltage rating of a switch shall be as indicated in Table 25.

8.3.2 Table 25 provides various voltage ratings for a given type of switch. To indicate its use on circuits where all of the poles of the switch will not be used, a switch may have, in addition to the standard rating, one or more of the applicable ratings shown for a switch having fewer poles. The rating or ratings applicable depend upon the fusing, spacings, and test performance of the switch. Except as noted in 8.3.3, the 120/240 V ac and the 125/250 V dc rating is applicable only to a switch intended for use on a 3-wire ac or dc system having a grounded neutral.

8.3.3 A 3-wire switch having three blades and three fuses may have an additional voltage rating of 120/240 V ac, or 125/250 V dc, under the following conditions:

a) The switch nameplate carries the applicable standard voltage rating,

b) If the switch nameplate carrying the standard voltage rating appears on the outside of the switch enclosure, the nameplate shall be marked ″For special water-heater applications, see rating inside″,

c) The additional voltage rating appears on a wiring diagram showing the use of the switch on a 2-wire 240 V (or 250 V) water-heater circuit derived from an Edison 3-wire system having a grounded neutral, with auxiliary equipment to provide off-peak service to a dual element water heater, and

d) The switch performs acceptably when subjected to the tests appropriate for the additional rating.

Table 25
Permissible voltage ratings of enclosed and deadfront switches

	Switch configuration			Voltage rating	
	Number of wires	Number of blades	Number of fuses	Direct current	Alternating current
A	1	1	1 or none	125	120 127
B	2	1 with solid neutral	1 or none	125 250[a]	120 127 240[a] 347
C	2	2	1	125 250[a]	120 127 240[a]
D	2	2	1, 2, or none	125 125/250 250[a] 600[a]	120 127 120/240 240[a] 480[a] 600[a]
E	3	2 with solid neutral	2 or none	125/250	120 127 120/240 220Y/127 240[a]
F	3	3	2	125/250	120 127 120/240 220Y/127 240[a]
G	3	3	None	125/250	120 120/240 240[a] 480[a] 600[a]
H	3	3	3		120 240[a] 480[a] 600[a]
I	4	3 with solid neutral	3 or none		240[a] 480[a] 600[a]
J	4	4	3		240[a] 480[a] 600[a]
K	4	4	4 or none		120 240[a] 480[a]

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Table 25 Continued

	Switch configuration			Voltage rating	
	Number of wires	Number of blades	Number of fuses	Direct current	Alternating current
					600[a]
L	5	4 with solid neutral	4 or none		120/240

[a] These ratings are not applicable to switches having plug fuses.

8.4 Horsepower or kilowatts

8.4.1 The horsepower or kilowatts rating of a switch shall be one of values indicated in Table 20 or Table 21.

8.4.2 The horsepower or kilowatts rating of a switch incorporating fuseholders shall not be higher than as indicated in Table 26.

Table 26
Power ratings of fused switches

Fuse-holder, amps	Switch rating in volts	Power ratings, kilowatts (horsepower)							
		2-pole single-phase		2-pole DC		3-pole, 3-phase		4-pole, 2-phase	
		Standard	Maximum[a]	Standard	Maximum[a]	Standard	Maximum[a]	Standard	Maximum[a]
30	120 AC 127 AC	0.373 (1/2)	1.492 (2)			1.119 (1-1/2)	2.238 (3)	1.492 (2)	2.238 (3)
60	120 AC 127 AC	1.119 (1-1/2)	2.238 (3)			2.238 (3)	5.60 (7-1/2)	2.238 (3)	7.46 (10)
30	125 DC			1.492 (2)	2.238 (3)				
60	125 DC			3.73 (5)					
30	240 AC	1.119 (1-1/2)	2.238 (3)			2.238 (3)	5.60 (7-1/2)	2.238 (3)	7.46 (10)
60	240 AC	2.238 (3)	7.46 (10)			5.60 (7-1/2)	11.19 (15)	5.60 (7-1/2)	14.92 (20)
100	240 AC	5.60 (7-1/2)	11.19 (15)			11.19 (15)	22.38 (30)	11.19 (15)	22.38 (30)
200	240 AC	11.19 (15)				18.65 (25)	44.76 (60)	22.38 (30)	37.30 (50)
400	240 AC					37.30 (50)	93.25 (125)	37.30 (50)	
600	240 AC					55.95 (75)	149.2 (200)		
800	240 AC					74.60 (100)	186.5 (250)		
30	250 DC			3.73 (5)					
60	250 DC			7.46 (10)					
100	250 DC			14.92 (20)					
200	250 DC			29.84 (40)					

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