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NEMA STANDARDS PUBLICATION

NEMA KS 1

ENCLOSED AND MISCELLANEOUS DISTRIBUTION EQUIPMENT SWITCHES (600 VOLTS MAXIMUM)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

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ENCLOSED AND MISCELLANEOUS DISTRIBUTION EQUIPMENT SWITCHES (600 VOLTS MAXIMUM)

Published by:

National Electrical Manufacturers Association
1300 North 17th Street
Rosslyn, VA 22209

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CONTENTS

FOREWORD ii

SECTION 1 GENERAL 1

1.1 SCOPE 1
1.2 REFERENCED STANDARDS 1
1.3 DEFINITIONS 2

SECTION 2 CHARACTERISTICS AND REQUIREMENTS OF SWITCHES 7

2.1 RATINGS 7
2.2 ACCESSORIES 8
2.3 ENCLOSURES 12
2.4 SERVICE EQUIPMENT 14
2.5 NUMBER OF SWITCHING POLES AND WIRES 15
2.6 CONSTRUCTION 17
2.7 PULLOUT SWITCH ENCLOSURES 19
2.8 SPACINGS 19
2.9 TERMINALS 20

SECTION 3 TESTS 43

3.1 DESIGN AND VERIFICATION TESTS 43
3.2 DESIGN TESTS 44
3.3 VERIFICATION TESTING 68
3.4 TEST CIRCUITS AND CALIBRATION OF CIRCUIT INSTRUMENTS 68
3.5 ADDITIONAL PULLOUT SWITCH TESTS 76

SECTION 4 CLASSIFICATIONS OF SWITCHES 79

4.1 GENERAL DUTY ENCLOSED SWITCHES (GD) 79
4.2 HEAVY DUTY ENCLOSED SWITCHES (HD) 79
4.3 DEADFRONT AND OPEN SWITCHES 80
4.4 PULLOUT SWITCHES 80

SECTION 5 APPLICATION INFORMATION 83

5.1 ENVIRONMENTAL CONDITIONS 83
5.2 SELECTION AND USER INFORMATION 83
5.3 MAINTENANCE 87
5.4 MARKING 87
5.5 PRODUCT WARNING INFORMATION 92

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Foreword

This Standards Publication is intended to provide a basis of common understanding within the electrical industry by aiding the user and specifier in properly selecting enclosed air-break switches for their particular application. It shall describe, as related to switches:

a. Definitions
b. Characteristics and requirements
c. Tests
d. Classifications
e. Application information

To assure a meaningful publication, copies of the draft publication were circulated to a number of individuals and organizations in the public and private sector having an interest in or responsibility for the purchase, testing, application, use, or inspection of enclosed switches. Their resultant comments and suggestions provided a vital user and general interest input and resulted in a number of substantive changes being made in the publication prior to final NEMA approval. As future major revisions to this publication are proposed, it is intended that the same or similar organizations or individuals will be offered a further opportunity to participate in the development of this publication.

These standards are periodically reviewed by the Switch Section of NEMA for any revisions necessary to keep them up-to-date with advancing technology. Proposed or recommended revisions should be submitted to:

Vice President, Engineering
National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209

This Standards Publication was developed by the Switch Section. Section approval of the standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the Switch Section was composed of the following members:

American Circuit Breaker Corp.—Albermarle, NC
Boltswitch, Inc.—Crystal Lake, IL
Cutler-Hammer, Inc.—Pittsburgh, PA
General Electric—Plainville, CT
The Pringle Electrical Manufacturing Company—Fort Washington, PA
Siemens Energy & Automation, Inc.—Alpharetta, GA
Square D Company—Palatine, IL
Test Switch Technology, Inc.—Canton, OH
Thomas & Betts Corporation—Memphis, TN

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Section 1
GENERAL

1.1 SCOPE

This Standards Publication covers enclosed and miscellaneous distribution equipment switches that are:

a. Rated at not more than 600 volts and 6000 amperes with or without a horsepower rating
b. With or without provision for fuses
c. With current-carrying parts and mechanisms enclosed in metallic or nonmetallic cases, or that are enclosed when mounted in an enclosed switchboard, panelboard, or the like
d. Manually operable by means of external handles

Note—These devices may also be automatically operable by means of shunt trips, electrical operators, ground fault devices, or other mechanisms.

This Standards Publication does not cover:

a. The common form of snap switches
b. Switching devices having features intended primarily for the starting and running protection of electric motors as described in NEMA Standards Publications ICS 1, ICS 2, and ICS 3
c. Circuit-breaker-type power circuit protectors
d. Molded case switches as described in NEMA Standards Publication AB 1

Fuses, lampholders, receptacles, wire connectors, wires and cables, etc., which may be provided as parts of an enclosed switch, are covered under other NEMA Standards Publications.

1.2 REFERENCED STANDARDS

National Electrical Manufacturers Association
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AB 1-1993	*Molded Case Circuit Breakers*
ICS 1-1993	*General Standards for Industrial Control and Systems*
ICS 2-1993	*Industrial Control Devices, Controllers, and Assemblies*
250-1991	*Enclosures for Electrical Equipment (1000 Volts Maximum)*

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

NFPA 70-1996	*National Electrical Code*
NFPA 70B-1993	*Electrical Equipment Maintenance*

American National Standards Institute
1430 Broadway
New York, NY 10017

ANSI/UL 512-1993	*Fuseholders*

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Underwriters Laboratories, Inc.
333 Pfingsten Road
Northbrook, IL 60062

UL 198B-1988 *Class H Fuses*

1.3 DEFINITIONS

For the purposes of this Standard, the following definitions apply:

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.

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.

ambient temperature: The temperature of the surrounding medium that comes in contact with the exterior of the switch enclosure.

auxiliary switch: A switch mechanically operated by the main switching device for switching, signaling, interlocking, or other purposes.

Auxiliary switch contacts may be designated as a or b as indicated below, but other contact arrangements may be used:

a. "a" Contacts that are open when the switch contacts are open and closed when the switch contacts are closed.
b. "b" Contacts that are closed when the switch contacts are open and open when the switch contacts are closed.

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.

available fault current rating: A rating applied to a switch indicating its suitability under prescribed conditions for use on circuits having up to that related level of available fault current.

bolted-pressure contact switches: Switches in which an additional pressure or clamping action is provided at both ends of the switch blades when the blades are in a fully closed position.

cartridge fuse: A fuse consisting of a current responsive element inside a fuse body with contacts on both ends.

clearance: The shortest distance through air between two conductors or between a conductor and a grounded part.

clearing I^2t (of a fuse): The amount of ampere-squared seconds passed by a fuse during total clearing time under specified conditions.

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.

clearing time (of a fuse): The total time measured from the beginning of the specified overcurrent condition until the interruption of the circuit, at rated voltage. The clearing time is equal to the sum of the melting time and the arcing time.

conducting part: A part that is capable of conducting current.

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creepage distance: The shortest distance along the surface of an insulating material between two conductive parts.

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.

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.

current-limiting fuse range (AC): The range of symmetrical rms available currents equal to or less than the interrupting rating in which the total clearing time at rated voltage and frequency is less than one half cycle.

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.

deadfront switch: A switch that has all current carrying parts enclosed when it is mounted in an enclosed panelboard, deadfront switchboard, or the like. (See 3.3).

dependent manual operation (of a mechanical switching device): An operation solely by means of directly applied manual energy, such that the speed and force of the operation are dependent upon the action of the operator.

design 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.

Design 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 design 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.

dielectric tests: Tests made to determine the ability of insulating materials and spacings used to withstand specified overvoltages.

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.

electrical close: A means for releasing energy previously stored in a mechanism to close a switch upon the application of a specified voltage.

electrical operator: A means of electrically closing and opening the contacts of a device through the use of a motor or similar means.

electrical trip; shunt trip: (See shunt trip)

enclosed switch: A switch with or without fuseholders, having all current carrying parts completely enclosed, that is operable without opening the enclosure.

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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.

fuse: A protective device that opens by the melting of a current-sensitive element during specified overcurrent conditions.

fuse clips: The contacts of the fuseholder that support the fuse and connect the fuse terminals with the circuit.

fuseholder: An assembly of base, fuse clips and necessary insulation for the mounting or connecting of a fuse into a circuit.

fuse interrupting rating: The highest direct or rms alternating current that the fuse is capable of interrupting safely under specified conditions.

fusible switch; switch fuse: 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.

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).

Ground (Earth) may have an identification symbol in accordance with IEC Publication 417:

417 IEC-5019  Protective ground (earth)

hazardous materials: Those gases, vapors, combustible dusts, fibers, or flyings that are explosive under certain conditions.

hazardous locations: Those areas that contain hazardous materials in sufficient quantity to create an explosion (See Article 500, *National Electrical Code*).

high-pressure butt contact switches: Devices having butt type contacts and a spring-charged mechanism.

independent manual operation (of a mechanical switching device): A stored energy operation where the energy originates from manual power, stored and released in one continuous operation, such that the speed and force of the operation are independent of the action of the operator.

interlock (mechanical): A mechanism that limits the operations of a switch to a specified sequence.

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.

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jogging; inching: The quickly repeated opening and closing of a circuit to stop and start a motor from rest for the purpose of accomplishing small movements of the driven machine.

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.

live parts: Parts that are designed to operate at a voltage different from that of the earth.

locked-rotor current of a motor: The steady-state current taken from the line with the motor locked and with rated voltage (and rated frequency in the case of ac motors) applied to the motor.

main circuit (of a switching device): All the conductive parts of a switching device included in the circuit which it is designed to close or open.

nonventilated: This indicates that an enclosure is so constructed as to provide no intentional circulation of external air through the enclosure.

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.

open switch: A switch that is provided without an enclosure (See 3.3.).

operating cycle (of a switch): This consists of one complete opening and closing of the contacts.

operating mechanism of a switch: It is the mechanism by which the contacts of a switch are actuated to open or close the circuit.

operating overload: This is the overcurrent to which the switch is subjected in the course of the normal operating conditions which it can encounter.

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.

peak let-through current, Ip: The highest instantaneous current passed by the overcurrent protection device during the interruption of the current.

peak let-through current, Ip (AC): The maximum instantaneous current during the total clearing time.

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.

plugging: A control function that provides braking by reversing the motor line voltage polarity or phase sequence so that the motor develops a counter-torque that exerts a retarding force.

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.

power circuit device: A switch (fused or unfused) having a 100 percent continuous current rating usually of a bolted pressure contact or high pressure butt contact design.

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.

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pullout switch: A switch, enclosed or non-enclosed, which is operated to open a circuit by manually separating the movable contact from the stationary contact, and is operated to close a circuit by manually reconnecting the movable contact and the stationary contact.

enclosed pullout switch: A pullout switch, with or without fuseholders, having all current carrying parts completely enclosed when hinged cover is in the closed position (in the case of hinged pullouts) or detachable member is in the installed position (in the case of detachable pullouts).

detachable pullout: A type of pullout switch that is operated by physical removal and reinsertion of a detachable pullout member.

hinged pullout: A type of pullout switch that is operated by opening or closing a hinged cover.

rating: A designated limit of operating characteristics based on specified conditions of current, voltage, frequency, and such.

the recovery voltage: This is the voltage that occurs across the terminals of a pole of a circuit-interrupting device upon the interruption of the current.

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.

short-circuit current rating: The maximum available rms symmetrical current in amperes (which is marked on the switch) that the (fused or unfused) switch will withstand or close against when equipped with the proper overcurrent protective device(s). The overcurrent protective devices, if any, may have a higher interrupting rating than that of the switch.

shunt trip; electrical trip: A means for releasing energy previously stored in a mechanism to open the switch upon the application of a specified voltage.

single-throw switch: A switch which has an open and a closed circuit position only.

stored energy operation: An operation by means of energy stored in the mechanism itself prior to the completion of the operation and sufficient to complete it under predetermined conditions.

This kind of operation may be subdivided according to:

a. How the energy is stored (spring, weight, and such)
b. How the energy originates (manual, electric, and such)
c. How the energy is released (manual, electric, and such)

switch (switching device): A device, manually operated, unless otherwise designated, for opening and closing or for changing the connection of a circuit. This is 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 such) provided the poles are coupled in such a manner as to operate together.

test link; (dummy fuse): This is 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-sectional area as are obtained on terminals of the fuse that it is intended to replace. A test link is not a protective device.

ventilated (the term): This indicates that an enclosure has been so constructed as to provide for the circulation of external air through the enclosure to remove excess heat, fumes, or vapors.

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Section 2
CHARACTERISTICS AND REQUIREMENTS OF SWITCHES

2.1 RATINGS

The rating of a switch shall include the following:

a. Voltage rating (see 2.1.1)
b. Frequency rating (see 2.1.2)
c. Current rating (see 2.1.3)
d. Horsepower rating, fusible switches (see 2.1.4)
e. Horsepower rating, non-fusibles (see 2.1.5)
f. Fuses (see 2.1.6)
g. Short circuit current rating (see 2.1.6)

2.1.1 Voltage Rating

The voltage rating of switches shall be in accordance with Table 2-1.

The table permits various voltage ratings for a given type of switch. To indicate its suitability for 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 fusings, spacings, and test performance of the switch. A 120/240- or 125/250-volt rating is applicable only to a switch suitable for use on a 3-wire ac or dc having a grounded neutral.

2.1.2 Frequency Rating

The frequency rating of ac switches shall be 60 hertz unless the switch is otherwise marked. Switches having a dc rating shall be marked dc (see 4.2).

2.1.3 Current Rating

Switches shall be rated 30, 60, 100, 200, 400, 600, 800, 1200, 1600, 2000, 2500, 3000, 4000, 5000, or 6000 amps.

2.1.4 Fusible Switch Horsepower Ratings

2.1.4.1 Horsepower Rating Standard

Standard horsepower ratings shall be in accordance with Table 2-2. These are based on the ability to start typical single-speed motors under normal service conditions using fuses which have been selected without regard to their time-delay characteristics.

2.1.4.2 Horsepower Rating Maximum

Maximum horsepower ratings of fusible switches used with fuses having time-delay characteristics suitable for the starting characteristics of the motor shall be in accordance with Table 2-3.

2.1.5 Non-fusible Switch Horsepower Ratings

The horsepower rating for a non-fusible switch shall be in accordance with Table 2-3.

2.1.6 Short Circuit Current Rating

The rms fault current rating (short-circuit rating) of a switch shall be one or more of the values shown in Table 2-4. For switches with specified overcurrent protective devices, the rating shall not be greater than that of the specified overcurrent protective device. The switch rating shall be 10,000A for plug, class H, and class K fuses. The switch rating shall not be less than 25,000A for class CC, G, J, L, R, or T fuses.

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2.2 ACCESSORIES

Switches may have provisions for a number of accessories to provide additional features or functions. In some cases, the accessories are supplied in the form of field-installed kits with instructions and mounting material. In other cases, the accessories may only be available as a factory-installed item. Only accessories recommended by the switch manufacturer should be used to ensure that the addition of the accessory does not interfere with the safe and dependable operation of the switch. Some of the accessory features are covered as follows.

2.2.1 Auxiliary Switches

Auxiliary switches arranged to open or close their contacts in coordination with the main circuit contacts are available for mounting within the switch enclosure.

Auxiliary switches are described by reference to:

a. The number of sets of switching contacts
b. The contact arrangement, Type a or b (or both)
c. The electrical ratings of each set of contacts including
    1. Rated voltage
    2. Rated frequency (if other than 60 Hz, ac)
    3. Rated current carrying capacity
    4. Rated making and breaking capacity (if different than current carrying capacity)

The contact arrangement (Type a or b) may further be described on devices where the main switch blades have wiping contacts. If the auxiliary switch contact actuates prior to the switch blades break contact or after the blades make contact, it is identified as "Position 1." If the auxiliary switch contact actuates after the switch blades break contact or prior to the switch blades make contact, it is identified as "Position 2."

2.2.2 Interlocked Receptacle Switches

An interlocked receptacle switch is an enclosed switch that has a receptacle wired to the load end of the switch. The switch operating mechanism is interlocked with receptacle so that the mating plug can neither be installed nor removed if the switch contacts are in the closed position. This type of switch is designed primarily for use in connecting portable equipment for special application use.

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Table 2-1
VOLTAGE RATINGS OF SWITCHES**

Switch Configuration			Voltage Ratings	
Number of Wires	Number of Switching Poles	Number of Fuses	Direct Current†	Alternating Current ††
1	1	1 or none	125	120
2 (including solid neutral)	1	1 or none	125 250*	120 240*
2	2 (including switched neutral)	1	125 250*	120 240*
2	2	2 or none	125 125/250 250* 600*	120 120/240 240* 480* 600*
3 (including solid neutral)	2	2 or none	125/250 250*	120 120/240 240*
3	3 (including switched neutral)	2	125/250 250*	120 120/240 240*
3	3	None	125/250 250*	120 120/240 240* 480* 600*
3	3	3	...	120 240* 480* 600*
4 (including solid neutral)	3	3 or none	...	240 480* 600*
4	4 (including switched neutral)	3	...	240* 480* 600*
4	4	4 or none	...	120 240* 480* 600*
5 (including solid neutral)	4	4 or none	...	120/240

NOTES:
*These ratings shall not be applicable to enclosed switches having plug fuses.
**Shaded area indicates standard ratings of general duty enclosed switches. (See 4.1)
†A switch having one of the dc ratings shall also be considered to be suitable for use on alternating current.
††A switch having one of the ac ratings shall not have one of the dc ratings unless it is so marked.

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Table 2-2
STANDARD HORSEPOWER RATINGS*

Size of Fuseholder, Amperes	Volts	Two-Pole Single-Phase	Two-Pole Direct Current	Horsepower Ratings of Enclosed Switches	
				Three-Pole Three-Phase	Four-Pole Two-Phase
30	120 ac	1/2	...	1-1/2	2
60		1-1/2	...	3	3
30	125 dc	...	2	...	...
60		...	5	...	...
30	240 ac	1-1/2	...	3	3
60		3	...	7-1/2	7-1/2
100		7-1/2	...	15	15
200		15	...	25	30
400		...	...	50	50
600		...	...	75	...
800		...	...	100	...
30	250 dc	...	5	...	...
60		...	10	...	...
100		...	20	...	...
200		...	40	...	...
400		...	50	...	...
30	480 ac	3	...	5	7-1/2
60		5	...	15	15
100		10	...	25	25
200		25	...	50	50
400		...	...	100	...
600		...	...	150	...
800		...	...	200	...
30	600 ac	3	...	7-1/2	10
60		10	...	15	20
100		15	...	30	30
200		30	...	60	50
400		...	...	125	...
600		...	...	200	...
800		...	...	250	...
30	600 dc	...	10	...	...
60		...	25	...	...
100		...	40	...	...
200		...	50	...	...

*Shaded areas indicate standard ratings of general duty enclosed switches.

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Table 2-3
MAXIMUM HORSEPOWER RATINGS*

Size of Fuseholder in Amps or Ampere Rating of Nonfused Switch	Volts	Two-Pole Single-Phase	Two-Pole Direct Current	Three-Pole Three-Phase	Four-Pole Two-Phase
30	120 ac	2	...	3	3
60		3	...	7-1/2	10
30	125 dc	...	...	...	...
60		...	3	...	...
30	240 ac	3	...	7-1/2	10
60		10	...	15	20
100		15	...	30	30
200		...	...	60	30
400		...	...	125	...
600		...	...	200	...
800		...	...	250	...
30	250 dc	...	5	...	...
60		...	10	...	...
100		20	20	...	...
200		40	40	...	...
400		50	50	...	...
30	480 ac	7-1/2	...	15	20
60		20	...	30	40
100		30	...	60	50
200		50	...	125	...
400		...	...	250	...
600		...	...	400	...
800		...	...	500	...
30	600 ac	10	...	20	25
60		25	...	50	50
100		40	...	75	50
200		50	...	150	...
400		...	...	350	...
600		...	...	500	...
800		...	...	500	...
30	600dc	...	15	...	...
60		...	30	...	...
100		...	50	...	...
200		...	...	...	...

* Shaded area indicates standard ratings of general duty enclosed switches (see 4.1).

Table 2-4
SHORT-CIRCUIT CURRENT RATING, RMS AMPERES

5,000*	25,000	65,000*
7,500*	30,000*	85,000*
10,000	35,000*	100,000
14,000*	42,000*	125,000*
18,000*	50,000	150,000*
22,000*		200,000

*These ratings are applicable only to combinations of the switch and a circuit breaker.

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2.2.3 Fuse Adapters and Rejectors

Fuse adapters and rejectors allow modification of the enclosed switch fuseholders to accept only certain classes of fuses and reject other classes.

The switch marking should identify the fuseholder alteration that can be made and the ratings that will apply after the modifications.

2.2.4 Wire Connectors

Wire connector kits allow an enclosed switch to accommodate different or extended wire size ranges or to accommodate crimp-type connectors.

2.2.5 Hubs

Hubs are available for various types of enclosed switches which after proper installation, allow the conductor entry opening to maintain the environmental capability indicated by the enclosure type number. At times the conductor entry opening along with any required hub mounting holes are provided as a standard feature of the enclosed switch; at other times they are added in the field.

2.2.6 Neutral or Ground Lugs

Neutral or ground lugs, or both, are often provided as an integral part of the switch but may also be provided as a field-installed accessory.

2.3 ENCLOSURES

Switch enclosures shall be in accordance with NEMA Standards Publication No. 250 (see 5.2.6).

2.3.1 Purpose of Enclosures

The enclosure of an enclosed switch is 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 (see 2.3.6).

2.3.2 Conductor Entry

Enclosures should be used with the appropriate conductor entry fittings so as to maintain the specified environmental capability after installation.

2.3.3 Operating Mechanism

External operating mechanisms, when mounted on or through the enclosure, shall pass the applicable test for the enclosure as specified in NEMA Standards Publication No. 250.

2.3.4 Materials

Enclosures shall be made of materials that will not support combustion in air. They shall be made of corrosion-resistant materials or shall have both inside and outside surfaces suitably protected by enameling, painting, galvanizing, plating, or other equivalent means. Consult the manufacturer if application conditions are more severe than those represented by the applicable design test.

2.3.5 Applications

Refer to 5.2.6 for application purposes.

2.3.6 Type Designations

The enclosures shall be designated by the type number that is intended to indicate the environmental conditions for which they are suitable. Enclosures that meet the requirements of more than one type enclosure may be designated by a combination of type numbers, the lower number being given first.

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Enclosures shall be classified as follows. Refer to NEMA Standards Publication No. 250 for a more detailed description of enclosures.

Type 1—Enclosures are intended for indoor use primarily to provide a degree of protection against contact with the enclosed equipment.

Type 2—Enclosures are intended for indoor use primarily to provide a degree of protection against limited amounts of falling water and dirt.

Type 3—Enclosures are intended for outdoor use primarily to provide a degree of protection against windblown dust, rain, sleet, and external ice formation.

Type 3R—Enclosures are intended for outdoor use primarily to provide a degree of protection against falling rain, sleet, and external ice formation.

Type 3S—Enclosures are intended for outdoor use primarily to provide a degree of protection against windblown dust and rain, sleet and to provide for operation of external mechanisms when ice laden.

Type 4—Enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, and hose-directed water.

Type 4X—Enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, and hose-directed water.

Type 5—Enclosures are intended for indoor use primarily to provide a degree of protection against settling airborne dust, falling dirt, and dripping noncorrosive liquids.

Type 6—Enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against the entry of water during occasional temporary submersion at a limited depth.

Type 6P—Enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against the entry of water during prolonged submersion at a limited depth.

Type 7—Enclosures are for use indoors in locations classified as Class I, Groups A, B, C, or D as defined in the *National Electrical Code*, Article 501.

Type 9—Enclosure for use in indoor locations classified in Class II, Groups E, F, or G as defined in the *National Electrical Code*, Article 502.

Type 12—Enclosures are intended for indoor use primarily to provide a degree of protection against dust, falling dirt, and dripping noncorrosive liquids.

Type 12K—Enclosures with knockouts are intended for indoor use primarily to provide a degree of protection against dust, falling dirt, and dripping noncorrosive liquids other than at knockouts.

Type 13—Enclosures are intended for indoor use primarily to provide a degree of protection against dust, spraying of water, oil, and noncorrosive coolant.

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Table 2-5
CONVERSION OF NEMA TYPE NUMBERS TO IEC CLASSIFICATION DESIGNATIONS
(Do not use to convert IEC Classification Designations to NEMA type Numbers)

NEMA Enclosure Type Number	IEC Enclosure Classification Designation
1	IP10
2	IP11
3	IP54
3R	IP14
3S	IP54
4 and 4X	IP56
5	IP52
6 and 6P	IP67
12 and 12K	IP52
13	IP54

NOTE—This comparison is based on tests specified in IEC publication 529.

2.4 SERVICE EQUIPMENT

Switches suitable for use as service equipment shall meet the requirements of this section.

2.4.1 Service Equipment Rated Less Than 1,000 Amperes

2.4.1.1 Provisions for Grounded Service Conductor

A switch that is marked to indicate that it is suitable for service equipment and has provision for the connection of a grounded service conductor but does not interrupt the grounded conductor, shall be provided with a means for disconnecting the grounded service conductor from the load conductors.

The required disconnecting means shall be permitted to be a link, screw, or similar conducting piece designed to make connection between two terminals. It shall be permitted to be a terminal plate provided with wire connectors or lugs or with wire binding screws and upturned lugs for clamping a No. 10 AWG or smaller wire; or it shall be permitted to be a single stud provided with wire connectors or lugs, or with nuts and cupped washers for clamping a No. 10 AWG or smaller wire; or it shall be permitted to be a wire connector which is intended for the connection of a single conductor and also for the connection of two conductors.

A single wire connector shall be permitted to be employed for both the disconnecting means for the grounded service conductors and the connection of the service grounding conductor if the connector is acceptable for securing one, two, or three conductors.

A switch that is marked for service equipment use shall have a terminal(s) for a grounded service conductor even though there may be no provision for a load conductor to be connected to the grounded service conductor. If there is no provision for such a load conductor, the grounded service conductor terminal shall:

a. Accommodate a conductor of the same size as the grounding electrode conductor specified in Table 2-6
b. Be bonded to the enclosure
c. Be directly connected to the grounding electrode conductor terminal
Exception: When the terminals are omitted, the switch shall be marked with a catalog number of a kit including the terminals (or information stating the wire size or terminals required) and instructions for assembly in the enclosure.

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2.4.1.2 Provisions For Grounding Electrode Conductor

An enclosed switch marked as being acceptable for use as service equipment shall have provision for connection of the grounding electrode conductor to the grounded service conductor. The size of the grounding electrode conductor shall be in accordance with Table 2-6. A soldering lug or other connection means that depends upon solder is not acceptable.

2.4.2 Service Equipment Rated 1,000 Amperes and Above

The *National Electrical Code* (see Section 1), Section 230-95, requires that ground-fault protection of equipment be provided for service disconnecting means rated 1,000 amperes or more on solidly grounded wye electrical services of more than 150 volts to ground, but not exceeding 600 volts phase-to-phase. The ground-fault protection must operate automatically to open the service disconnecting means in the presence of a ground fault.

If the switch is provided with an automatically operable mechanism acceptable for use with ground fault protection, the sensors, or relaying equipment, or a combination of the above, may be in a separate enclosure. The switch shall be marked with instructions indicating the proper interconnections.

There is an exception in the *National Electrical Code* to 230-95 for continuous industrial processes. Installations that meet the exception and the other ratings included in this publication are suitable for use as service equipment when the requirements of 2.4.1 are met.

2.4.3 Provisions for Bonding

When an insulated neutral is provided, a main bonding jumper consisting of a separate screw, connector strap, or other means shall be provided to bond it to the enclosure of an enclosed switch that is suitable for use as service equipment to the insulated grounded circuit conductor (the insulated neutral) of an ac circuit. The bonding means shall be of copper or aluminum, except as listed in the notes to Table 2-6; and shall have a cross-sectional area as indicated in Table 2-6.

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

2.4.4 Service Disconnect Marking

(See 5.4.2, items h and i, and 5.4.3, items o and p.)

2.5 NUMBER OF SWITCHING POLES AND WIRES

Switches have configurations according to: (1) the number of main circuit contacts (poles) that can be opened and closed by operating the switch; and (2) the total number of main supply conductors (wires).

A switch with a solid neutral has provisions for one more supply conductor than the number of poles.

Example (1): a "3 Pole Switch" has 3 switching poles and no neutral.

Example (2): a "3 Pole 4 Wire" has 3 switching poles plus a solid neutral.

Example (3): a "3 Pole (Including Switched Neutral) Switch" has 2 normal switching poles and one neutral switching pole.

Switches are normally supplied with 1, 2, 3, or 4 Poles, with or without a solid neutral.

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Table 2-6
SIZE OF GROUNDING ELECTRODE CONDUCTOR AND MAIN BONDING JUMPER

Ampere Rating Not Exceeding	Size of Main Bonding Jumper (Minimum)*, §§		Cross Section of Main Bonding Jumper in Square Inches (mm^2) (Minimum)*, §§				Size of Grounding Electrode Conductor (Minimum)	
	Copper	Aluminum	Copper		Aluminum		Copper	Aluminum
60	8 AWG	6 AWG	0.013**	(8.4)**	0.021**	(13.5)**	8 AWG	6 AWG
100	6	4	0.021**	(13.5)**	0.033**	(21.3)**	6	4
200	4	2	0.033†	(21.3)†	0.052†	(33.5)†	4	2
400	0††	3/0††	0.083§ ††	(53.5)§ ††	0.132§ ††	(85.2) § ††	0††	3/0††
600	2/0	4/0	0.105	(67.7)	0.166	(107)	2/0	4/0
800	2/0	4/0	0.105	(67.7)	0.166	(107)	2/0	4/0
1000	3/0	250 kcmil	0.132	(85.2)	0.196	(126)	3/0	250 kcmil
1200	250 kcmil	250	0.177	(114)	0.196	(126)	3/0	250
1600	300	400	0.236	(152)	0.294	(190)	3/0	250
2000	400	500	0.294	(190)	0.353	(228)	3/0	250
2500	500	700	0.353	(228)	0.515	(332)	3/0	250
3000	600	750	0.412	(266)	0.589	(380)	3/0	250
4000	750	1000	0.589	(380)	0.810	(523)	3/0	250
5000	900	1250	...	...	0.957	(617)	3/0	250
6000	1250	1500	...	...	1.178		3/0	250

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

** A No. 8 or larger brass or No. 10 or larger steel screw shall be permitted to be used.

† A No. 10 or larger brass or steel screw shall be permitted to be used.

†† When the ampere rating is 400 amperes and the wire terminal connectors for the main service conductors are acceptable for two No. 3/0 AWG copper or No. 250 kcmil aluminum conductor but will not accept a 600 kcmil conductor, these values shall be permitted to be reduced to No. 2 AWG (0.052 sq. in.) (33.6 mm^2) copper or No. 0 AWG (0.083 sq. in.) (53.6 mm^2) aluminum.

§ A ¼ (6.4 mm) diameter or larger brass or steel screw shall be permitted to be used.

§§ For equipment that is rated 1200 amperes and that has wiring terminals 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(s) of the same material (copper or aluminum) for any phase.

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2.6 CONSTRUCTION

2.6.1 General

The design and construction of the operating mechanism shall be such as to assure ample strength and rigidity. Screws and nuts serving to attach operating parts to cross bars or other movable members shall be upset or otherwise locked to prevent loosening under the jarring of continued use. Stops shall be provided if required to remove undue strain from switch parts. Materials shall be suited for the particular application. All metal parts, unless of corrosion resistant material, shall be galvanized, plated enameled, painted, or otherwise treated to prevent corrosion.

2.6.2 Operating Handle

A suitable handle shall be provided for safety and convenient operation of the switch. An operating handle of conducting material shall be in electrical connection with the enclosure. A metal rod using the wall of the enclosure as a bearing shall be considered to be in electrical connection with the enclosure.

In the case of a pullout switch, an operating handle shall be so constructed that it is insulated from electrical contact with any live part when the pullout switch member is in any installed position.

If the position of the switch contacts is indicated by the position of the operating handle, there shall be definite off and on indicated positions for the handle, and the design 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. Switch contacts shall be capable of being opened manually with the operating handle after the tests specified in 4.2. If handle movement is vertical, the upper position shall be on.

A handle or other member that indicates the position of the switch blades or contacts (closed or open) shall be designed so that the door, front, or cover cannot be closed and secured in place in the intended manner with the handle or member indicating off when the switch blades or contacts are in the closed position. When the handle on a heavy duty switch is moved to its full off position, it shall be capable of positively operating the contacts to their off position without requiring spring assistance.

2.6.3 Operating Mechanism

Means other than friction or gravity shall be provided to hold a heavy duty switch in the on or off position.

Heavy duty switches rated 30 through 1200 amperes shall be designed for independent manual operation. The design of the operating mechanism in conjunction with the contact structure shall be such that, in normal operation, the persons operating the switch cannot restrain the operation of the contacts after they have initially touched or parted when closing or opening the switch.

A general or heavy duty double throw switch so designed that it will tend to close by gravity shall be provided with suitable means for holding the operating mechanism in the off position.

In an enclosed pullout switch, there shall be no interference between the recessed ends of the recessed female contact and the male blade of a removable member that will stop insertion of blades of the removable member at any angle of approach permitted by the construction.

A detachable pullout switch member shall not be insertable in a holder for a detachable pullout switch member that has a lower current rating, and shall not be interchangeable with a member intended to accept a different class of fuse.

Exception: A class H fuseholder shall also be permitted to accept a Class K or Class R fuse.

A pullout switch shall be of a type that indicates whether the circuit is open or closed. There shall be an off position with the pullout member installed in the base. When the pullout member is installed in the off position, it shall be retained in place by the door when the door is closed and latched, or other means shall

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be provided to retain the pullout member in place. Removal of fuses, or simply removing a detachable pullout member, shall not be depended on to accomplish the off position.

2.6.4 Mechanical Interlock

Heavy duty switches rated 30 through 1200 amperes and having a Type 1, 3, 3R, 5, 12, 12K, or 13 enclosure shall have the box, cover, and switch operating mechanism mechanically interlocked so that the main cover of the cabinet (and, if provided, an auxiliary cover giving access to the main fuses); (1) is normally prevented from being opened when the switch contacts are in the closed position; and (2) the switch contacts are normally prevented from being closed when the main or auxiliary cover of the switch cabinet is open.

Interlocks for heavy duty switches shall be permitted to be provided with an interlock release by which a qualified person (1) using a tool can open the main or auxiliary cover to inspect the switch in the on position, (2) can close the contacts with the door open. Such interlocking is not necessary for enclosures where the use of tools is required to open the cover.

2.6.5 Padlocking

Means shall be provided for padlocking enclosure doors shut.

Means shall be provided to positively lock the switch with the contacts in the off position with a padlock. In the case of a heavy duty switch, such means shall accommodate at least three padlocks with hasp diameters within the range of 3/16 inch (4.762 mm) through 5/16 inch (7.938 mm). Any single padlock shall be capable of providing locking. A switch marked for isolating use only shall have provision for locking a switch in the on position.

2.6.6 Accessibility of Fuses

The design and construction of an enclosed single throw switch and the location of fuses shall be such that the fuses will be readily accessible when the switch contacts are open so that they can 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 not be energized when the switch contacts are open.

A plug fuse is considered accessible if when the switch is in the full off position, a test gauge 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 1/2 inch (12.7 mm).

A plug fuse test gauge is to be in the form of a plug fuse having dimensions specified for plug fuses and having an overall height of 1-3/4 inches > (44.5 mm) and a diameter of 1-1/4 inches > (3.18 mm) at the section above the male screw shell.

A double throw switch that is installed as a transfer device between two sources of power with common load that has energized fuses when the switch is in the off position must be disconnected from both sources before changing fuses. The switch shall be marked per ee of 5.4.3.

2.6.7 Accessibility of Live Parts

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

A live part shall not be considered to be exposed to unintentional contact if it is recessed 1/8 inch (3.2 mm) or more from the plane of an opening having at least one dimension not greater than 3/8 inch (9.6 mm). An opening, the smallest dimension of which is more than 3/8 inch (9.6 mm) but not more than

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11/16 inch (17.5 mm), shall be acceptable if the live part is recessed no less than twice the difference between such opening dimension and 5/32 inch (4.0 mm).

2.7 PULLOUT SWITCH ENCLOSURES

The enclosure of a pullout switch shall enclose completely all current-carrying parts, when a detachable pullout member is in the installed position. A pullout switch member shall be so constructed that no live parts will be exposed to unintentional contact by the operator when the detachable or hinged pullout member is in any position. The enclosure shall include a deadfront shield that will allow access to a switch handle without exposing live parts of the wiring.

2.8 SPACINGS

2.8.1 General

Except as otherwise noted in this clause, the spacings in an enclosed switch shall be as indicated in Table 2-7. Grounded metal includes the enclosures and any metal that is in electrical connection with the enclosure.

Table 2-7
MINIMUM SPACINGS, INCHES (mm)

Voltage Between Parts Involved	Between Uninsulated Live Metal Parts of Opposite Polarity		Between Uninsulated Live Metal Parts and Any Grounded Metal	
	Over Surface	Through Air	Over Surface	Through Air
0–125	3/4 (19.05)	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)
126–250	1-1/4 (31.75)	3/4 (19.05)	1/2 (12.7)	1/2 (12.7)
251–600	2 (50.8)	1 (25.4)	1 (25.4)	1/2 (12.7)

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 shall be permitted to be less than those indicated in the foregoing table 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 3/4 inches (19.05 mm). However, such spacings shall not be less than 1/4 inches (6.35 mm) in any case.

A four-wire switch having three blades and a solid neutral rated 240 volts and designed for use on a three-phase four-wire 208Y/120-volt circuit shall be permitted to have 125-volt spacings between uninsulated metal parts connected to the neutral and those connected to any of the other three lines.

The spacings in the foregoing table shall not be required to be maintained between switch blades and the enclosure cover when the switch if in the off position and the blades are not energized, but such spacing shall be not less than 1/8 inch (3.175 mm).

There shall be a spacing of not less than 1/8 inch (3.175 mm) between line and load terminals of the same polarity.

Compression lugs and pressure wire connectors shall be prevented from turning to the extent that spacing would be reduced to less than those in the Table 2-7, except that, if such minimum or greater spacings are maintained when the lugs are turned 30 degrees toward each other or toward other uninsulated live or grounded metal parts, no means to prevent turning need to be provided.

2.8.2 Between Live Parts and Bushings in Knockouts

The spacings in an enclosed switch between uninsulated current-carrying parts and bushings installed in at least two usable knockouts shall be in accordance with 2.3.1. For the purpose of measurement, it shall be assumed that required bushings having the dimensions shown in Table 2-8 are in place and that no

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locknuts are used between the enclosure wall and bushings. Also, for the purpose of measurement, the conduit size shall be the minimum required for the maximum number and gauge of wires necessitated by the switch rating. Switches provided without knockouts shall have adequate room for installation of conduit and fittings.

Table 2-9 shall be used as a guide for conduit sizes for three- and four-wire systems using 60°C or 75°C copper or aluminum conductors.

Table 2-8
BUSHING DIMENSIONS

Trade Size of Conduit (Inches)	Bushing Dimensions Inches (mm)	
	Overall Diameter	Height
1/2	1 (25.4)	3/8 (9.5)
3/4	1-15/64 (31.4)	27/64 (10.7)
1	1-19/32 (40.5)	32/64 (13.1)
1-1/4	1-15/16 (49.2)	9/16 (14.3)
1-1/2	2-13/64 (56.0)	19/32 (15.1)
2	2-45/64 (68.7)	5/8 (15.9)
2-1/2	3-7/32 (81.8)	3/4 (19.1)
3	3-7/8 (98.4)	13/16 (20.6)
3-1/2	4-7/16 (112.7)	15/16 (23.8)
4	4-31/32 (126.2)	1 (25.4)
4-1/2	5-35/64 (140.9)	1-1/16 (27.0)
5	6-7/32 (158.0)	1-3/16 (30.2)
6	7-7/32 (184.0)	1-1/4 (31.8)

2.8.3 Pullout Switches

Spacings in pullout switches shall be measured with the removable member in both the full on and off positions.

2.9 TERMINALS

2.9.1 General

A switch shall have suitable wiring terminals for the connection of conductors having an ampacity not less than the current rating of the device except as noted in the following exceptions. In addition, the terminals of a switch having a horsepower rating shall be capable of accommodating conductors having an ampacity equal to 125 percent of the motor-running current corresponding to the horsepower rating. A wiring terminal shall be provided with a pressure wire connector sized per conductors shown in Table 2-10.

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Table 2-9
TRADE SIZE OF METALLIC CONDUIT OF TUBING BASED ON NEC CHAPTER 9

Table 1 for 40% fill and tables 3A, 3B, & 4—refer to NEC Chapter 9 for maximum number of conductors in trade sized of metallic conduit or tubing, properties of conductors must agree with NEC Chapter 9, Table 8. Dimensions of insulated conductors per NEC Chapter 9 (Table 5 for copper, Table 5A for aluminum THW, THHN, XHHW)
(underlined insulation type indicates dry and damp location only ratings)

Table 310-16 Ampacity Insulated Copper	CU Wire Size AWG kcmil	(75°F) (167°F) *THW *RHW Use Without Outer Covering		CU Wire Size AWG kcmil	75°C (167°F) *THWN, *XHHW		CU Wire Size AWG kcmil	90°C (194°F) FEP (14-2) *THHN FEPB (14-8), *XHHW	
		Conduit 3W	Conduit 304W		Conduit 3W	Conduit 304W		Conduit 3W	Conduit 304W
15	14†	1/2	1/2	#14†	1/2	1/2	...	...	...
15	...	...	...	...	...	...	#14†	1/2	1/2
20	12†	1/2	1/2	#12†	1/2	1/2	...	...	...
20	...	...	...	...	...	...	#12†	1/2	1/2
30	10†	1/2	1/2	#10†	1/2	1/2	...	...	...
40	...	...	...	...	...	...	10†	1/2	1/2
50	8	3/4	1	#8	1/2	3/4	...	...	...
55	...	...	...	...	...	...	#8	1/2	3/4
65	#6	1	1	#6	3/4	3/4	...	...	...
75	...	...	...	...	...	...	#6	3/4	3/4
85 (100*)	#4	1	1-1/4	#4	1	1	...	...	...
95 (100*)	...	...	...	...	...	...	#4	1	1
100 (110*)	#3	1-1/4	1-1/4	#3	1	1-1/4	...	...	...
110	...	...	...	...	...	...	#3	1	1-1/4
115 (125*)	#2	1-1/4	1-1/4	#2	1	1-1/4	...	...	...
130 (125*)	...	...	...	...	...	...	#2	1	1/4
130 (150*)	#1	1-1/4	1-1/2	#1	1-1/4	1-1/2	...	...	...
150 (150*)	...	...	...	...	...	...	#1	1-1/4	1-1/2
150 (175*)	1/0	1-1/2	2	1/0	1-1/4	1-1/2	...	...	...
170 (175*)	...	...	...	...	...	...	1/0	1 1/3	1-1/2
175 (200*)	2/0	1-1/2	2	2/0	1-1/2	2	...	...	...
195 (200*)	...	...	...	...	...	...	2/0	1-1/2	2
200	3/0	2	2	3/0	1-1/2	2	...	...	...
225	...	...	...	...	...	...	3/0	1-1/2	2
230	4/0	2	2-1/2	4/0	2	2	...	...	...
255	250	2-1/2	2-1/2	250	2	2-1/2	...	...	...
260	...	...	...	...	...	...	4/0	2	2
285	300	2-1/2	3	300	2	2-1/2	...	...	...
290	...	...	...	...	...	...	250	2	2-1/2
310	350	2-1/2	3	350	2-1/2	3	...	...	...
320	...	...	...	...	...	...	300	2	2-1/2
335	400	3	3	400	2/1/2	3	...	...	...
350	...	...	...	...	...	...	350	2-1/2	3
380	...	...	...	...	...	...	400	2-1/2	3
380	500	3	3-1/2	500	3	3	...	...	...
420	600	3	3-1/2	600	3	3-1/2	...	...	...
430	...	...	...	...	...	...	500	3	3
460	700	3-1/2	4	700	3	3-1/2	...	...	...
475	750	3-1/2	4	750	3-1/2	4	600	3	3-1/2
520	...	...	...	...	...	...	700	3	3-1/2
535	...	...	...	...	...	...	750	3-1/2	4

See page 23 for explanation of table references

(Table continued next page.)

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Table 2-9 (Continued)
TRADE SIZE OF METALLIC CONDUIT OF TUBING BASED ON NEC CHAPTER 9

Table 310-16 Ampacity Insulated Aluminum	All Wire Size AWG kcmil	75°C (167°F) *THW Conduit 3W	75°C (167°F) *THW Conduit 304W	Table 310-16 Ampacity Insulated Copper	All Wire Size AWG kcmil	75°C (167°F)* THWN, *XHHW Conduit 3W	75°C (167°F)* THWN, *XHHW Conduit 304W	All Wire Size AWG kcmil	+ 90°C (194°F) *THHN, *XHHW Conduit 3W	+ 90°C (194°F) *THHN, *XHHW Conduit 304W
...	...	...	...	15	...	...	...	...	...	...
...	...	...	...	15	...	...	...	...	...	...
...	...	...	...	20	...	...	...	...	...	...
...	...	...	...	20	...	...	...	...	...	...
...	...	...	...	30	...	...	...	...	...	...
35	...	...	...	40	...	...	...	...	...	...
40	8	3/4	3/4	50	#8	1/2	3/4	...	...	...
45	...	...	...	55	...	...	...	...	...	...
50	#6	3/4	3/4	65	#6	3/4	3/4	...	...	...
60	...	...	...	75	...	...	...	#6	3/4	3/4
65	#4	1	1	85 (100*)	#4	1	1	...	...	...
75	...	...	...	95 (100*)	...	...	...	#4	1	1
75	...	...	1	100 (110*)	...	...	...	...	...	...
85	...	...	...	110	...	...	...	...	...	...
90 (100*)	#2	1	...	115 (125*)	#2	1	1-1/4	...	...	...
100 (100*)	...	...	...	130 (125*)	...	...	...	#2	1	1-1/4
100 (100*)	#1	1-1/4	1-1/4	130 (150*)	#1	1-1/4	1-1/4	...	...	...
115 (110*)	...	...	...	150 (150*)	...	...	...	#1	1-1/4	1-1/4
120 (125*)	1/0	1-1/4	1-1/2	150 (175*)	1/0	1-1/4	1-1/2	...	...	...
135 (125*)	...	...	...	170 (175*)	...	...	...	1/0	1-1/4	1-1/2
135 (150*)	2/0	1-1/2	2	175 (200*)	2/0	1-1/4	1-1/2	...	...	...
150 (150*)	...	...	...	195 (200*)	...	...	...	2/0	...	1-1/2
155 (175*)	3/0	1-1/2	2	200	3/0	1-1/2	2	...	...	...
175 (175*)	...	...	...	225	...	...	...	3/0	1-1/2	2
180 (200*)	4/0	2	2	230	4/0	1-1/2	2	...	...	...
205	250	2	2-1/2	255	250	2	2	...	...	...
205 (200*)	...	...	...	260	...	...	...	4/0	1-1/2	2
230	300	2	2-1/2	285	300	2	2-1/2	...	...	...
230	...	...	...	290	...	...	...	250	...	...
250	350	2-1/2	3	310	350	2	2-1/2	...	...	...
255	...	...	...	320	...	...	...	300	2	2-1/2
270	400	2-1/2	3	335	400	2-1/2	3	...	...	...
280	...	...	...	350	...	...	...	350	2	2-1/2
305	...	...	...	380	...	...	...	400	2-1/2	3
310	500	3	3	380	500	2-1/2	3	...	...	...
340	600	3	3-1/2	420	600	3	3	...	...	...
350	...	...	...	430	...	..	...	500	2-1/2	3
375	700	3	3-1/2	460	700	3	3-1/2	...	...	...
385	750	3	3-1/2	475	750	3	3-1/2	600	3	3
420	...	...	...	520	...	...	...	700	3	3-1/2
435	...	...	...	535	...	...	...	750	3	3-1/2

See page 23 for explanation of table references

(Table continued next page.)

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Table 2-9 (concluded)
AMPACITY CORRECTION FACTORS

For ambient temperatures other than 30°C (86°F), multiply the ampacities shown by the appropriate factor shown below.

Ambient Temp. °C	60°C (140°F)	75°C (167°F)	90°C (194°F)	Ambient Temp. °F	60°C (140°F)	75°C (167°F)	90°C (194°F)
21-25	1.08	1.05	1.04	70-77	1.08	1.05	1.04
26-30	1.00	1.00	1.00	79-86	1.00	1.00	1.00
31-35	0.91	0.94	0.96	88-95	0.91	0.94	0.96
36-40	0.82	0.88	0.91	97-104	0.82	0.88	0.91
41-45	0.71	0.82	0.87	106-113	0.71	0.82	0.87
46-50	0.58	0.75	0.82	115-122	0.58	0.75	0.82
51-55	0.41	0.67	0.76	124-131	0.41	0.67	0.76
56-60	...	0.58	0.71	133-140	...	0.58	0.71
61-70	...	0.33	0.58	142-158	...	0.33	0.58
71-80	...	...	0.41	160-176	...	...	0.41

*Ratings for three-wire, single-phase residential service entrance conductors and three-wire, single-phase feeder that carries the total current supplied by that service, (NEC Note 3 to Table 310-16 for conductor types RHH, RHW, THW, THWN, THHN, XHHW). The grounded service entrance conductor (neutral) may be two AWG sizes smaller than the ungrounded conductors provided the requirement of NEC 230-42(c) and 250-23(b) are met.

On a 4-wire, 3-phase wye circuit where the major portion of the load consists of electric discharge lighting, data processing, or similar equipment derate ampacities to 80 percent per notes 8 and 10 to NEC Table 310-16.

&#6 XHHW copper requires 1" conduit for 304W.
#8 XHHW copper requires 1/4" conduit for 3W.

Special 90°C rating for THW (14-8) within electric discharge lighting equipment per NEC Article 410-31 and Table 310-13.

+ For panelboard circuits, wire size should be no smaller than shown above for 75°C wire. 90°C wire should be used for locations where ambient temperature above 30°C (86°F) is expected, and then derated per correction factors in NEC Table 310-16.

†The overcurrent protection for these conductor types shall not exceed 15 amperes for 14 AWG, 20 amperes for 12 AWG, and 30 amperes for 10 AWG copper after any correction factors for ambient temperatures and number of conductors have been applied. (These are the values shown in this table.)

NEC 220-3 (a) Continuous and Noncontinuous Loads.

The branch-circuit rating shall not be less than the noncontinuous load plus 125 percent of the continuous load. (See exceptions in NEC.)

NEC 220-10(b) Continuous and Noncontinuous Loads.

Where a feeder supplies continuous loads of any combination of continuous and noncontinuous loads, the ratings of the overcurrent device shall not be less than the noncontinuous load plus 125 percent of the continuous load.

The ampacity of the ungrounded service conductor shall not be less than the noncontinuous load plus 125 percent of the continuous load. (See exceptions in NEC.)

NEC 430-22 (a) Single Motor Circuit Conductors.

Branch circuit conductors supplying a single motor shall have an ampacity not less than 125 percent of the motor full-load current rating. (See exceptions in NEC.)

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It shall be assumed that field-installed conductors will be:

a. Wire rated at 75°C (167°F) in size 1/0 AWG and larger
b. Wire rated at 60°C (140°F) in sizes 1 AWG and smaller, except that 75°C (167°F) wire may be used if the switch is so marked
c. Aluminum wire at any terminal identified as being suitable for use with such wire

Exceptions:

a. A wire binding screw shall be permitted to be employed in place of a pressure wire connector at a wiring terminal intended for the connection of a No. 10 AWG or smaller solid copper conductor. Wire binding screws shall be provided with upturned lugs or the equivalent to retain the conductor under the head of the screw when the screw is loosened sufficiently to permit shifting of the conductor.

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

    1. Component terminal assemblies shall be available from the equipment manufacturer, or one or more suitable pressure terminal connectors shall be specified for field installation on the equipment.

    2. Fastening devices such as studs, nuts, bolts, spring washers, or flat washers, or both, and so forth, are required for effect installation, shall either be provided as a part of the component terminal assembly or be mounted on or separately packaged with the equipment.

    3. The installation of the terminal assembly shall not involve the loosening or disassembling 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.

    4. If the pressure wire 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.

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

    6. The equipment shall be marked in accordance with 5.4.3, item z.

c. A terminal may be omitted if:

    1. The switch is specifically designed to be used with such other equipment that the terminal is unnecessary.

    2. A suitable means such as a bus bar link or the equivalent is provided to connect the two pieces.

    3. Both pieces of equipment are marked in accordance with 5.4.3, item cc.

2.9.2 Wire Bending Space

Minimum wire bending spaces for enclosed switches are given in Table 2-10. The line or load wiring spaces shall not be required if the line or load connections are intended to be made using bus bars.

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2.9.3 Clear Wiring Space (Wire Gutter)

The space within the enclosure of a switch shall be sufficient to provide ample room for the distribution of wires and cables. The clear wiring space at any point, independent of all projections and obstructions, and free from interference from moving parts of the switching mechanism shall be not less in width and depth than the values given in Table 2-11 and shall be not less in cross-sectional area than 250 percent of the total cross-section area of the maximum number of wires that may be used in such a space. The minimum areas of the clear wiring space for some of the more common multiple wires shall be in accordance with Table 2-11.

2.10 Fuseholders

Fuseholders and fuse terminals shall be of the type to accommodate either cartridge enclosed or plug fuse type fuses.

2.10.1 Plug Fuse Type S Fuseholders

A Type S fuseholder shall accommodate only a Type S fuse.

A Type S fuse rated more than 15 amperes shall not be usable with a Type S fuseholder rated 15 amperes.

A Type S fuse rated more than 20 amperes shall not be usable with a Type S fuseholder rated 20 amperes.

There shall be no live parts exposed when a Type S fuse and fuseholder are installed and assembled together.

The contact-rejection member of a 20-ampere fuseholder shall not crack or distort when subjected to a torque of 20 1b-inch.

Just below the upper contact ring of a Type S fuseholder there shall be a hardened steel ring, as illustrated in Figure 2-1, that is protected against corrosion by a suitable metallic-plated coating. This ring shall provide approximately one complete female thread for engagement with the threaded portion of a fuse body; the pitch of the thread shall be the same as that of the threads in the molded insulating material, and the apex of the thread shall be serrated.

The dimensions of a Type S fuseholder shall be as specified in Figure 2-1.

A 20-ampere fuseholder shall incorporate a contact-rejection member such as a cup, either integral with the contact or secured under the contact, or a spacer. The dimensions of the fuseholder shall be as specified in Figure 2-1 with reference to this feature, and the cup or spacer shall be secured by suitable means that will prevent its being readily removed.

A Type S fuseholder shall, when tested with gauges* based on the dimensions given in Figure 2-1, go and no-go as applicable. The marked current rating of a Type S fuseholder shall be located so that it will be plainly visible after installation.

*Conversion Factor: 1 inch = 25.4 mm

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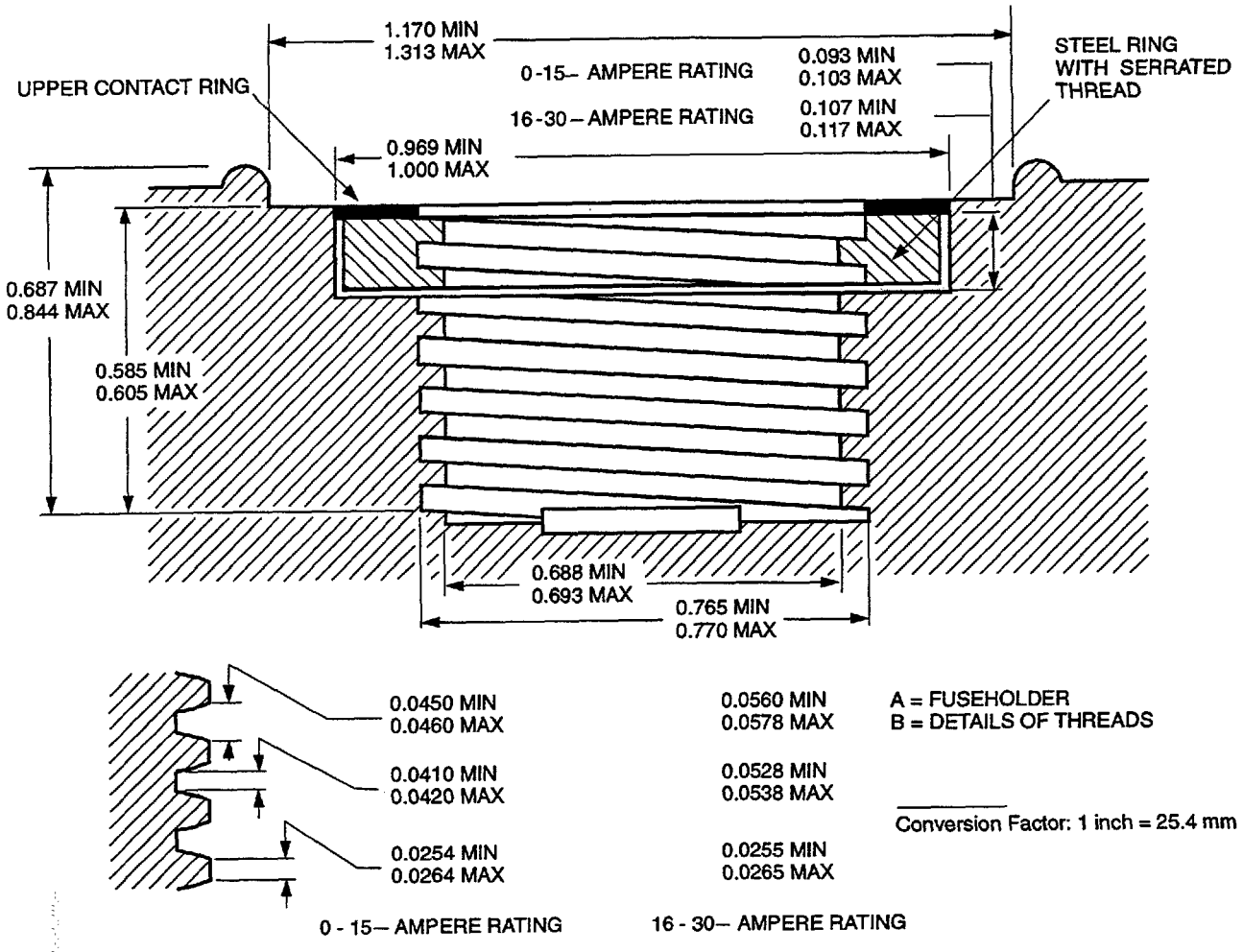


Figure 2-1
DIMENSIONS OF A TYPE S FUSEHOLDER, INCHES

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Table 2-10
MINIMUM WIRE BENDING SPACE FOR ENCLOSED SWITCHES
(Based on the NEC)

Copper Wire					Aluminum Wire				
Switch Nameplate Rating Amperes	60°C Wire	75°C Wire	Ampacity	Wire Bending Space, Inches	60°C Wire	75°C Wire	Ampacity	Wire Bending Space, Inches	Switch Nameplate Rating, Amperes
30*	1–#10	...	30	Not specified except as noted	1–#8	...	30	1-1/2	30*
30*	1–#10	...	35	Not specified except as noted	...	1–#8	40	1-1/2	30*
60	1–#4	...	70	3	1–#3	...	65	3	60
60	...	1–#6	65	2	...	1–#4	65	3	60
100	1–#1	...	110	4-1/2	1–1/0	...	100	5-1/2	100
100	...	1–#3	100	3	...	1–#1	100	4-1/2	100
200	...	1–3/0	200	6-1/2 [1/2]**	...	1–250 kcmil	205	8 -/2 [2] **	200
400†	...	2–4/0	460	7-1/2 [1-1/2] **	...	2–300 kcmil	460	10 [2] **	400†
600	...	2–350 kcmil	620	12 [3] **	...	2–500 kcmil	620	14 [3] **	600
800	...	3–300 kcmil	855	11 [1] **	...	3–400 kcmil	810	14 [3] **	800
1200	...	4–350 kcmil	1240	14 [2] **	...	4–500 kcmil	1240	16 [3] **	1200
1600	...	5–400 kcmil	1675	15 3**	...	5–600 kcmil	1700	19 3**	1600
2000	...	6–400 kcmil	2010	15 3**	...	6–600 kcmil	2040	19 3**	2000
2500	...	6–600 kcmil	2520	19 3**	...	8–600 kcmil	19	19 3**	2500
3000	...	9–400 kcmil		15 3**	...	10–500 kcmil		16 3**	3000
4000	...	12–400 kcmil		15 3**	...	13–500 kcmil		16 3**	4000
5000	...	15–400 kcmil		15 3**	...	16–500 kcmil		16 3**	5000
6000	...	18–400 kcmil		15 3**	...	19–500 kcmil		16 3**	6000

*Wire Bending Space and terminals for line connections for 30 ampere switches marked suitable for use as service equipment shall be 1-1/2" for No. 8 copper or 2" for No.6 aluminum.

**For removable and lay-in wire terminals intended for only one wire, bending space shall be permitted to be reduced by the number of inches shown in parentheses.

†For ampere rated 400-ampere switches (with no horsepower rating) wire bending space is permitted to be 6-1/2" for (2) 3/0 copper conductors or 8-1/2" for (2) 250 Kcmil aluminum conductors.

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Table 2-11
WIRING SPACE

Maximum Size of Wire or Cable	Minimum Width and Depth of Wiring Space		Minimum Areas in Square Inches (mm^2) Required for Multiple Wires Based on Factor of 2.5											
			Two Wires		Three Wires		Four Wires		Five Wires		Six Wires		Seven Wires	
Involved	Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm	Inch	mm
10AWG	3/8*	9.5	0.23	148	0.34	210	0.48	297	0.57	368	0.68	439	0.80	516
8	1/2	12.7	0.43	277	0.64	413	0.85	548	1.07	690	1.26	825	1.50	968
6	5/8	15.9	0.62	400	0.83	600	1.24	800	1.56	1000	1.96	1200	2.17	1400
4	3/4	19.1	0.80	516	1.20	774	1.80	1032	2.00	1290	2.40	1548	2.80	1808
3	3/4	19.1	0.91	587	1.36	877	1.82	1174	2.27	1465	2.27	1756	3.18	2052
2	7/8	22.2	1.03	665	1.56	1000	2.06	1329	2.58	1665	3.10	2000	3.61	2329
1	1	25.4	1.36	877	2.04	1316	2.72	1756	3.40	2194	4.08	2632	4.76	3071
1/0	1	25.4	1.55	1000	2.33	1503	3.10	2000	3.88	2503	4.66	3006	5.43	3503
2/0	1	25.4	1.79	1155	2.68	1729	3.58	2310	4.47	2884	5.38	3458	6.29	4039
3/0	1-1/8	28.6	2.06	1342	3.11	2006	4.16	2684	5.19	3348	6.22	4013	7.27	4690
4/0	1-1/4	31.8	2.42	1561	3.62	2342	4.84	3123	6.05	3903	7.26	4684	8.47	5465
250kcmil	1 3/8	34.9	2.06	1910	4.44	2885	5.92	2885	7.40	4774	8.88	5729	10.36	6684
300	1-1/2	38.1	3.81	2456	5.72	3880	7.62	4916	8.55	5616	10.26	6619	11.96	7716
350	1-1/2	38.1	3.81	2458	5.72	3890	7.62	4916	9.53	6149	11.44	7381	13.34	8606
400	1-5/8	41.3	4.18	2997	6.27	4045	8.36	5384	10.45	8742	12.54	8090	14.53	9439
500	1-3/4	44.5	4.92	3174	7.38	4761	9.84	6348	12.30	7835	14.76	9623	17.22	11110
600	1-7/8	47.8	5.97	3882	8.96	5791	11.94	7703	14.93	9632	17.92	11561	20.90	12484
700	2	50.8	6.65	4310	10.02	6445	13.36	8619	16.70	10774	20.04	12929	23.38	15083
750	2	50.8	7.04	4542	10.56	6813	14.08	9084	17.60	11355	21.12	13626	24.64	15896
800	2-1/8	54.0	7.39	4768	11.09	7156	14.79	9635	18.48	11923	22.18	14310	25.87	16690
900	2-1/4	57.2	8.08	5219	12.13	7626	16.16	10439	20.22	13045	24.26	15652	28.31	18264
1000	2-1/4	57.2	8.77	5658	13.15	8484	17.54	11316	21.92	14142	26.30	16963	30.59	19800
1250	2-1/2	63.5	11.03	7116	16.56	10677	22.06	14232	27.56	17794	33.10	21355	38.61	24910
1500	2-3/4	69.6	12.74	8219	19.11	12329	25.48	16439	31.85	20548	38.22	24658	44.59	28758
1750	2-7/8	73.0	14.45	9323	21.87	13861	28.90	18645	36.12	23303	43.34	27961	50.57	32626
2000	3-1/8	79.4	16.04	10348	24.06	15523	32.08	20697	40.10	25871	48.12	31045	56.14	36219

*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 1/2 inch (12.7mm) in any case.

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2.10.2 Type S Fuse Adapters

The design of a Type S fuse adapter shall be such that when installed, only a Type S fuse can be accommodated.

A Type S fuse rated more than 15 amperes shall not be usable with a Type S fuse adapter rated 15 amperes.

A Type S fuse rated more than 20 amperes shall not be usable with a Type S fuse adapter rated 20 amperes.

The male screw shell of an adapter shall be formed from brass or copper alloy not less than 0.008 inches (0.2032 mm) thick.

Exception: A screw shell formed from metal nominally 0.008 inches (0.2032 mm) thick may be thinner after forming due to commercial tolerances in the thickness of metal and the possible deformation of the metal during the forming, but in no case shall the minimum thickness measured on the bottom or flat portion of the shell be less than 0.0065 inches (0.1651 mm).

The male screws shall be of the medium base size and shall, when tested with gauges made in conformity with the ANSI/UL Standard 512 go and no go as applicable.

A locking device provided as part of a Type S adapter shall be designed so that the adapter cannot be removed after it has been installed in an Edison base plug fuseholder. The design of a locking device is not specified.

If the lock employed is designed to engage the female shell of an Edison base plug fuseholder, it shall be located 7/16 ± 1/32 inches (11.11 ± 0.79 mm) from the plane of the outside center contact of the adapter.

Just below the upper contact surface of a Type S adapter, there shall be a hardened steel ring, as illustrated in Figure 2-2, that is protected against corrosion by a suitable metallic-plated coating. This ring shall provide approximately one complete female thread for engagement with the threaded portion of a fuse body, the pitch of the thread shall be the same as that of the threads in the molded insulating material, and the apex of the thread shall be serrated.

The dimensions of a Type S adapter shall be as specified in Figure 2-2.

A Type S adapter shall be so constructed that the female threaded portion will, when tested with gauges* made in conformance with ANSI/UL Standard 512 go and no go as applicable.

*Drawings of those gauges are available from Underwriters Laboratories, Inc.

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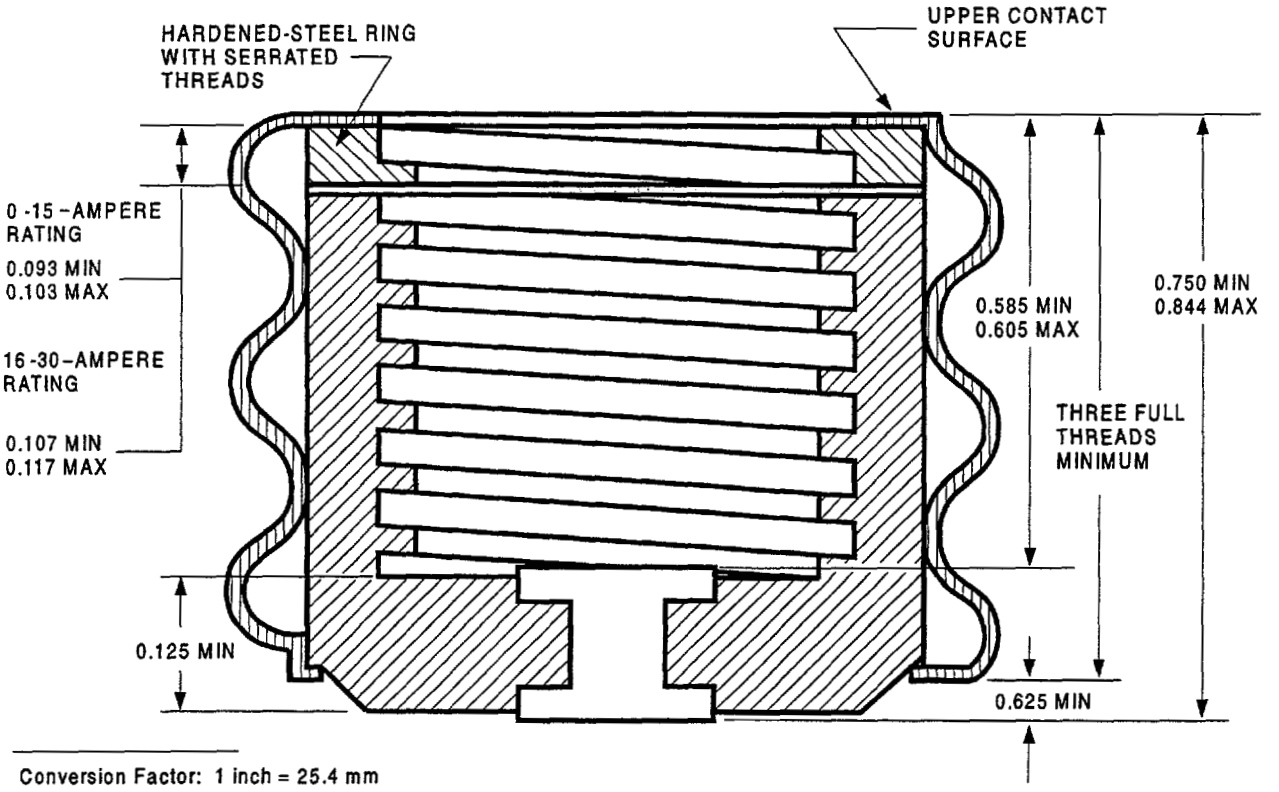


Figure 2-2
DIMENSIONS OF A TYPE S ADAPTER, INCHES

A 20-ampere adapter shall incorporate a contact-rejection member such as a cup, either integral with the contact or secured under the contact, or a spacer. The dimensions of the adapter shall be as specified in Figure 2-3 with reference to this feature, and the cup or spacer shall be secured by suitable means that will prevent it from being readily removed.

The marked current rating of a Type S adapter shall be located so that it will be plainly visible after the adapter is installed in an Edison-base fuseholder.

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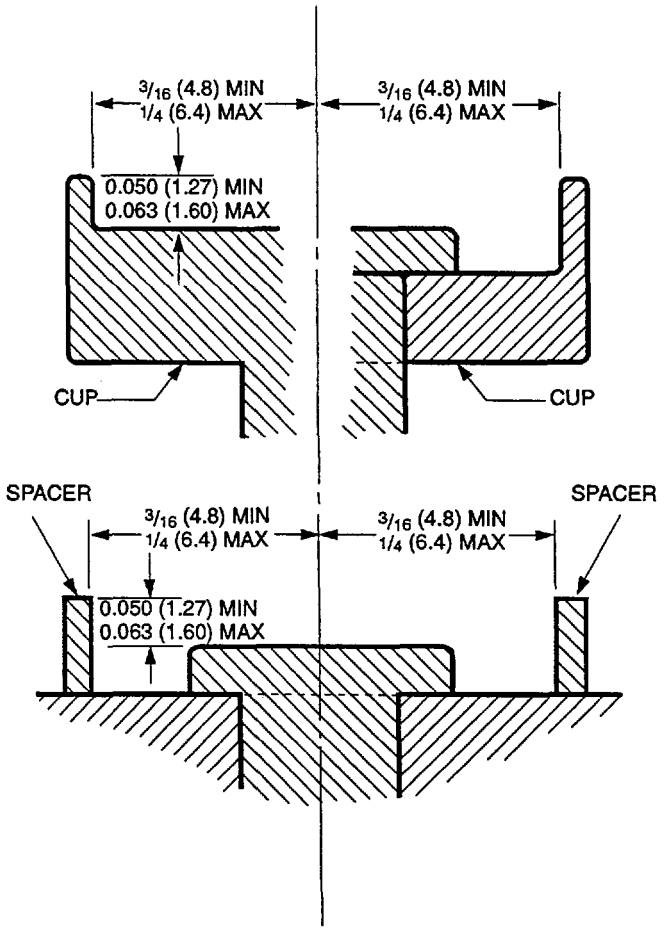


Figure 2-3
CONTACT-REJECTION CUP AND SPACER, INCHER (MM)

2.10.3 Cartridge Fuseholders Class CC, G, H, J, K, L, R, or T

The fuse contact clips of a cartridge fuseholder shall be constructed so that a reliable and adequate electrical contact with a fuse of the corresponding rating will be assured. Ferrule-contact clips shall be made of bronze or the equivalent, and knife-blade-contact clips shall be made of copper. End stops shall be provided to assure the proper location of a ferrule-type cartridge fuse in the contact clips.

The design of a fuseholder shall be such that it will reject a fuse having either: (1) a current rating greater than or (2) a voltage rating less than that of the fuse size for which it is intended. The values in the tables that specify fuseholder dimensions ensure that these conditions will be met.

Barriers, stops, and the like for Class L fuseholders that are provided to comply with the rejection feature requirement shall be substantial and not readily removable. They shall cause a displacement of an oversize fuse of not less than 3/4 inch (19.1 mm) as an indication that the misuse is obvious.

Parts of contact clips for knife-blade type fuses that are held in slots milled in the mounting piece shall fit together closely, shall be sweated with solder, and also shall be secured with one or more rivets or screws.

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Exception: For a 100-ampere fuseholder, the soldering and pinning shall be permitted to be omitted if the contact clips are forced through holes in the mounting piece to make a tight joint and are upset or riveted on the underside of the mounting piece.

The dimensions of a cartridge fuseholder, other than Class R, L, or CC shall be as specified in Tables 2-13, and Figures 2-4, 2-5, and 2-6, whichever are applicable.

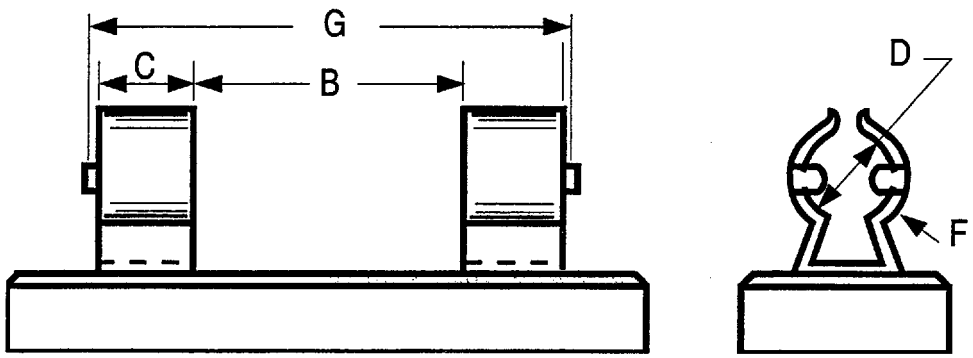


Figure 2-4
CARTRIDGE FUSEHOLDER—FERRULE CONTACT TYPE (EXCEPT CLASS R)

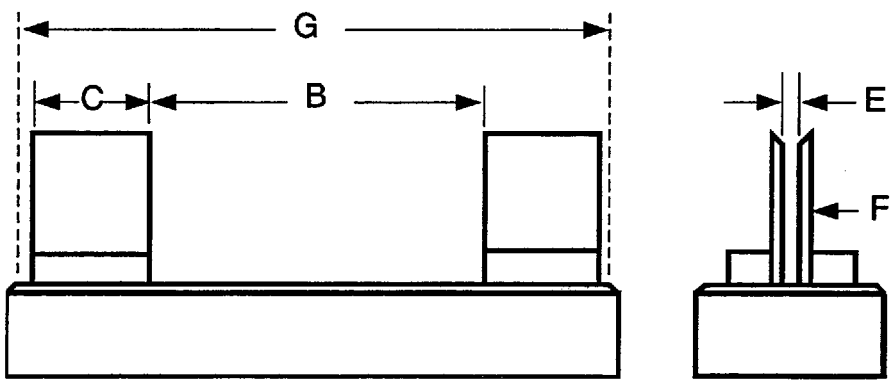


Figure 2-5
CARTRIDGE FUSEHOLDER—KNIFE BLADE TYPE (EXCEPT CLASS R)

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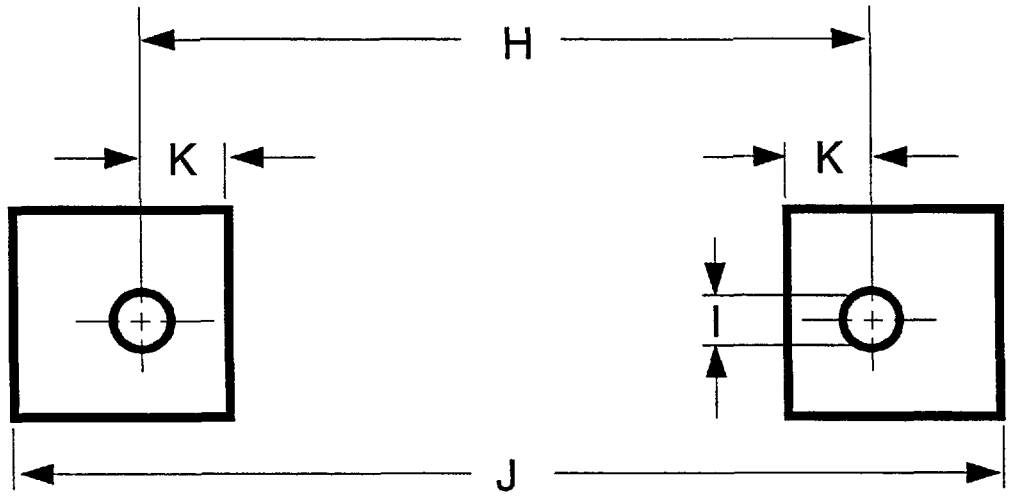


Figure 2-6
FUSEHOLDER—FUSE BOLTED IN PLACE, CLASS "J" OR "T"

Exception: A fuseholder with other constructions shall be acceptable if it has been shown by appropriate investigation to be suitable for the purpose.

The investigation shall include consideration of the ability of the fuseholder to accommodate a cartridge fuse of standard dimensions and to provide means for mounting the fuse securely in place without overheating or other evidence of unacceptable performance.

The dimensions of a cartridge fuseholder designed for Class CC fuses shall be as shown in Table 2-18 and Figure 2-10.

The dimensions of a cartridge fuseholder designed for a Class R fuse shall be the same as specified in Table 2-14. All other dimensions shall be the same as for Class H fuse.

A rejection member for Class R fuses shall have either the configuration illustrated in Figures 2-7 or 2-8, whichever is applicable, and the dimensions specified in Table 2-14.

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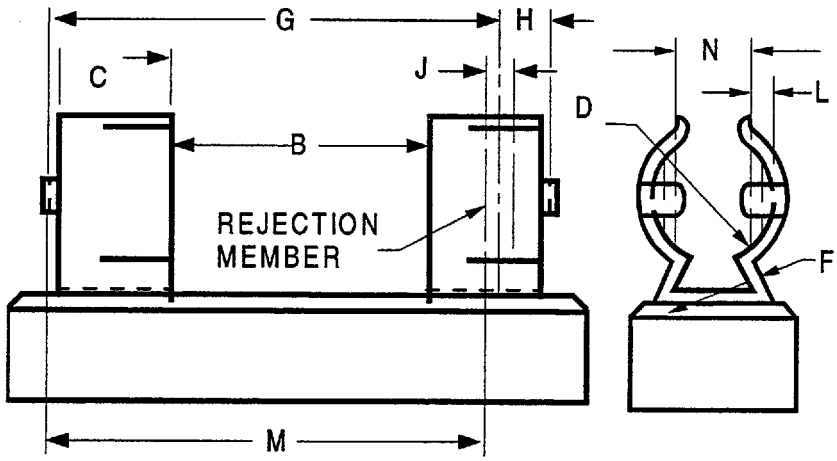


Figure 2-7
CLASS R FUSEHOLDER FERRULE CONTACT TYPE WITH REJECTION MEMBER

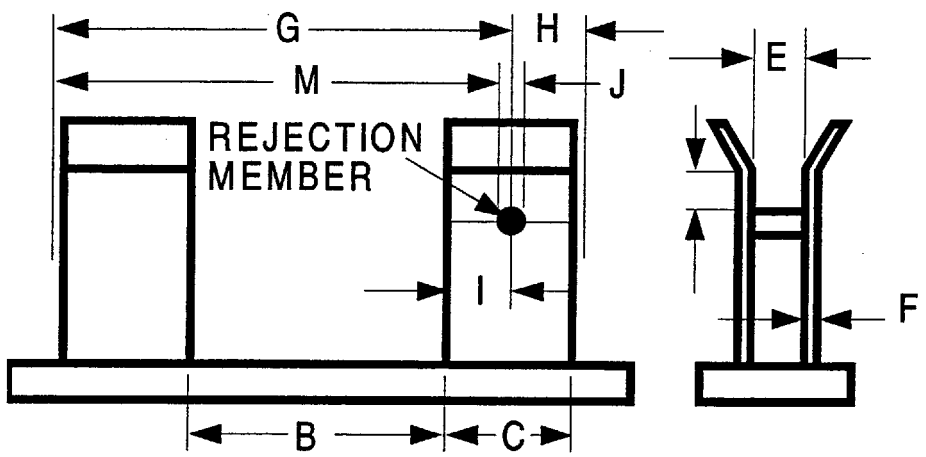
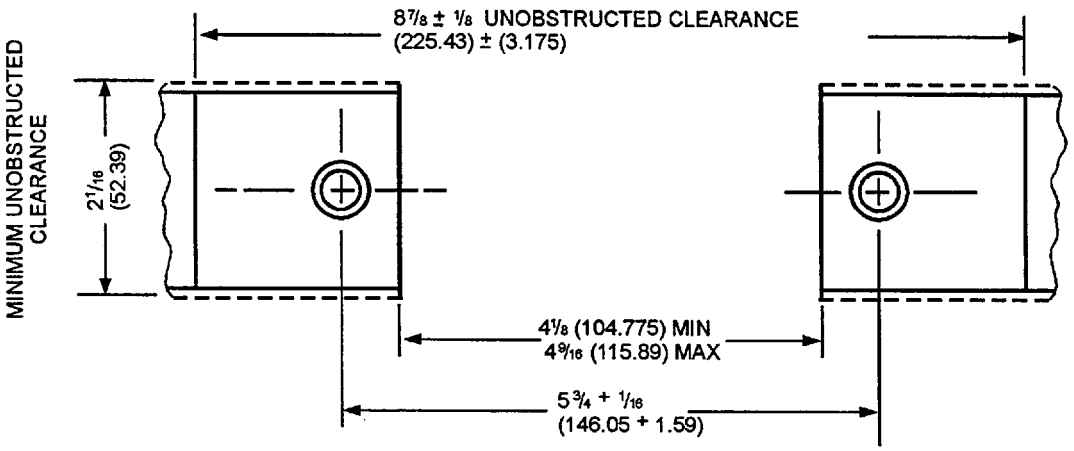
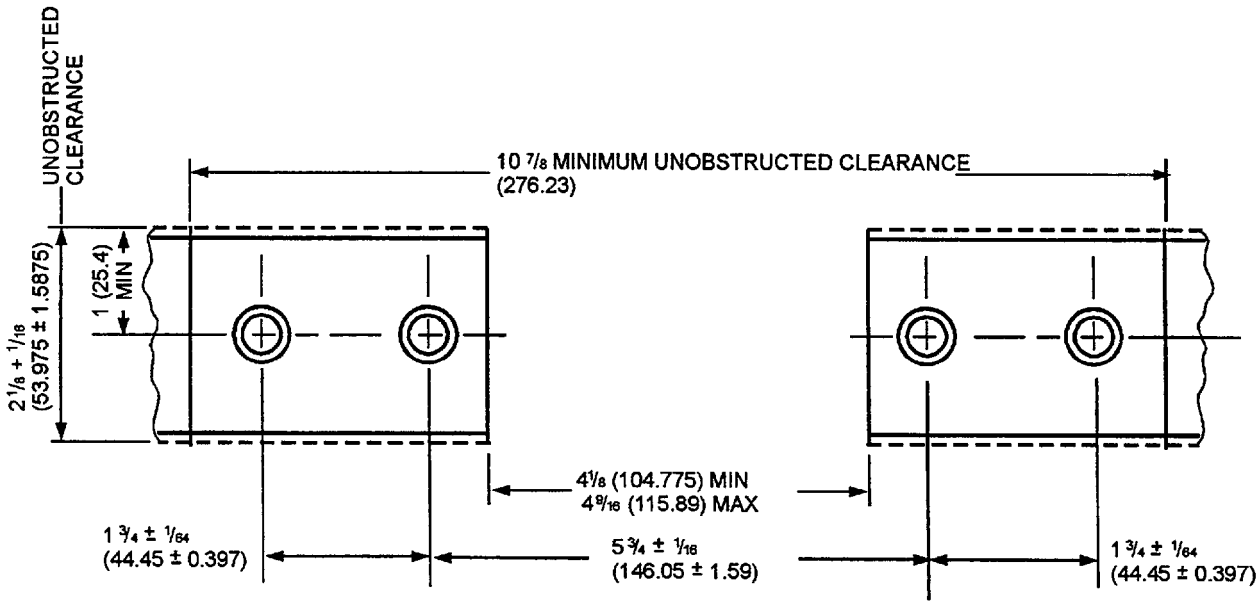


Figure 2-8
CLASS R FUSEHOLDER BLADE TYPE WITH REJECTION MEMBER

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800-AMPERE FUSE MOUNTING



1200-AMPERE FUSE MOUNTING

NOTE - A Rejection means to prevent the use of fuses having an ampere rating higher than the ampere rating of the switch must be incorporated in the design.

Figure 2-9
MOUNTING MEANS FOR 800—AND 1200 —AMPERE CLASS "L" FUSES

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If the end stops of a ferrule-type clip are formed from the metal of the clip itself, the construction shall be such that the effective width of the clip that will engage the ferrule of a fuse will be not less than the dimension specified in Column C of Table 2-13.

The length of the bolted contact of a fuse clip of the bent-up type that is screwed or bolted to a connecting strap or link, shall be not less than the full width of the fuse clip (see C in Table 2-13).

The fuse clips for 60-ampere, 250-volt, Class H fuseholders shall be permitted to be used for (1) a 30-ampere, 600-volt, Class H or K fuseholder if the distance between the clips (dimension B in Figure 2-4) is 3-3/4 inches and for (2) a 30-ampere, Class J fuseholder if that distance is one inch.

Minimum distances are specified between end stops for the knife-blade type of fuseholder because a fuseholder forming a part of an enclosed switch or service equipment is often designed so that the fuse sets into a well in porcelain or other insulating material. In order that a fuse of the maximum overall length may be inserted in the clips, it is necessary that the end walls that automatically form end stops have a certain minimum distance between them. No maximum end stop spacings are necessary for the knife-blade type of fuseholder, because the centering of the fuse is automatically taken care by the spacing between the contact clips, for other than Class T fuses. See Table 2-13, daggered note, for use of maximum spacing between end stops.

A fuseholder designed for a Class R or CC fuse shall be provided with a rejection member to prevent installation of fuses of other classes.

The rejection member in a fuseholder designed for a Class R fuse shall be permitted to consist of a pin, a bolt, or lancing of the clips. Other methods shall be permitted to be used if shown to be suitable for the purpose. A fuseholder for a Class R or CC fuse shall be designed so that removal of the rejection member by using ordinary tools and methods causes obvious damage to the fuseholder. A rejection member in a fuseholder designed for a Class R fuse shall remain effective after being subjected for one minute to the forces specified in Table 2-12. A rejection member in a fuseholder designed for Class CC fuses shall remain effective after being subjected for one minute to an insertion force of 50 pounds (222 N).

Table 2-12
WITHSTAND FORCE FOR CLASS R FUSEHOLDERS

Amperes	Volts	Force, Pounds	Force, Newtons
30	250	50	222.41
30	600	80	355.85
60	250/600	80	355.85
100	250/600	100	444.82
200	250/600	150	667.23
400	250/600	150	889.6
600	250/600	200	889.6

Note—The force shall be applied using a Class H fuse or a test link.

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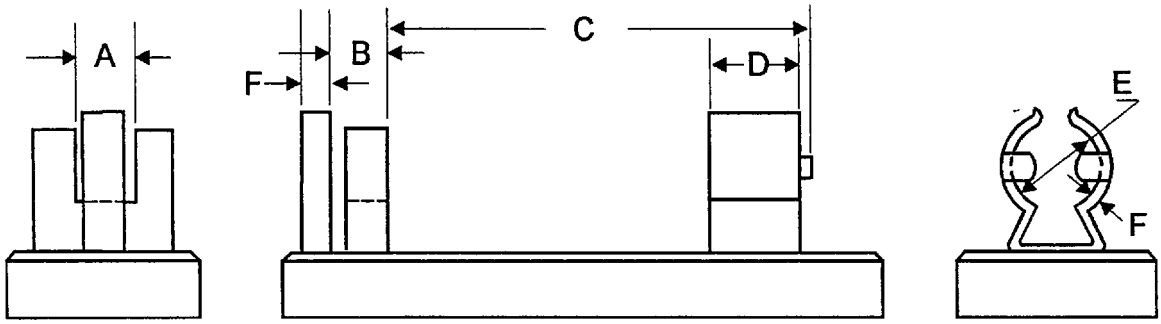


Figure 2-10
CLASS CC FUSEHOLDER FERRULE CONTACT TYPE WITH REJECTION MEMBER

Table 2-13
DIMENSIONS OF A CARTRIDGE FUSEHOLDER, in. (mm)

Class of Fuse	Potential Rating of Fuse, Volts	Current Rating of Fuse, Amps	B Distance Between Contact Clips	C Minimum Width of Contact Clip	D Diameter of Ferrule	E Thickness of Blade	F Minimum Thickness of Contact Clip	G Distance Between End Stops Minimum	G Distance Between End Stops Maximum
H or K	250	30	1* (25.4)	1/2 (12.7)	9/16 (14.29)	...	0.028 (0.71)	2-1/32 (51.59)	2-1/8 (53.975)
		60	1-3/4* (44.45)	5/8 (15.87)	1-3/16 (20.63)	...	0.040 (1.027)	3-1/32 (76.99)	3-1/8 (79.375)
		100	4 (101.6)	7/8 (22.22)	...	1/8 (3.175)	0.062 (1.6)	5-15/16 (150.81)	...
		200	4-1/2* (114.3)	1-1/4 (31.75)	...	3/16 (4.76)	0.062 (1.6)	7-3/16 (182.36)	...
		400	5* (127)	1-3/4 (44.45)	...	1/4 (6.35)	0.093 (2.36)	8-23/32 (221.46)	...
		600	6* (152.4)	2-1/8 (53.975)	...	1/4 (6.35)	0.125 (3.175)	10-15/32 (265.91)	...
	600	30	4*†(101.6)	1/2 (12.7)	1-3/16 (20.360)	...	0.028 (0.7112)	5-1/32 (127.79)	5-1/8 (130.175)
		60	4-1/4* (107.95)	5/8 (15.87)	1-1/16 (26.99)	...	0.040 (1.016)	5-17/32 (140.49)	5-5/8 (144.175)
		100	6*(152.4)	7/8 (22.22)	...	1/8 (3.175)	0.062 (1.57)	7-15/16 (201.61)	...
		200	7* (177.8)	1-1/4 (31.75)	...	3/16 (4.76)	0.062 (1.57)	9-11/16 (246.06)	...
		400	8* (203.2)	1-3/4 (44.45)	...	1/4 (6.35)	0.093 (2.36)	11-23/32 (297.66)	...
		600	9* (228.6)	2-1/8 (53.975)	...	1/4 (6.35)	0.125 (3.175)	13-15/32 (330.67)	...

See page 38 for explanation of table references

(Table continued on next page)

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Table 2-13 (Concluded)

Class of Fuse	Potential Rating of Fuse, Volts	Current Rating of Fuse, Amps	B Distance Between Contact Clips	C Minimum Width of Contact Clip	D Diameter of Ferrule	E Thickness of Blade	F Minimum Thickness of Contact Clip	G Distance Between End Stops Minimum	G Distance Between End Stops Maximum
G	300	15	3/4* (19.05)	0.305 (7.75)	1-3/32 (10.32)	...	0.017 (0.430)	1.345 (34.16)	1.365 (34.67)
		20†	27/32* †† (21.43)	0.305 (7.75)	1-3/32 (10.32)	...	0.017 (0.43)	1.440 (36.58)	1.460 (37.08)
		30	1-1/16* (26.99)	0.305 (7.75)	1-3/32 (10.32)	...	0.017 (0.43)	1.660 (42.16)	1.700 (43.18)
		60	1-1/4 (31.75)	0.500 (12.7)	1-3/32 (10.32)	...	0.040 (1.106)	2.281 (57.94)	2.375 (60.325)
J	600	30	1-1/4*† (931.75)	1/2 (12.7)	1-3/16 (20.63)	...	0.028 (0.7112)	2-9/32 (51.08)	2-3/8 (60.325)
(Fuse Not Bolted in Place)		60	1-1/8* (28.575)	5/8 (15.87)	1-1/16 (26.99)	...	0.040 (1.016)	2-13/32 (61.12)	2-1/2 (63.50)
		100	2-3/4* (69.85)	7/8 (22.22)	...	1/8 (3.175)	0.062 (1.57)	4-23/32 (119.89)	...
		200	3-1/8* (79.375)	1-1/4 (31.75)	...	3/16 (4.76)	0.062 (1.57)	5-27/32 (148.43)	...
		400	3-1/2* (88.9)	1-3/4 (44.45)	...	1/4 (6.35)	0.093 (2.36)	7-7/32 (183.36)	...
		600	3-7/8* (98.425)	2 (50.8)	...	3/8 (9.52)	0.125 (3.175)	8-3/32 (203.29)	...
T	300	30	0.300* (7.6)	0.290 (7.36)	0.406 (10.31)	...	0.028 (0.7112)	0.900 (22.86)	0.930 (23.62)
(Fuse Not Bolted in Place)		60	0.300** (7.6)	0.290 (7.36)	0.563 (14.30)	...	0.040 (1.106)	0.900 (22.86)	0.930 (23.62)
		100	0.910 § (23.11)	0.515 (13.08)	...	1/8 (3.175)	0.062 (1.520)	2.176 (55.27)	2.398 (60.9
		200	0.910 § (23.11)	0.655 (16.637)	...	3/16 (4.76)	0.062 (1.57)	2.458 (62.43)	2.690 (68.326)
		400	0.920§ (23.36)	0.805 (20.447)	...	1/4 (6.35)	0.093 (2.36)	2.790 (70.87)	3.003 (76.276)
		600	0.940 § (23.87)	0.955 (24.257)	...	3/8 (9.52)	0.125 (3.175)	3.103 (78.82)	3.300 (83.82)
	600	30	0.930§§ (23.62)	0.290 (7.366)	0.563 (14.30)	...	0.028 (0.7112)	1.540 (39.12)	1.580 (40.132)
		60	0.740** (18.79)	0.390 (9.906)	0.812 (20.620)	...	0.40 (1.016)	1.600§§ (40.64)	1.630§§ (41.40)

*Tolerance for the B dimensions are: 60 amperes or less: + 1/32 inch (0.793 mm) and -1/16 inch (1.59 mm); 100 and 200 amperes: =1/16 inch (1.59 mm) and-1/32 inch (0.793 mm); 400 and 600 amperes: + 3/32 inch (2.38 mm)
**Tolerance 0.050 inch (1.27 mm)
†See 3.10.3
‡Minus tolerance shall be permitted to be 5/32 inch (3.97 mm)
§Tolerance 0.030 inch (0.762 mm)
††Tolerance 0.020 inch (0.508 mm)
§§Minimum of 0.070 inch (1.778 mm) clearance at one end shall be provided for plate. Distance may be 1.670–1.700 inches (42.42–43.18 mm) with clearance at each end for plate

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Table 2-14
DIMENSIONS OF A CARTRIDGE FUSEHOLDER FOR CLASS R FUSES HAVING A REJECTION MEMBER, Inches (mm)

Voltage Rating of Fuse, Volts	Current Rating of Fuse, Amps	G Minimum Distance From Center of Rejection Member to End Stop	H Minimum Distance From Center of Rejection Member to End Stop	J Maximum Width of Rejection Member	K* Contact Above Rejection Member	L**,† Extension of Rejection Member From Inside Surface of Clip	M Maximum Distance From End of Rejection Member to End Stop	N§,† Distance Between Rejection Member	It Minimum–Maximum Distance to Center Rejection Member
250	30	1.892 (48.06)	0.165 (4.19)	0.065†† (1.65)	...	0.080 (2.03)	1.906 (48.41)	0.405 (10.287)	...
	60	2.890 (72.64	0.106 (4.98)	0.081§§ (2.06)	...	0.080 (2.03)	2.906 (73.81)	0.655 (16.637)	...
	100	5.469 (138.91)	0.531 (13.49)	0.255 (6.48)	0.281 (7.14)	...	5.750 (146.05)	...	0.430-0.484 (10.92-12.29)
	200	6.531 (165.89)	0.719 (18.26)	0.255 (6.48)	0.469 (11.91)	...	...	...	0.618-0.672 (15.70-17.07)
	400	7.813 (198.45)	0.969 (24.61)	0.380 (9.65)	0.656 (16.66)	...	...	...	0.869-0.923 (22.07-23.44)
	600	9.375 (238.13)	1.156 (29.36)	0.505 (12.83)	0.781 (19.84)	...	...	...	1.056-1.110 (26.82-28.19)
600	30	4.860 (123.44)	0.196 (4.98)	0.081§§ (2.06)	...	0.080 (2.03)	4.906 (124.61)	0.655 (16.37)	...
	60	5.298 (134.57)	0.260 (6.60)	0.081§§ (2.06)	...	0.080 (2.06)	5.406 (137.31)	0.905 (22.987)	...
	100	7.469 (189.71)	0.531 (13.49)	0.255 (6.48)	0.281 (7.14)	...	7.750 (196.85)	...	0.430-0.484 (10.9-12.29)
	200	9.031 (229.39)	0.719 (18.26)	0.255 (6.48)	0.469 (11.91)	...	...	...	0.618-0.672 (15.70-17.07)
	400	10.813 (274.65)	0.969 (24.61)	0.380 (9.65)	0.656 (16.66)	...	...	...	0.869-0.923 (22.07-28.19)
	600	12.375 (314.33)	1.156 (29.36)	0.505 (12.83)	0.781 (19.34)	...	...	...	1.056-1.110 (26.82-28.19)

* Column K tolerance: +0.031 inch (0.7874 mm)—dimension E in Table 2-13 Multiplied by 0.5.
** Column L tolerance: -0.016 inch (0.406 mm), +0.000 applicable when rejection member is integral part of fuse clip.
† Other methods of fuse rejection will require reference to fuse groove shape and dimensions, including tolerances, to determine suitability of rejection means. Dimensions J, L, and N assume rectangular cross-section members.
§ Column N tolerance: -0.000 inch, +0.060 inch (1.524 mm) applicable when rejection member is not integral part of fuse clip.
†† Assumes rectangular cross-section, may be 0.127 inch (3.23) if portion in contact with fuse has 0.031 inch (.7874 mm) radius on each side.
§§ Assumes rectangular cross-section, may be 0.143 inch (3.63) if portion in contact with fuse has 0.031 inch (0.7874 mm) radius on each side.

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Table 2-15
DIMENSIONS OF A CLASS J FUSEHOLDER—FUSES BOLTED IN PLACE

Current Rating of Fuse, Amperes	Dimensions, Inch (mm)				
	H Center-to-Center of Studs or Clearance Holes*	Diameter of Stud	I Diameter of Clearance Hole	J Minimum Obstructed Clearance	K End of Terminal to Center of Stud or Clearance Hole Maximum
100	3-3/8 (92.075)	1/4	9/32 (7.14)	4-23/32 (102.32)	3/8 (9.53)
200	4-3/8 (111.125)	1/4	9/32 (7.14)	5-27/32 (148.43)	9/16 (14.29)
400	5-1/4 (133.35)	3/8	13/32 (10.32)	7-7/32 (178.02)	51/64 (20.24)
600	6 (152.4)	1/2	17/32 (13.49)	8-3/32 (205.58)	68/64 (25.0)

*Tolerance ±1/16 inch (1.5875 mm).

Table 2-16
DIMENSIONS OF A CLASS T FUSEHOLDER-FUSES BOLTED IN PLACE

Potential Rating- of Fuse, Volts	Current Rating of Fuse, Amperes	Dimensions, Inch (mm)				
		H	I	J		K
		Center-to Center of Studs or Threaded Holes*	Size of Stud or Threaded Hole**	Minimum Obstructed Clearance	Minimum Clearance Between End Stops**	End of Terminal to Center of Stud or Threaded Hole, Max.
300	100	1.556 (39.52)	1/4	2.176 (55.27)	2.398 (60.91)	0.340 (8.64)
	200	1.695 (43.05)	5/16	2.458 (62.43)	2.690 (68.33)	0.410 (10.41)
	400	1.844 (46.84)	3/8	2.790 (70.87)	3.003 (76.28)	0.480 (12.19)
	600	2.031 (51.59)	7/16	3.103 (78.82)	3.315 (84.20)	0.560 (14.22)
	800	2.219 (56.36)	1/2	3.415 (86.74)	3.940 (100.08)	0.650 (16.51)
	1200	2.531 (64.29)	9/16	4.040 (102.62)	...	0.710 (18.03)
600	100	2.352 (59.74)	1/4	2.993 (76.02)	3.190 (81.03)	0.340 (8.64)
	200	2.507 (63.68)	5/16	3.290 (83.57)	3.565 (90.55)	0.410 (10.41)
	40	2.719 (69.06)	3/8	3.665 (93.09)	3.924 (99.67)	0.480 (12.19)
	600	2.953 (75.01)	7/16	4.024 (102.21)	4.268 (108.41)	0.560 (14.22)
	800	3.172 (80.51)	1/2	4.368 (110.96)	...	0.630 (16.00)

*Tolerance ±0.015 inch (0.381 mm) where specified rigid stud or threaded hole.
**End stops required when captive stud floats in fuseholder or when stud or threaded hole 1/16 inch (1.5875 mm) or smaller size to prevent insertion of larger case size fuse in smaller fuseholder.

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Table 2-17
CLASS L FUSE MOUNTING DIMENSIONS, INCHES (MM)

Cartridge Size, Amperes	A	B*	C**		D†	E**			F**
	Fuse Gap Minimum	Bus Width	Hole Centers C¹	Hole Centers C²	Unobstructed Distance Minimum	Hole Locations E¹ Minimum	Hole Locations E¹ Maximum	E²	Hole Centers
601-800	4-1/4 (109.95)	2	5-3/4(146.05)	...	2-1/4 (57.15)	5/8 (15.875)	3/4 (19.05)	...	...
801-1200	4-1/4 (109.95)	2	5-3/4(146.05)	9-1/4(234.95)	3-3/8 (85.73)	5/8 (15.875)	3/4 (19.05)	1-3/4 (44.45)	...
1201-1600	4-1/4 (109.95)	2-3/8	5-3/4(146.05)	9-1/4 (234.95)	3-3/8 (85.73)	5/8 (15.875)	3/4 (19.05)	1-3/4 (44.45)	...
1601-2000	4-1/4 (109.95)	2-3/4	5-3/4(146.05)	9-1/4 (234.95)	3-3/8 (85.73)	5/8 (15.875)	3/4 (19.05)	1-3/4 (44.45)	...
2001-2500	4-1/4 (109.95)	3-1/2	5-3/4(146.05)	9-1/4 (234.95)	3-3/8 (85.73)	5/8 (15.875)	3/4 (19.05)	1-3/4 (44.45)	1-5/8(41.275)
2501-3000	4-1/4 (109.95)	4	5-3/4(146.05)	9-1/4 (234.95)	3-3/8 (85.73)	5/8 (15.875)	3/4 (19.05)	1-3/4 (44.45)	1-5/8(41.275)
3001-4000	4-1/4 (109.95)	4 3/4	5-3/4(146.05)	9-1/4 (234.95)	3-3/8 (85.73)	5/8 (15.875)	3/4 (19.05)	1-3/4 (44.45)	3-1/4 (82.55)
4001-5000	4-1/4 (109.95)	5-1/4	5-3/4(146.05)	9-1/4 (234.95)	3-3/8 (85.73)	5/8 (15.875)	3/4 (19.05)	1-3/4 (44.45)	1-5/8(41.275)
5001-6000	4-1/4 (109.95)	5-3/4	5-3/4(146.05)	9-1/4 (234.95)	3-3/8 (85.73)	5/8 (15.875)	3/4 (19.05)	1-3/4 (44.45)	1-5/8(41.275)

NOTE—All tolerances ±1/16 inch unless otherwise indicated.

*Maximum bus width B not specified but stops shall be provided to prevent over fusing. Tolerance on dimensions given 1/16 inch for ratings 601–1600 A; ±1/8 inch for ratings 1601–6000A.

**Hole or stud center to center spacings ±1/32 inch (0.79 mm).

†Maximum clearance D not currently specified but stops to prevent overfusing of 800A ratings required.

Table 2-18
DIMENSIONS OF A CARTRIDGE FUSEHOLDER FOR CLASS CC FUSES HAVING A REJECTION MEMBER

Potential Rating of Fuse, Volts	Current rating of Fuses, Amperes	Dimensions, inches (mm) A Width of Rejection Hole	B* Minimum Distance Between Shoulder Stop and Contact Bus	C* Distance Between Stops Min.	C* Distance Between Stops Max.	D Width of Contact Clip	E Diameter of Ferrule	F Minimum Thickness of Contact Clip and Bus
600	30	.276† (7.01)	0.031 (.787)	1.411 (35.83)	1.441 (36.60)	.376** (9.52)	.406 (10.31)	0.017 (.431)

* The sum of dimensions B and C is to be such that the fuseholder will accept a fuse having an overall length of 1.500 ± 0.031 inches.

† Tolerance is minus 0.020 inch, plus 0.120 inch.

** Tolerance is ± 0.020 inch.

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Section 3
TESTS

3.1 DESIGN AND VERIFICATION TESTS

Design and verification tests shall be conducted to verify the performance characteristics of enclosed switches.

3.1.1 Design Tests for Switches

Design tests for switches are as follows (see definition of design test):

Heating test	3.2.1
Overload test	3.2.2
Endurance test	3.2.3
Strength of insulating base and support test	3.2.4
Clamped joint test	3.2.5
Dielectric voltage withstand test	3.2.6
Fault current tests	3.2.7
Contact opening test	3.2.8
Enclosure tests	3.2.9
Operation test	3.2.10
Pullout switch heating with fuses test	3.5.1 and 3.5.2
Pullout switch overload-cycle heating test	3.5.3

3.1.2 Verification Tests for Switches

Verification tests shall be those listed below that are made by the manufacturer to check the quality and uniformity of workmanship and materials.

a. Construction..... 3.3.1
b. Performance 3.3.2

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3.2 Design Tests

Design tests shall be made on representative switches of new and revised design to substantiate ratings assigned to all other switches of a similar design.

A representative sample of each switch rating shall be subjected to the tests mentioned and in the order shown in Table 3-1. Separate samples shall be permitted to be used as indicated in the table. A switch marked with two or more ratings shall be tested at each rating unless a test at one rating is representative of performance at the other ratings.

Table 3-1 contains a list of the design tests (referred to by clause number) for a given classification of equipment.

3.2.1 Heating Test

3.2.1.1 Sample Preparation

The switch shall be mounted in the smallest intended enclosure as in actual service, with the door and other openings, such as knockouts, closed. Openings intended for enclosure ventilation during actual service shall be permitted to remain open. For additional requirements for deadfront switches, see 3.2.1.4. Except as noted below, test links or the equivalent shall be used in place of regular fuses in the clips or female screw shells. The switch shall be wired with not less than 4 ft. (1.22 m) of wire per terminal, the wire size corresponding to the ampere rating of the switch. A switch employing Class L or T fuses or 400- or 600-A Class J fuses shall be tested with fuses in place. For switches rated 800 amperes and above, see Table 3-2.

For Class L fused switches tested at 100 percent of rated current per 4.2.1.3, bus bars of the size given in Table 3-2 shall be used for connecting the device to a source of supply except that, if there is only provision for cable connection, the cables of the size indicated or other cables of no greater total capacity and representative of field installation shall be used. The spacing between widths of multiple bus bars is to be 1/4 inch (6.4 mm) with no intentionally wider spacing except as necessary at the individual terminals of the device. The bus bars for the 3000- and 4000-A switch test are to be arranged in pairs with not more than 4 inches (102 mm) between pair centers. The bus bars for the 5000- and 6000-A switch test are to be arranged in sets of three with not more than 4 inches between centers of adjacent sets.

3.2.1.2 Temperature Measurements

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

Thermocouples and related instruments shall be accurate and calibrated in accordance with good laboratory practice.

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

The ambient air temperature shall be measured by means of at least two thermometers or thermocouples equally distributed around the equipment at about half its height and at a distance of about 3 feet (0.91 meters) from the equipment. The thermometers or thermocouples shall be protected against air currents, heat radiation, and indicating errors due to rapid temperature changes. The ambient air temperature shall be maintained within the range of 10°C to 40°C (50°F to 104°F).

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Table 3-1
DESIGN TESTS

		Test*	Referenced Clause	Switch Classification and Test Samples* General Duty Enclosed and Hinged Pullout Switches	Heavy Duty Enclosed and Power Circuit Devices	Detachable Pullouts
		Heating	3.2.1	A	A	A
		Heating with fuses	3.5.1	...	...	B
		Overload cycle heating	3.5.3	...	...	C1
		Overload hp rating	3.2.2	B1	B1	L1
		Overload ampere rating	3.2.2	C1	C1	D1
		Endurance	3.2.3	B2/C2	B2/C2	D2/L2
		Dielectric	3.2.6	B3/C3	B3/C3	D3/L2
		Strength of insulating base	3.2.4	D	D	I
		Bonding continuity	3.2.9.2	...	...	J
		Clamped joint	3.2.5	E	E	K
		Enclosure test	3.2.9.1	H	L	...
Fault Current Rating	≥10 KA	Short circuit withstand	3.2.7.4	F1	F1	E
		Low level dielectric	3.2.7.5	F2	F2	E
		Closing	3.2.7.6	G1	G1	F
		Low level dielectric	3.2.7.5	G2	G2	F
	≤10 KA	Close-open	3.2.7.3	...	H1	G
		Dielectric	3.2.7.5	...	H2	G
		Short circuit withstand	3.2.7.7	...	H3	G
		Low level dielectric	3.2.7.5	...	H4	G
		Closing	3.2.7.8		I1	H
		Low level dielectric	3.2.7.5		I2	H
Electrically Tripped or Operated		Operation	3.2.10	...	J1	...
		Contact opening	3.2.8	...	J2	...
		Dielectric	3.2.6	...	J3	...
		Temperature of coil	3.2.1.6	...	K	...
		Endurance	3.2.3.23	...	J4	...

*Different test samples are designated by the use of different alphabetical characters. Manufacturers have the option of conducting multiple tests on a single sample. When multiple tests are required on the same sample, those tests shall be conducted in the order specified by the superscripts following the sequencing letter.

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Table 3-2
CONDUCTOR SIZES FOR HEATING TEST*†

Device Rating, Amperes	Size of Copper Bus Bar, Inches**	Size of 75°C Copper Cable, Kcmil **
800	(1) 1/4 by 3	(3) 300
1200	(1) 1/4 by 4	(4) 350
1600	(2) 1/4 by 3	(5) 400
2000	(2) 1/4 by 4	(6) 600
2500	(2) 1/4 by 5	(6) 600
3000	(4) 1/4 by 4	...
4000	(4) 1/4 by 5	...
5000	(6) 1/4 by 5	...
6000	(6) 1/4 by 6	...

*Bus Bars shall be used unless the device is marked for only cable connections. In such cases, the appropriate cable shall be permitted to be used.
**Numbers in parentheses indicate the number of conductors per pole.
†Bus bar spacings for this test shall be:
1600-2500A—1/4" between pairs
3000-4000A—1/4" between pairs and not more than 4" between two pairs/pole
5000-6000A—1/4" between sets of three with not more than 4" between centers of the sets

3.2.1.3 Method General

The switch shall be caused to carry, at any convenient voltage, the following 60 Hz, essentially sinusoidal currents, until constant temperatures are attained. Direct current shall be permitted for a switch marked for direct current only.

a. Ampere rated switch (except as noted in c and d below) rated current
b. Ampere and Horsepower rated switch (except as noted in c and d below) rated current, or 115 percent of current corresponding to the horsepower rating, whichever is greater
c. A switch employing Class L or T fuses or 400 or 600 ampere Class J fuses 80 percent of its rated current
d. A switch employing Class L fuses and suitable for use at 100 percent of its rated current shall be tested at rated current

A temperature is considered to be constant when three successive readings taken at 15-minute intervals (30 minute intervals for 100 percent rated switches 800 amperes and larger) indicate no change.

3.2.1.4 Deadfront Switches

3.2.1.4.1 General

A deadfront switch shall be tested in an enclosed panelboard or the equivalent having main bus bars rated two times the ampere rating of the switch under test.

Exception No. 1: A 30-A switch may be tested in a 100 amp panelboard and a 60-A switch may be tested in a 150 amp panelboard or a 30- or 60-A switch may be tested in the smallest current rated panelboard for which it is intended to be used.

Exception No. 2: For a deadfront switch that may be used as a main switch, the bus bars shall be rated equal to the ampere rating of the switch.

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Exception No. 3: Lower rated bus bars shall be permitted to be used if agreeable to those concerned.

In the test of 3.2.1.4.1, the switch under test shall be mounted in the top position and loaded in accordance with 3.2.1.3. 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.

Except as noted in 3.2.1.1, test links shall be used in place of regular fuses in clips or female screw shells.

If a deadfront switch has a magnetic steel shell that completely encircles the ungrounded conductors in the switch, the switch additionally shall be tested in accordance with 3.2.1.4.2 and 3.2.1.4.3 if the grounded circuit conductor does not pass through the switch.

3.2.1.4.2 Three-Pole Switches

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.

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 3.2.1.1 and loading shall be in accordance with 3.2.1.3 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 1,000 amperes per square inch (1.55 A/mm^2), shall extend approximately 3 inches (76 mm) beyond the switch enclosure, and shall terminate in wire connectors appropriate for the rating of the switch.

Exception: Bus bars of cross section other than specified above shall be permitted to be used if agreeable to those concerned.

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.

The same sample shall then 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 no higher than observed in the test with the conductors to the lower switch pole inside the switch enclosure or shell.

3.2.1.4.3 Two-Pole Switches

A two-pole deadfront switch having a steel shell in accordance with 3.2.1.4.1 and having an enclosure smaller than the equivalent three-pole switch of the same voltage and ampere rating shall be subjected to the test described in 3.2.1.4.2 except that: (1) test links shall be used in the two poles; (2) a three-phase current shall be adjusted to 100 percent of the switch rating; and (3) 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 (54°F).

Exception: A two-pole switch marked for single-phase use only need not be tested.

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3.2.1.5 Evaluation

The switch shall not show a temperature rise greater than that indicated in Table 3-3 nor shall any fuse open when tests are performed with fuses.

3.2.1.6 Heating Test for Coils

The maximum temperature rise on a coil or winding intended for continuous duty shall be not greater than that indicated in Table 3-4, when operated at rated voltage.

The resistance method consists of the determination of the temperature of a copper or aluminum winding by comparing the resistance of the winding at the temperature to be determined with the resistance at a known temperature, according to the formula:

$$\Delta T = \frac{R}{r}[(k+t_1) - (k+t_2)]$$

in which ΔT is the temperature rise, R is the resistance of the coil at the end of the test, r is the resistance of the coil (coil at t_1) at the beginning of the test, t_1 is the room temperature C at the beginning of the test, t_2 is the room temperature C at the end of the test, and k is 234.5 for copper and 225.0 for electrical conductor grade (EC) aluminum. Values of the constant for other grades must be determined.

As it is generally necessary to deenergize the winding before measuring R, the value of R at shutdown shall be permitted to be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values and the time shall be permitted to be plotted and extrapolated to give the value of R at shutdown.

Table 3-3
MAXIMUM ACCEPTABLE TEMPERATURE RISES OVER AMBIENT

Materials and Components	°C	°F
Terminals for field-installed conductors:		
Unfused switches	50	90
Fused switches for use with 60°C (140°F) wire and tested links	30	54
Fused switches for use with 75°C (167°F) wire and tested links*	45	81
Class T fuse switches rated 100 A or less for use with 60°C wire	50	90
Class T fused switches rated 100A or less for use with 75°C wire*	65	117
Class J (rated more than 200 A), Class T (rated more than 100A) fused switches	60	108
Class L fused switches tested at 80% per 3.2.1.3	60	108
Class L fused switches tested at 100% per 3.2.1.3	60	108
All other current-carrying parts:		
Unfused switches	50	90
Fused switches for use with 60°C (140°F) wire and tested with test links	30	54
Fused switches for use with 75°C (167°F) wire and tested with test links	50	90
Class T, Class J (rated more than 200 A) fused switches	85	153
Class L fused switches tested at 80% per 3.2.1.3	85	153
Class L fused switches tested at 100% per 3.2.1.3	**	**

*Applicable to a connector for copper wire. Also applicable to a connector for aluminum wire or aluminum-bodied connector, if the connector has a temperature rating of 90°C (194°F).
**Temperature rise shall not adversely affect any insulating materials used.

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Table 3-4
COIL TEMPERATURE RISE*

Kind of Coil	Coil Insulation Systems	Maximum Acceptable Temperature Rise	
		By Thermocouple Method	By Resistance Method
Multiple-Layer	Class 90	50°C (90°F)	70°C (126°F)
	Class 105	65°C (117°F)	85°C (153 °F)
	Class 130	85°C (153°F)	105°C (189°F)
	Class "over 200"	No Limit is Specified	
Single-layer coil with exposed surfaces uninsulated or enameled	Class 105	90°C (162°F)	

*The temperature test on a coil shall be permitted to be conducted with the coil mounted in the switch as intended with the switch carrying rated current or separately in an ambient that is representative of the operating ambient conditions within the switch.

A coil temperature is to be determined by the change-of-resistance method if the coil is inaccessible for mounting thermocouples.

3.2.2 Overload Test

Switches shall be subjected to overload tests as follows:

a. Ampere Rated * 3.2.2.2
b. Ampere/Horsepower Rated * 3.2.2.3

*In the case of double-throw switches:

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

   1. With the line connected to the hinge jaws and the load connected to one set of contact jaws

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

   3. With the line connected to one set of contact jaws and the load connected to the hinge jaws

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

b. A double-throw switch not of the hinged knife-blade type shall be subjected to four tests corresponding to those mentioned in paragraph a.

   Except as noted in the footnote to the table an overload test at any voltage rating shown in Table 3-5 shall be considered to be representative of an overload test at any voltage rating given below it in the table, where the same current or a smaller current is involved.

c. A double-throw switch for use in accordance with Article 702 of the *National Electrical Code* shall be 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 three-phase supply or 180 electrical degrees for a single-phase supply.

   Exception No. 1: A double-throw switch described above and 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 may be tested in accordance with paragraph a.

   Exception No. 2: A double-throw switch described above and 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 may be tested in accordance with paragraph a.

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A cycle for a double-throw switch for use in accordance with Article 702 of the *National Electrical Code* is defined as making and breaking the required test current on both sets of contacts.

Table 3-5
OVERLOAD AND ENDURANCE TESTS

	Switch Rating in Volts	DC or Number of Phases AC	Power Factor of Test
1	600*	DC	...
2	600	3	0.40–0.50
3	600*	1	0.40–0.50
4	600	3	0.70–0.80
5	600*	1	0.70–0.80
6	480	3	0.40–0.50
7	480*	1	0.40–0.50
8	480	3	0.70–0.80
9	480	1	0.70–0.80
10	250*	DC	...
11	240	3	0.40–0.50
12	240*	1	0.40–0.50
13	240*	3	0.70–0.80
14	125–250*	DC	...
15	240	1	0.70–0.80
16	120–240	1	0.70–08.0
17	125	DC	...
18	120	3	0.40–0.50
19	120*	1	0.40–0.50
20	120	3	0.70–0.80
21	120	1	0.70–0.80

*An overload or endurance test at any rating marked with an asterisk shall not be considered representative of a test at the voltage rating on the next line down in the column.

This table applies to devices having an interrupting means for each wire of the circuit, but a single-throw switch shall not be considered to be representative of a double-throw switch of the same rating.

If a horsepower rated switch has the same horsepower rating of 100 horsepower or less at more than one voltage, an overload test at the highest voltage shall be considered representative of performance at any lower voltage. A motor-circuit switch or any switch having a horsepower rating greater than 100 horsepower shall be tested at the maximum voltage and also at the maximum current. An overload test on a three-phase circuit shall be considered to be representative of performance on a two-phase circuit of the same voltage for the same horsepower rating.

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3.2.2.1 Sample Preparation

A switch shall be mounted as in actual service. Switches intended for the purpose shall be mounted in a panelboard or other representative chassis providing spacings from live parts in the switch to the main bus, and grounded chassis metal are representative of those in the complete panelboard. The line terminals shall be connected to a supply circuit as described in 3.4.2 and the load terminals shall be connected to the necessary resistance or impedance.

A cotton pad indicator shall be used over any louvers or other openings specifically intended for enclosure ventilation. Test links shall be installed in the switch for the overload test. If the fuse mounting means are located in or near the arcing zone of the switch, the test links shall closely resemble the intended fuse in physical configuration.

An enclosed switch shall be tested in a metal enclosure having no paint, enamel, or other coating of insulating material. Optionally, a painted or coated enclosure shall be permitted to be used, if the interior finish is scraped off, scratched, or abraded through to the base metal, in those areas where arcing or gassing is likely to occur, so as to simulate the use of an unpainted or uncoated enclosure.

A switch shall not be adjusted, lubricated, or otherwise conditioned during the overload test with current, or the endurance test without current; but switch blades and break jaws that are readily accessible shall be permitted to 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.

For switches rated more than 1200 amperes, when the capacity of the load bank requires, or at the option of the manufacturer, the operations shall be permitted to be performed in groups of five or more with an interval of unstated length between groups of operations. During this interval, the cover or door of the switch shall be permitted to be opened for purposes of inspection or to purge the enclosure.

3.2.2.2 Overload Test Ampere Rated Switch

A switch shall successfully perform the number of operations and at the speed of operation specified in Table 3-6.

3.2.2.3 Overload Test Ampere/Horsepower Rated Switches

3.2.2.3.1 100 Horsepower and Less

AC overload tests at 100 horsepower and less shall be run at a lagging power factor of 40 percent to 50 percent at the rate of operation shown in Table 3-6. DC overload tests shall be run with a non-inductive resistance load, at the rate shown in Table 3-6.

a. *General Duty*—A general duty switch shall perform successfully when operated for 50 cycles, making and breaking the current given in Table 3-7 at the rate of operation indicated in Table 3-6.

b. *Heavy Duty*—A heavy-duty switch shall perform successfully where operated for 50 cycles, making and breaking the current given in Tables 3-7 or 3-8, except for a heavy-duty switch with an ac horsepower rating of 50 horsepower or less. The first ten operations shall be made at an overload current ten times the endurance current in Table 3-9 for the specified horsepower rating followed by 40 operations at the overload current in Table 3-7 for the specified horsepower rating.

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Table 3-6
OVERLOAD TEST PARAMETERS*

Switch Ratings, Amperes	Operations per Minute
30–100	6
200	5
400	4
600	3
800	2
1200	1
1600–2500	1
3000–4000	1
4001–6000	1

Test Voltage—In accordance with 3.4.1
Test Current—150% of Rated Current
Test Cycles—50
Power Factor—0.70 0.80 (noninductive loading, if dc)
Frequency—60 Hz (ac Test Only)
*Switches marked for isolating use only and rated at more than 600 amperes shall be subjected to 10 overload test cycles.

3.2.2.3.2 More than 100 Horsepower

Switches having ratings of more than 100 horsepower shall perform successfully for ten cycles, making and breaking the currents shown in Table 3-7. Tests shall be run at a power factor of 40 percent to 50 percent and the rate of operation shall be one cycle per minute. This shall be followed by either:

a. An additional 40 operations at the values given in Table 3-6 for ampere-rated switches, in which case the switch shall be marked per 5.4.3, item k

b. An additional 40 operations at 100 horsepower, at 40 percent to 50 percent power factor, at the rate given in Table 3-6, in which case the switch shall be marked per 5.4.3, item l

3.2.2.4 Evaluation

The device shall be considered to be acceptable if no undue pitting, burning, or welding of the contacts or electrical or mechanical breakdown has occurred; the enclosure fuse referred to in 3.4.2.6 has not opened; and the cotton pad indicator used over ventilated openings has not ignited.

3.2.3 Endurance Test

3.2.3.1 *Test Sample Preparation*

A switch shall be mounted as in actual service with doors, covers, and any other openings not intended to provide ventilation during actual service closed. Test links, or the equivalent, shall be used in place of regular fuses in fuseholders. The line terminals shall be connected to a supply circuit as outlined in 3.4.2 (see Figure 3-1).

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.

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Table 3-7
OVERLOAD TEST CURRENTS FOR AC SWITCHES, IN AMPERES

Switch Rating In Horsepower	120 Volts			240 Volts			480 Volts			600 Volts		
	Single Phase	Two Phase, 4 Wire, Three Phase		Single phase	Two Phase, 4 Wire Three Phase		Single phase	Two Phase, 4 Wire, Three Phase		Single phase	Two Phase, 4 Wire, Three Phase	
		BCD	E		BCD	E		BCD	E		BCD	E
1/2	58.8	40	40	29.4	20	20		10	10		8	8
3/4	82.8	50	50	41.4	25	25	21	12.5	12.5	16.8	10	10
1	96	60	60	48	30	30	24	15	15	19.2	12	12
1-1/2	120	80	80	60	40	40	30	20	20	24	16	16
2	144	100	100	72	50	50	36	25	25	28.8	20	20
3	204			102	64	73	51	32	36.5	40.8	25.6	29.2
5	336			168	92	122	84	46	61	67.2	36.8	48.8
7-1/2	480			240	127	183	126	63.5	91.5	96	50.8	73.2
10	600			300	162	225	156	81	113	120	64.8	90
15	810			408	232	337	204	116	169	162	93	135
20				528	290	449	264	145	225	210	116	180
25				660	365	562	330	183	281	264	146	225
30				816	435	674	408	218	337	324	174	270
40				1060	580	824	528	290	412	420	232	330
50				1300	725	1030	648	363	515	516	290	412
60					870	1236		435	618		348	494
75					1085	1545		543	773		434	618
100					1450	1873		725	937		580	749
125					1815	2341		908	1171		726	936
150					2170	2809		1085	1405		868	1124
200					2900	3745		1450	1873		1160	1498
250					3650	4688		1825	2344		1460	1875
300					4400	5618		2200	2809		1760	2247
350					5100	6554		2550	3277		2040	2622
400					5800	7490		2900	3745		2320	2996
450					6500	8427		3250	4214		2600	3371
500					7250	9363		3625	4682		2900	3746

3.2.3.2 Method

3.2.3.2.1 Voltage

In accordance with 3.4.1.

3.2.3.2.2 Amperage

a. For ampere-rated switches, the load portion of the endurance test shall be made at the rated current of the device.

b. For horsepower-rated switches, full-load motor-running currents are given in Tables 3-9 and 3-10. The endurance test shall be made with whichever is greater the rated current of the device or the current selected from the appropriate table, except that a fused horsepower- rated switch is to be tested at 125 percent of the current value shown in Table 3-9 or 3-10. The current for the common wire of a two-phase, three-wire system is 1.414 times the value in Table 3-9 for a two-phase, four-wire system.

3.2.3.2.3 Power Factor

0.70–0.80 (AC test only).

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3.2.3.2.4 Frequency

60 Hz (AC test only).

3.2.3.2.5 Ambient Temperature and Humidity

The endurance tests outlined above shall be performed at an ambient temperature in the range of 25+5°C (77+9°F) and at room humidity.

3.2.3.2.6 Number of Operations

Heavy-duty switches shall perform successfully when operated for the required number of operations shown in Columns 5 and 6 of Table 3-11.

All other air-break switches shall perform successfully when operated for the required number of operations shown in Columns 3 and 4 of Table 3-11.

If a fused switch is provided with an electrical or mechanical tripping mechanism, or both, in addition to the normal operating mechanism, each such mechanism shall be capable of performing successfully for 10 percent of the number of operations shown. These operations shall be permitted to be performed as part of the endurance test of 3.2.3.

Table 3-8
OVERLOAD-TEST CURRENTS FOR DC SWITCHES, IN AMPERES

Switch Rating in Horsepower	125 Volts	250 Volts	600 Volts
1	38	19	7
1-1/2	53	26	10
2	68	34	14
3	100	49	20
5	160	80	33
7-1/2	232	116	48
10	304	152	64
15	448	220	92
20	592	288	124
25	...	356	152
30	...	424	184
40	...	560	244
50	...	692	300

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Table 3-9
ENDURANCE TEST CURRENT FOR AC SWITCHES, IN AMPERES*

Switch Rating in Horse-power	120 Volts			240 Volts			480 Volts			600 Volts		
	Single Phase	Two-Phase, Four-Wire	Three Phase	Single Phase	Two-Phase, Four-Wire	Three Phase	Single Phase	Two-Phase, Four-Wire	Three Phase	Single Phase	Two-Phase, Four-Wire	Three Phase
1/2	9.8		4.4			2.2			1.1			0.9
3/4	13.8	4.8	6.4	6.9	2.4	3.2	3.5	1.2	1.6	2.8	1	1.3
1	16	6.4	8.4	8	3.2	4.2	4	1.6	2.1	3.2	1.3	1.7
1-1/2	20	9	12	10	4.5	6	5	2.3	3	4	1.8	2.4
2	24	11.8	13.6	12	5.9	6.8	6	3	3.4	4.8	2.4	2.7
3	34	16.6		17	8.3	9.6	8.5	4.2	4.8	6.8	3.3	3.9
5	56	26.4		28	13.2	15.2	14	6.6	7.6	11.2	5.3	6.1
7-1/2	80	38		40	19	22	21	9	11	16	8	9
10	100	48		50	24	28	26	12	14	20	10	11
15	135	72		68	36	42	34	18	21	27	14	17
20		94		88	47	54	44	23	27	35	19	22
25		118		110	59	68	55	29	34	44	24	27
30		138		136	69	80	68	35	40	54	28	32
40		180		176	90	104	88	45	52	70	36	41
50		226		216	113	130	108	56	65	86	45	52
60					133	154		67	77		53	62
75					166	192		83	96		66	77
100					218	248		109	124		87	99
125					270	312		135	156		108	125
150					312	360		156	180		125	144
200					416	480		208	240		167	192
250									302			242
300									361			289
350									414			336
400									477			382
450									515			412
500									590			472

*Common values for B, C, D, and E three-phase motors

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Table 3-10
ENDURANCE TEST CURRENTS FOR DC SWITCHES, IN AMPERES

Switch Rating in Horsepower	125 Volts	250 Volts	600 Volts
1	9.5	4.7	1.8
1-1/2	13.2	6.6	2.6
2	17	8.5	3.4
3	25	12.2	5.0
5	40	20	8.3
7-1/2	58	29	12
10	76	38	16
15	112	55	23
20	148	72	31
25	...	89	38
30	...	106	46
40	...	140	61
50	...	173	75

3.2.3.3 Evaluation

The switch shall be considered to be acceptable if there is no electrical or mechanical breakdown of the device nor undue pitting, burning, or welding of the contacts. The enclosure fuse referred to in 3.4.2.6 shall not have opened.

3.2.4 Strength of Insulating Base and Support Test

3.2.4.1 Sample Preparation

The insulating base of the switch shall be mounted as in actual use.

3.2.4.2 Method

The insulating base of a switch shall not be damaged when wire connectors securing short lengths of conductors of rated switch ampacity are tightened to 110 percent of the highest torque value marked on the switch or on any field-installable kit marked for use with the switch.

3.2.4.3 Evaluation

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

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3.2.5 Clamped Joint Test

Where switches incorporate a clamped joint between two insulators to provide the required spacings, the clamped joint shall be tested to ensure that it can withstand the application for one second of 5000 volts between metal parts on opposite sides of the joint without dielectric breakdown.

3.2.5.1 Sample Preparation

Two representative samples of the clamped joint shall be subjected to the following test.

3.2.5.2 Method

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

The second sample shall then be tested at a potential of: (1) 5000 V rms, 60 Hz or (2) 110 percent of the breakdown voltage of the first sample, whichever is greater. The potential shall be increased to the required value and held for one second.

3.2.5.3 Evaluation

The second sample, with the clamped joint intact, shall not break down.

Table 3-11
ENDURANCE TEST CYCLES FOR SWITCHES

Switch Ratings in Amperes	Number of Cycles of Operation per Minute*	Number of Cycles of Operation, Ampere-Rated or Ampere and Horsepower Rated			
		General Duty**		Heavy Duty	
		w/Current	w/o Current	w/Current	w/o Current
30–60	6	6000	4000	8000	7000
100	6	6000	4000	7000	7000
200	5	6000	2000	6000	6000
400	4	1000	5000	1500	6000
600	3	1000	4000	1200	4800
800	2	...	...	600†	2900
1200	1	...	...	600†	1900
1600–2500	1††	...	...	500†	1500
3000–4000	1††	...	...	400†	600
5000–6000	1††	...	...	200†	600

*The indicated number of operating cycles per minute applies only to that part of the test made with current. When no current is used, the switch shall be permitted to be operated at any convenient speed.
†Switches rated at more than 600 amperes shall be permitted to be operated without current, if the switch is marked "FOR ISOLATING USE ONLY-DO NOT OPEN UNDER LOAD."
**The exposed switch blades of a detachable pullout switch shall be permitted to be lubricated as needed to resume intended operation.
††Rate of operation -1 cycle per minute for first 10 operations, then in groups of five with a time interval between groups agreeable to all concerned.

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3.2.6 Dielectric Voltage Withstand Test

3.2.6.1 Method

The switch shall be stressed by means of a suitable 500 VA or larger transformer, the output voltage of which can be varied. The applied potential shall be increased from zero until the required test value is reached and is to be held at that value for 1 minute. The increase in the applied voltage shall be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by the voltmeter.

If an electrically actuated operating mechanism is associated with the switch, the test potential shall be twice the maximum rated control voltage plus 1000 volts and shall be applied between live parts of the actuating mechanism and the frame, except that a motor that is part of such a circuit and is rated at 250 volts or less is required to withstand a maximum potential of 1000 volts.

Some constructions, such as at a control transformer, may require the opening of a ground connection on one side of a circuit to conduct the tests.

A switch (with fuses, if any, in place) shall withstand for 1 minute the required test potential, as follows:

a. Between live parts and the enclosure with the switch closed
b. Between terminals of opposite polarity with the switch closed
c. Between the line and load terminals with the switch open

Voltage—2 times maximum rated voltage plus 1000 volts
Frequency—60 Hz, essentially sinusoidal

Exception: A double-throw switch for use in accordance with Article 702 of the *National Electrical Code* shall have the potential 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
d. Between terminals of the normal source and the alternate source with the switch in both normal and alternate positions

For a double-throw switch for use in accordance with Article 702 of the *National Electrical Code* the test specified in 3.2.6.1 shall be performed on both sets of contacts.

Exception: If the construction of both sets of contacts is representative of each other, the test need only be conducted on one set.

3.2.6.2 Evaluation

There shall be no dielectric breakdown during the dielectric voltage withstand test.

3.2.7 Fault Current Tests

The fault-current rating (short-circuit rating) of a switch shall be one or more of the values shown in Table 3-12. For switches with specified overcurrent protective devices, the rating shall not be greater than that of the specified overcurrent protective device. The rating shall be 10,000A for plug, class H, and class K fuses. The rating shall not be less than 25,000A for class CC, G, J, L, R, or T fuses.

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Table 3-12
SHORT-CIRCUIT CURRENT RATING RMS AMPERES

5,000*	25,000	65,000*
7,500*	30,000*	85,000*
10,000	35,000*	100,000
14,000*	42,000*	125,000*
18,000*	50,000	150,000*
22,000*		200,000

*These ratings are applicable only to combinations of the switch and a circuit breaker.

3.2.7.1 Requirements for Switches for 10 KA Maximum Available Fault Current Circuits

3.2.7.1.1 Fused Switches

For switches incorporating fuseholders with a continuous current rating equal to or less than the continuous current rating of the switch, no additional testing is required.

For switches incorporating fuseholders with continuous current ratings greater than the continuous rating of the switch, the following tests will be required:

a. Short-circuit withstand test at 10KA per 3.2.7.4
b. Low-level dielectric voltage withstand test per 3.2.7.5
c. Closing test at 10KA per 3.2.7.6
d. Low-level dielectric voltage withstand test per 3.2.7.5

3.2.7.1.2 Unfused Switches

Specified Overcurrent Protective Means

An unfused switch, having a 5000, 7500, or 10,000 A short-circuit rating and marked for use with overcurrent protective devices having a continuous current rating greater than that of the switch shall be subjected to the following tests (the 5000- and 7500-A ratings are applicable only to combinations of the switch and a circuit breaker):

a. Short-circuit withstand test at 5000, 7500, or 10,000 A, as appropriate, per 3.2.7.4
b. Low-level dielectric voltage Test per 3.2.7.5
c. Closing test at 5000, 7500, or 10,000A, as appropriate, per 3.2.7.6
d. Low-level dielectric voltage test per 3.2.7.5

For switch marked to specify use with overcurrent protective means with continuous current ratings less than or equal to the continuous current rating of the switch, no additional testing is required.

Unspecified Overcurrent Protective Means

For an unfused switch with a 5000-, 7500-, or 10,000-A short-circuit rating and not marked as requiring a specific circuit breaker or fuse, tests shall be run as for switches with specified overcurrent protective means, except that the test current for the short circuit withstand test and the closing test shall be maintained for three cycles.

3.2.7.2 Requirements for Switches for Greater than 10 KA Available Fault Current Circuits

These requirements specify the additional performance requirements with which switches shall comply if they are to be acceptable for use on circuits greater than 10 KA as evidenced by marking.

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3.2.7.2.1 Fused Switches

Fused switches for use on circuits capable of delivering more than 10,000A shall undergo the following tests:

a. Close-open test per 3.2.7.3
b. Dielectric voltage withstand test per 3.2.6
c. Short-circuit withstand test at 25,000, 50,000, 100,000, or 200,000 A as appropriate per 3.2.7.7
d. Low-level dielectric voltage withstand test per 3.2.7.5
e. Closing test at 25,000, 50,000, 100,000, or 200,000 A as appropriate per 3.2.7.8
f. Low-level dielectric voltage withstand test per 3.2.7.5

3.2.7.2.2 Unfused Switches with Specified Overcurrent Protective Means

An unfused switch marked for use with specified fuses or circuit breakers, for use on circuits capable of delivering more than 10,000 A, shall undergo the following tests:

a. Close-open test per 3.2.7.3
b. Dielectric voltage withstand test per 3.2.6
c. Short-circuit withstand test at the appropriate fault current level from Table 3-12 per 3.2.7.7
d. Low level dielectric voltage withstand test per 3.2.7.5
e. Closing test per 3.2.7.8
f. Low-level dielectric voltage withstand test per 3.2.7.5.

3.2.7.3 Close-Open Test

3.2.7.3.1 Sample Preparation

A previously untested sample shall be used. The line terminals of the switch are to be connected to the power supply circuit as described in 3.4.2.1 and 3.4.2.6 and the load terminals of the switch are to be connected to an inductive load. (See Figure 3-1.)

3.2.7.3.2 Method

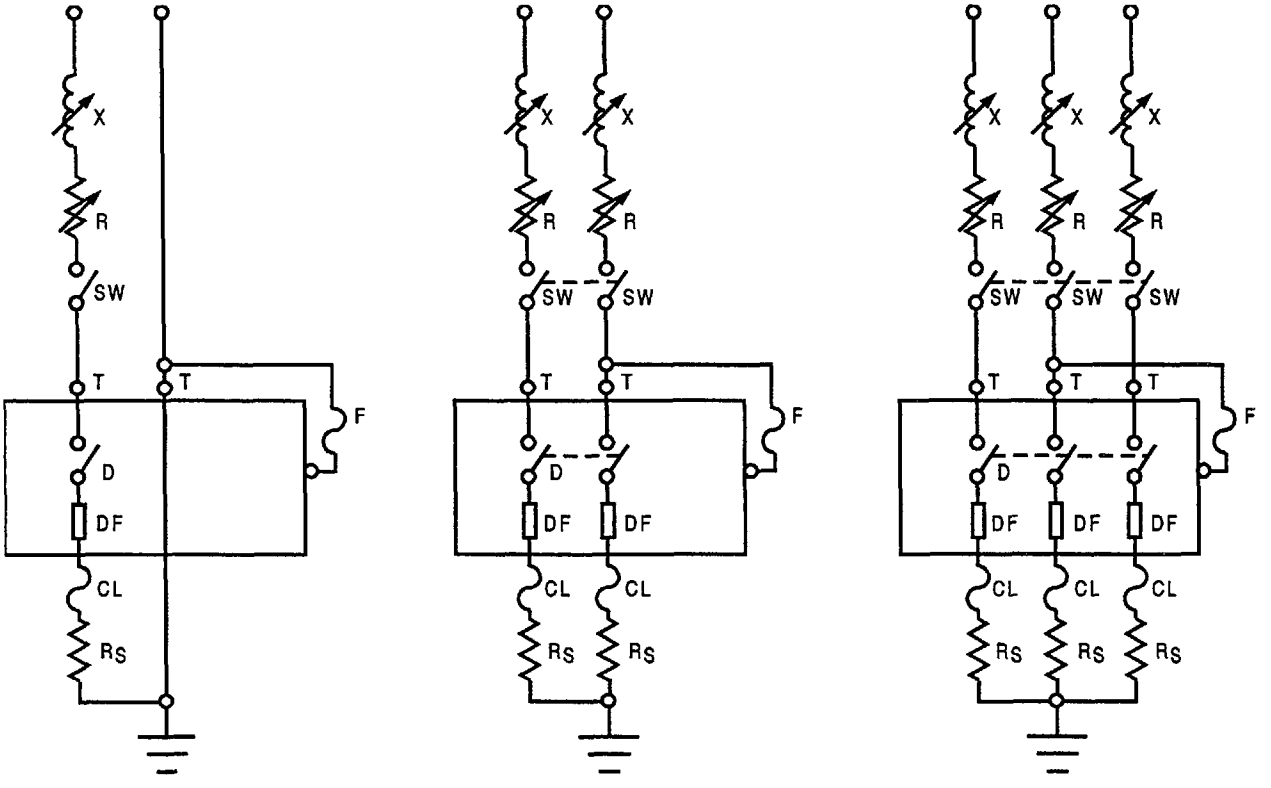
A switch shall perform successfully when actuated for the number of close-open operations indicated in Table 3-13, making and breaking required current. The rate of operation is not specified. The blades and jaws shall be permitted to be serviced before each operation. Servicing shall be considered to be filing, lubricating, deburring, and such. No disassembly of the sample is permitted to accomplish the servicing. Servicing shall not include replacement of any part.

For class L fused switches without horsepower ratings, if characteristics such as pinch effect (magnetic attraction between current-carrying parts), as determined by a test of two samples, prevents the opening at 600 percent of rated current, the test current shall be reduced to that at which the switch can be opened but to not less than 480 percent of rated current. If the switch does not open by 480 percent, it is considered unacceptable.

NOTE—For some constructions, such as a control transformer, it may be necessary to open a ground connection on one side of a circuit to conduct the tests. (Note approved as Authorized Engineering Information.)

For class L fused switches without horsepower ratings, each closing and opening operation cycle shall be permitted to consist of: (1) closing under load, (2) opening under no-load, (3) closing under no-load, and (4) opening under load. All required operations, however, shall be made using the same test sample. Servicing is only permitted after each complete cycle.

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X = VARIABLE TAP AIR-CORE REACTOR
R = VARIABLE RESISTOR
SW = CLOSING SWITCH - MAY BE LOCATED AS SHOWN OR AHEAD OF LIMITING IMPEDANCE
F = ENCLOSURE FUSE
D = DEVICE UNDER TEST
R_S = COAXIAL SHUNTS FOR METERING CURRENT
C.L.= CURRENT-LIMITING FUSES USED DURING TEST. TO BE INSTALLED IN SWITCHES OR MOUNTED EXTERNALLY AS SHOWN
DF = DUMMY FUSE
T = TEST TERMINALS

COMMON CONNECTION OF OUTER SHELLS OF COAXIAL SHUNTS MAY BE GROUNDED IF NO OTHER GROUNDS ON THE CIRCUIT.

Figure 3-1
CIRCUIT FOR WITHSTAND AND CLOSING TESTS

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For class L fused switches without horsepower ratings, in the closing operations indicated in Table 3-13, the contacts are not required to go to the full extent of their travel if such is the result of forces resulting from the overload current that is passing through the device. A switch that does not close fully or will not open at 600 percent of rated current shall be investigated to determine if any hazard or overheating is caused.

The test circuit power factor shall be as indicated in Table 3-14, except that a lower power factor shall be permitted to be used if agreeable to those concerned.

Table 3-13
CLOSE-OPEN TEST OPERATION

Type of Switch	Number of Operations
Polyphase	3
Single Phase	5

Voltage—in accordance with 3.4.1
Current—6 times rated current
Frequency—60 Hz

Table 3-14
TEST CIRCUIT POWER FACTOR

Switch Ampere Rating	Power Factor
30–1200	0.45–0.50
1600–2500	0.25–0.30
3000–6000	0.15–0.20

3.2.7.3.3 Evaluation

At the conclusion of this test, the switch shall be in operating condition or capable of being put into operable condition by servicing (per 3.2.7.3.2), but such servicing shall not be performed prior to the dielectric test in 3.2.7.5. The fuse described in 3.4.2.6 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.

Upon completion of the close-open test, the test sample shall not be serviced in any manner and shall be subjected to the dielectric test noted in 3.2.7.5.

3.2.7.4 Short-Circuit Withstand Test (10,000 Maximum Short-Circuit Rating)

3.2.7.4.1 Sample Preparation

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 of 4 ft. (1.22 m) per terminal, each of which has an ampacity not less than the current rating of the switch.

A deadfront switch shall be tested when installed in a representative panelboard or on a representative chassis in accordance with 3.2.7.7.1. The switch shall be mounted in the top position and any unused positions in the panelboard and the load terminals of the switch shall be connected to the corresponding test circuit terminals with leads complying with 3.2.7.7.1.

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The open-circuit voltage of the power-supply circuit shall not be less than the maximum rated voltage of the switch. The circuit is to be as indicated in Figure 3-1. External overcurrent protective devices are to be connected where the CL fuses are indicated.

The power factor of the circuit shall be 0.45-0.50, lagging.

The enclosure of the switch shall be connected through a 30-A nonrenewable cartridge fuse acceptable for branch circuit use. The fuse shall have a voltage rating not less than the rating of the switch being tested. It shall be connected to the pole of the switch considered least likely to arc to the enclosure. This connection shall be made to the load side of the limiting impedance by a No. 10 AWG copper wire having a length of 4–6 ft. (1.22–1.83 m).

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

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

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

3.2.7.4.2 Test Method

A circuit of 5000, 7500, or 10,000 A rms available symmetrical current, shall be closed on the sample. For a switch marked for use with external fuses or a specified circuit breaker, the switch shall withstand the designated current until the overcurrent protective device(s) opens.

3.2.7.4.3 Evaluation

After the circuit is opened:

a. The fuse connected to the enclosure shall not have opened
b. There shall be no breakage to the extent that the integrity of the mounting of live parts is impaired
c. The door shall be kept from being blown open by its latch, without bolt or lock installed therein, (deformation of the case alone is considered to be acceptable)
d. The switch shall be capable of being opened manually with the operating handle
e. Fuses, if within the switch, shall not be completely ejected from the clips, and no fuse shall bridge from a fuse clip to dead metal

3.2.7.5 Low-Level Dielectric Voltage Withstand Test

A switch that has been subjected to the short-circuit withstand test (unless the same sample is to be subject to the closing test) and a switch that has been subjected to the closing test shall comply with the requirements in 3.2.6, except that the test potential is to be twice the rated voltage of the switch, but not less than 900 V.

3.2.7.6 Closing Test (10,000 A Maximum Short-Circuit Rating)

The sample for this test shall be that used for the short circuit withstand test (see 3.2.7.4) or a previously untested sample. The conditions of the closing test shall be the same as for the short-circuit withstand test. Complete physical closure of the switch contacts need not be established.

A sample of the switch shall be closed on a circuit capable of providing a current equal to the short-circuit rating. After the circuit has cleared, the switch shall comply with the requirements in 3.2.7.4.

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3.2.7.7 Short-Circuit Withstand Test (Greater than 10,000 A Short-Circuit Rating)

3.2.7.7.1 Sample Preparation

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 of 4 ft. (1.22 m) per terminal, each of which has an ampacity not less than the current rating of the switch. For a switch with an integral fuseholder, a test link consisting of 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 can 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.

Exception: Leads more than 4 ft. (1.22 m) in length may be used if the excess length over 4 ft. (1.22 m) is included in the test circuit when it is calibrated.

A deadfront switch shall be tested when installed in a representative panelboard or on a representative chassis in accordance with 3.2.1.4.1, 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 can 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 with short copper wire leads, maximum of 4 ft. (1.22 m) per terminal. 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. The ampacity of the load leads shall be not less than the ampere rating of the switch under test.

Exception: Leads more than 4 ft. (1.22 m) in length shall be permitted to be used if the excess length over 4 ft. is included in the test circuit when it is calibrated.

The overcurrent protective devices shall be one of the following:

a. For fused switches, fuses as described below
b. For unfused switches, externally connected fuses as described below or circuit breakers as marked on the switch

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

The fuse referred to in the preceding paragraph 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.

Fuses used for tests are to be selected from a lot from which two samples have been selected if the fuses are of Class CC, G, J, R (RK5), or T and one sample if the fuse is Class L and which have been calibrated to determine that their I^2t and Ip characteristics comply with the prescribed values.

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

The current available and other circuit characteristics shall be determined as indicated in 3.4.

The open-circuit voltage of the power-supply circuit shall not be less than the maximum rated voltage of the switch.

The available rms symmetrical short-circuit current in amperes shall not be less than the marked short-circuit current rating of the switch.

The circuit shall be as indicated in Figure 3-1 with any overcurrent protective 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.

Exception: Overcurrent protection means shall be permitted to be connected on the line side of an unfused switch, if the switch is marked to specify that the fuses (or circuit breaker) shall be installed ahead of the switch.

The power factor of the circuit shall be 0.25–0.30 lagging for a circuit of 10,001–20,000 A, and 0.15–0.20 lagging for circuits more than 20,000 A.

The enclosure of the switch shall be connected through a 30 A nonrenewable type fuse to the pole of the switch considered least likely to arc to the enclosure. The fuse shall have a voltage rating not less than the rating of the switch being tested. This connection shall be made to the load side of the limiting impedance by a No. 10 AWG (5.3 mm) copper wire having a length of 4–6 ft. (1.22–1.83 m).

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

3.2.7.7.2 Test Method

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

3.2.7.7.3 Evaluation

After the circuit is opened:

a. Neither end of a bar or tube as described in 3.2.7.7.1 shall be completely ejected from the fuse clips and no line end of a bar or tube shall bridge from a fuse clip to dead metal
b. The switch shall be capable of being opened manually with the operating handle
c. The fuse connected to the enclosure shall not have opened
d. There shall be no breakage to the extent that the integrity of the mounting of live parts is impaired
e. The door shall be kept from being blown open by its latch, without bolt or lock installed therein. Deformation of the case alone is not considered to constitute an unacceptable result.

3.2.7.8 Closing Test (Greater than 10,000 A Short-Circuit Rating)

The sample for this test shall be the one used for the short-circuit withstand test in 3.2.7.7, or a previously untested sample. The conditions of the closing test shall be the same as for the short circuit withstand test. Complete physical closure of the switch contacts need not be established.

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A switch shall be closed on a circuit capable of providing the maximum short-circuit withstand current for which the switch is rated. After the circuit has cleared, the switch shall comply with the requirements in 3.2.7.7.3 and 3.2.7.5.

3.2.8 Contact Opening Test

3.2.8.1 Method

A switch that is electrically operated or that has an electrical tripping mechanism shall be capable of being operated electrically to break levels of current as indicated in Table 3-15. The number of operations shall be in accordance with Table 3-13.

All required operations shall be made using the same test sample and the contacts shall be permitted to be serviced but not replaced after each operation.

Switches shall be tested at the rated voltage of the switch with the switch connected as shown in 3.2.2, except that a switch that has been subjected to the close-open test in 3.2.7.3 at six times rated current, shall be permitted to be connected as shown in Figure 3-1 with the external fuses omitted.

Test links shall be installed in the switch for this test. If the fuse mounting means are located in or near the arcing zone of the switch, the test links shall resemble the actual fuse intended for use in the mounting means in physical configuration.

Circuit parameters for the test shall be as follows:

a. Voltage in accordance with 3.4.1
b. Current in accordance with Table 3-15
c. Frequency 60 Hz
d. Power Factor in accordance with Table 3-14

3.2.8.2 Evaluation

At the conclusion of this test, the switch shall be in operable condition or capable of being put into operable condition by servicing, but such servicing shall not be performed prior to dielectric withstand test. The fuse described in 3.4.2.6 shall not have opened.

Upon completion of the contact opening test, the test sample shall not be serviced in any manner and shall be subjected to the dielectric test noted in 3.2.6.

Table 3-15
CONTACT OPENING-CURRENT MULTIPLIER

Type of Switch	Test Current
Electrically operated	10 X Rating*
Electrically tripped	10 X Rating
Electrically tripped—For use with class II ground-fault sensing and relaying equipment	10 X Rating
Electrically tripped—with integral lockout—for use with class I ground-fault sensing and relaying equipment	10 X Rating
Electrically tripped—without integral lockout—for use with class I ground-fault sensing and relaying equipment	12 X Rating

*May be six times rated current if the time required to open the switch with the electrical operator is not less than 1-1/2 seconds after initiation of the operator. Need not be performed if close-open test in 3.2.7.3 was conducted at six times rated current.

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3.2.9 Enclosure Tests

3.2.9.1 New switches shall meet the requirements of NEMA Standard 250 with switch mechanisms installed in the appropriate enclosure.

When operating handles extend outside of the enclosure, the following conditions shall be met:

a. If the endurance test can affect the outcome of applicable enclosure tests, the endurance sequence shall be performed on the enclosure to be evaluated prior to said enclosure test.

b. If the physical position of external operating handles can affect the outcome of applicable enclosure tests, the position deemed most detrimental shall be the one used for the enclosure tests. If most detrimental position is not obvious, tests shall be run in both the on and off positions.

3.2.9.2 Bonding Continuity Test

To verify adequate bonding continuity between the switch enclosure, cover, and any conductive operating handle, the resistance of the joints shall be tested in accordance with 3.2.9.2.1 through 3.2.9.2.3.

3.2.9.2.1 Sample Preparation

The switch enclosure and its cover shall be mounted as in actual service with all gaskets in place and fastening devices tightened in the intended manner.

3.2.9.2.2 Method

The resistance of the bond shall be determined by calculation from the voltage drop measured between two file marks, each located not more than 1/16 inch (1.6 mm) on opposite sides of the joint with 30 A flowing through the connection.

3.2.9.2.3 Evaluation

The resistance of the joint shall not exceed 0.005 ohms.

3.2.10 Operational Test

A switch that employs an electrical operating mechanism shall be subjected to the tests as described in 3.2.10.1 through 3.2.10.4.

3.2.10.1 An electrically operated trip 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.

3.2.10.2 A motor-operated mechanism shall operate successfully at 85 percent of its rated voltage to both close and open the switch, except that a motor operated mechanism designed to function when a ground fault exists shall operate successfully to open the switch at 55 percent of its rated voltage.

3.2.10.3 An electrically operated 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.

3.2.10.4 The capacitors of electrically operated trip mechanisms in which the tripping power is derived from capacitors, shall hold sufficient charge to open the switch a minimum of 5 seconds after loss of charging power when the capacitors have been supplied from a source of voltage 75 percent of the system rated voltage.

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3.3 Verification Testing

3.3.1 Construction

Inspection of switches and components thereof shall be made by the manufacturer to verify compliance with construction standards.

All switches shall be mechanically checked prior to shipment for the following:

a. On/off operation
b. Cover and mechanism interlock operation, if applicable
c. Fuse spacing

The dielectric voltage test described in 3.2.6 shall be performed on representative production samples.

Exception: (a.) The holding time at the required voltage shall be permitted to be reduced to one second if the test potential is increased 20 percent.

3.3.2 Performance

Testing shall be performed on representative samples of enclosed switches as described in Table 3-16 in order to verify their performance.

3.4 Test Circuits and Calibration of Circuit and Instruments

3.4.1 Test Voltages on Current-interrupting Tests

All current-interrupting tests shall be made on test circuits so adjusted that the closed-circuit voltage is not less than the rated voltage of the switch.

Exceptions:

a. For the overload and endurance tests on a switch, rated at more than 100 amperes and greater than 25 Hp, the closed-circuit voltage shall be permitted to be as much as 10 percent less than the rated voltage of the switch if the open-circuit voltage is not less than the rating of the switch nor more than 110 percent of the rated voltage of the switch.
b. For the close-open and contact opening test, the circuit on which the test is conducted shall have a normal frequency recovery voltage equal to the rated voltage of the device, except that the recovery voltage need not be determined if the closed-circuit voltage is not less than 90 percent of the rated voltage of the device. In any case, the open-circuit voltage shall not be less than 100 percent of the rated voltage.
c. The test voltage for a dc rated device shall be within 5 percent of the rated voltage of the switch for the endurance test.

Table 3-16
PERFORMANCE TESTS

Test	Clause
Heating	3.2.1
Overload	3.2.2
Endurance	3.2.3
Dielectric	3.2.6
Fault current	3.2.7
Contact opening	3.2.8

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3.4.2 Supply Circuits

3.4.2.1 AC Switches

An enclosed 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 frequency of 60 Hz, except that a lower frequency may be employed if agreeable to those concerned. Resistance and reactance components of the load shall not be connected in parallel, except that an air-core reactor in any phase may be shunted by resistance, the loss in which is approximately one percent of the total power consumption in that phase. The shunting resistance used with an air-core reactor shall be permitted to be calculated from the formula:

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

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

3.4.2.2 DC Switches

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

3.4.2.3 Two- and Three-Wire Switch with Solid Neutral

A two-wire and a three-wire enclosed switch intended for use on either three-wire dc or single-phase ac circuits with grounded neutral shall be tested on a three-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 3.4.2.6. If the enclosed switch is intended for use with alternating current only, it shall be tested with alternating current in a similar manner and in accordance with 3.4.2.1.

3.4.2.4 Three-Wire Switch without Solid Neutral and Four-Wire Switch with Solid Neutral

A three-wire enclosed switch without a solid neutral intended for use on ac circuits other than that described in 3.4.2.3 above and a four-wire enclosed switch having a solid neutral shall be tested on a three-phase circuit with a three-phase balanced load.

3.4.2.5 Four-Wire Switch without Solid Neutral and Five-Wire Switch

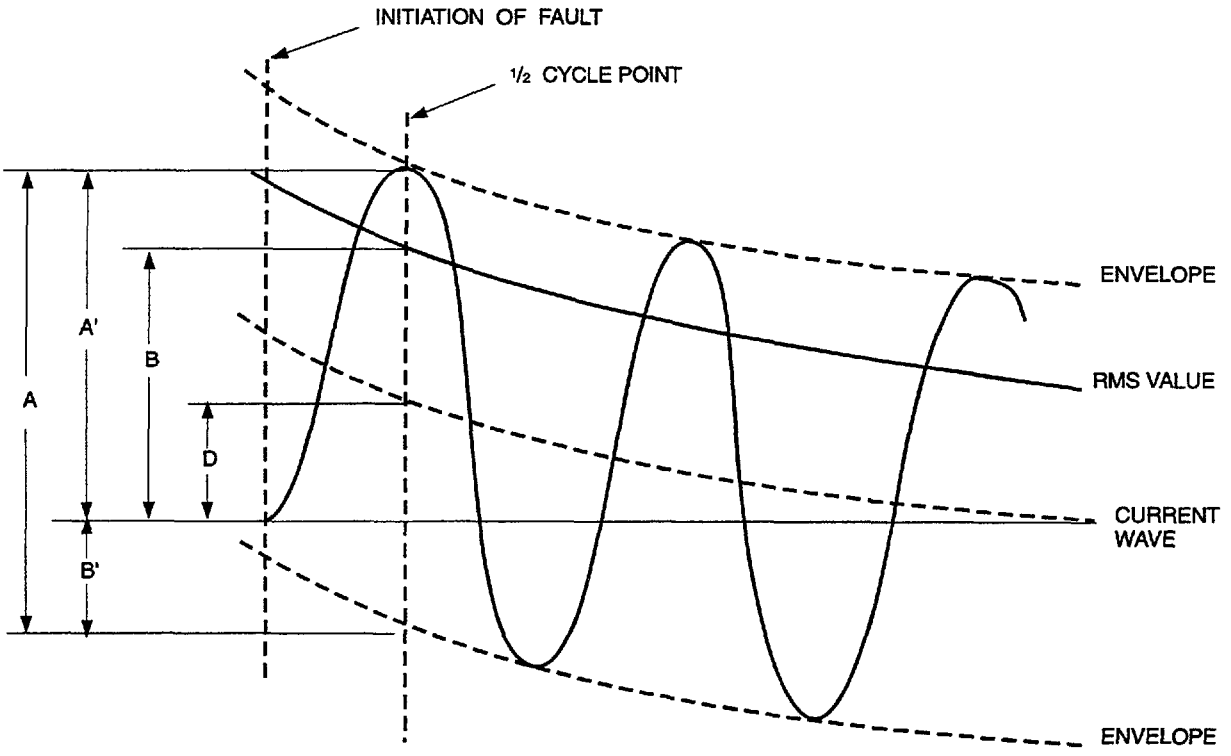
A four-wire enclosed switch without a solid neutral and a five-wire enclosed switch shall be tested on a single-phase circuit with connections to adjacent poles, one pole being that nearest the enclosure. If the spacings between the poles differ, an additional test shall be made with connections to the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

3.4.2.6 Enclosure Fuse

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

This fuse shall be a nonrenewable, nontime delay fuse having a voltage rating not less than the voltage rating of the device being tested.

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I = INSTANT FOR WHICH MEASUREMENT IS MADE (½ CYCLE)
A' = MAJOR ORDINATE
B' = MINOR ORDINATE
A = PEAK TO PEAK VALUE OF ALTERNATING COMPONENT = A' + B'

$D = \text{DC COMPONENT} = A' - \frac{A}{2}$

B = RMS ASYMMETRICAL CURRENT

$$= \sqrt{\left(\frac{A}{2.828}\right)^2 + D^2}$$

Figure 3-2
MEASUREMENT OF THE RMS VALUE OF AN ASYMMETRICAL WAVE

3.4.3 Supply Circuit

3.4.3.1 The circuit shall be as indicated in Figure 3-3 and shall include the necessary measuring equipment and the fuse mounting means. It shall be evaluated for instrumentation and calibration in accordance with 3.4.4 and 3.4.5.

3.4.3.2 The enclosure of the device shall be connected through a 30 A nonrenewable, nontime-delay fuse, having a voltage rating not less than the rating of the switch being tested, to the pole of the switch considered least likely to arc to the enclosure. This connection shall be made to the load side of the limiting impedance by a No. 10 AWG copper wire having a length of 4–6 ft. (1.22–1.83 m).

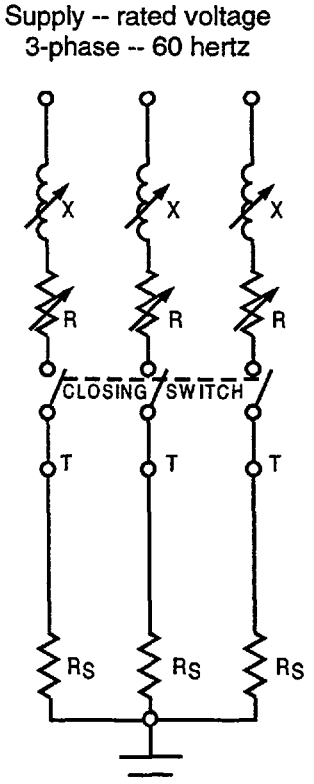
This fuse is to be a nonrenewable, nontime delay fuse having a voltage rating not less than the voltage rating of the device being tested.

3.4.3.3 For two-pole devices tested on a single-phase circuit, synchronous closing shall be employed so that maximum current flow (Ip) is obtained.

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3.4.4 Calibration of Fault Current Test Circuit

The test circuit shall be calibrated in accordance with the following clauses. The calibration tests shall be conducted with the test terminals connected together by means of an appropriate number of copper bars. The circuit shall be as shown in Figure 3-3.



X = VARIABLE TAP AIR-CORE REACTOR
R = VARIABLE RESISTOR
T = TEST TERMINALS
R_S = MANUFACTURER'S SHUNTS FOR METERING CURRENT. COAXIAL SHUNTS MAY HAVE SHELL GROUNDED IF NO OTHER GROUNDS ON CIRCUIT

COMMON CONNECTION OF OUTER SHELLS OF COAXIAL SHUNTS MAY BE GROUNDED IF NO OTHER GROUNDS ON THE CIRCUIT.

Figure 3-3
TEST CIRCUIT VERIFICATION

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3.4.4.1 Current

The rms symmetrical current shall be determined with the test terminals short-circuited by a shunt of negligible impedance by measuring the ac component of the wave at an instant 1/2 cycle (on the basis of a 60 Hz timing wave) after the initiation of the short circuit. The current shall be calculated in accordance with Figure 3-2.

For a three-phase test circuit, the rms total current shall be the average of all three phases, provided that the components of the circuit are such that essentially equal impedances (and currents) exist in all phases.

For a single-phase circuit, one test shall be made at the closing angle that will produce maximum current offset for the power factor employed.

The currents determined in accordance with the foregoing shall be not less than the intended rated interrupting rating involved.

3.4.4.2 Voltage

The open-circuit voltage shall be 100 to 105 percent of the rated voltage for the test being conducted, except that a voltage higher than 105 percent may be used if agreeable to all concerned.

3.4.4.3 Power Factor

The power factor shall be determined at an instant 1/2 cycle (on the basis of a 60 Hz timing wave) after the short-circuit occurs. Both the total asymmetrical rms amperes and the symmetrical rms amperes shall be measured in accordance with 3.4.4.1 and the ratio M_A or M_M calculated as follows:

$$\text{Ratio } M_A \text{ (for three-phase tests)} = \frac{\text{Average of 3 phases asymmetrical rms amperes}}{\text{Average of 3 phases symmetrical rms amperes}}$$

$$\text{Ratio } M_M \text{ (for single-phase tests)} = \frac{\text{Asymmetrical rms amperes}}{\text{Symmetrical rms amperes}}$$

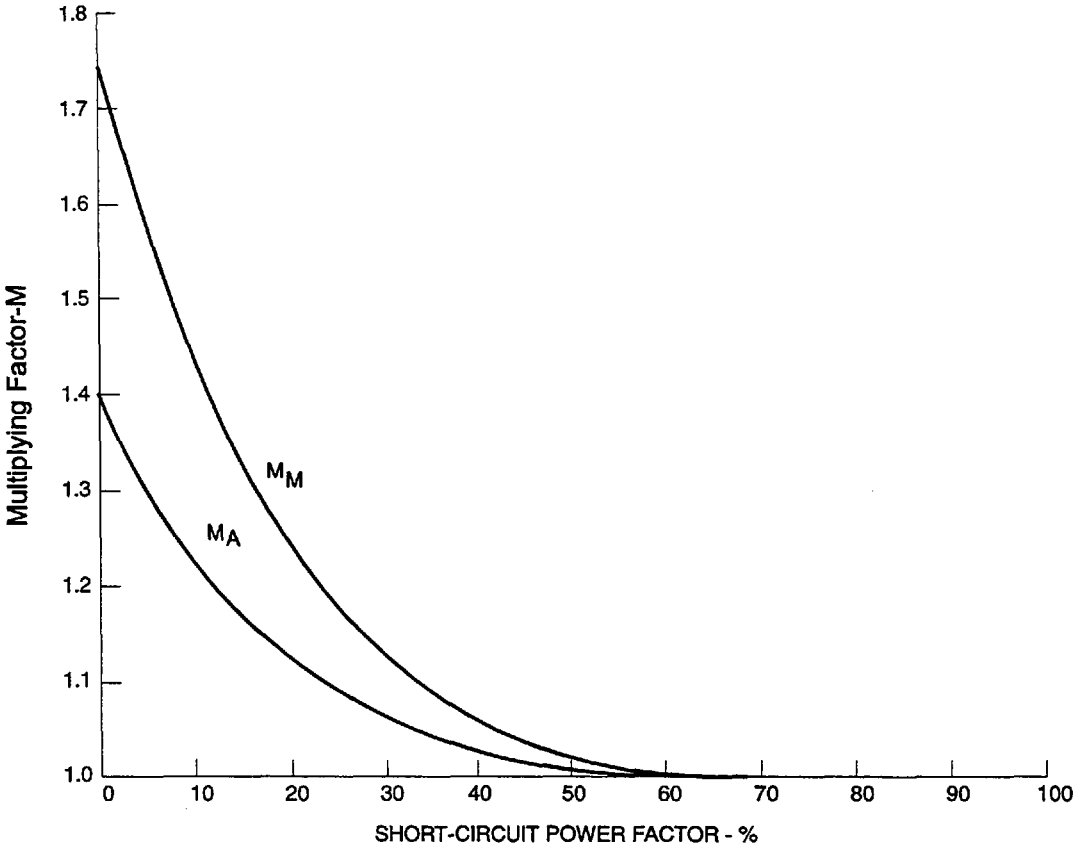
Using ratio M_A or M_M, the power factor shall be determined from Figure 3-4. For more accurate determination of the power factor, see Table 3-17.

The recovery voltage shall be at least equal to the rated voltage of the switch. The peak value of the recovery voltage within the first full half cycle after clearing and for the next five successive peaks shall be at least equal to 1.414 times the rms value of the rated voltage of the switch. Each of the peaks shall be displaced by not more than 10 electrical degrees from the peak values of the open-circuit recovery voltage, that is, the displacement of the peak from its normal position on a sinusoidal wave. The average of the instantaneous values of recovery voltage of each of the first six half cycles measured at the 45-degree and 135-degree points on the wave shall be not less than 85 percent of the rms value of the rated voltage of the switch. The instantaneous value of recovery voltage, measured at the 45-degree and 135-degree points of each of the first six half cycles, shall in no case be less than 75 percent of the rms value of the rated voltage of the switch.

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

The power factor of a three-phase circuit may also be calculated by using controlled closing so that, upon subsequent closings, a different phase will be caused to have maximum asymmetrical conditions. Each phase would then have the power factor determined by using the method described for single-phase circuits. The power factor of the three-phase circuit is considered to be the average of the power factors determined for each of the phases.

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NOTE—Multiplying factors to obtain short circuit asymmetrical current from symmetrical values, at a instant one-half cycle (60 Hz basis) after initiation of a fault.

Figure 3-4
POWER FACTOR

3.4.5 Instrument Calibration

Where an instrument employing magnetically deflected galvanometers is used for calibration of the test circuit, it shall conform to the following:

3.4.5.1 Frequency Response

The galvanometers in a magnetic oscillograph that is used for recording voltage and current during circuit calibration and testing shall be of a type having a flat (±5 percent) frequency response from 50 to 1200 cycles per second.

An audio-oscillator having output impedance and output voltage suitable for driving a magnetic-oscillograph galvanometer and capable of delivering at least 100 rms milliamperes with a wave form that remains sinusoidal within ±5 percent over a frequency range of 50 to 1200 Hz shall be used. The frequency of the signal applied to the galvanometer shall be increased gradually. The peak-to-peak amplitude of the galvanometer deflection shall not increase or decrease by more than 5 percent throughout this frequency range when corrected output voltage is supplied to the galvanometer and the sensitivity is adjusted to produce a deflection not less than 25 mm (1 inch).

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3.4.5.2 Calibration

a. When a shunt is used to determine the circuit characteristics, a dc calibrating voltage should normally be used. The voltage applied to the oscillograph galvanometer circuit shall result in a deflection of the galvanometer approximately equivalent to that expected when the same galvanometer circuit is connected to the shunt and the nominal short-circuit current is flowing. The voltage shall be so applied as to cause the galvanometer to deflect in both directions. Additional calibrations shall be made using approximately 50 percent and 150 percent of the voltage used to obtain the deflection indicated above except that if the anticipated maximum deflection is less than 150 percent, such as in the case of a symmetrically closed single-phase circuit, any other suitable calibration point shall be chosen.

   The sensitivity of the galvanometer circuit in volts per inch (or millimeters) shall be determined from the deflection measured in each case, and the results of the six trails averaged.

   The peak amperes per inch (or millimeter) shall be obtained by dividing the sensitivity by the resistance of the shunt. This multiplying factor shall be used for the determination of the rms current.

b. A 60 Hz sinusoidal potential may be used for calibrating the galvanometer circuit, using the same general method described in item a. The resulting factor shall be multiplied by 1.414.

c. When a current transformer is used to determine the circuit characteristics, an alternating current shall be used to calibrate the galvanometer circuit. The value of current applied to the galvanometer circuit shall result in a deflection of the galvanometer approximately equivalent to that expected when the same galvanometer is connected to the secondary of the current transformer and nominal short-circuit current is flowing in the primary. Additional calibrations shall be made at approximately 50 percent and 150 percent of the current used to obtain the deflection indicated above, except that if the anticipated maximum deflection is less than 150 percent, such as in the case of a symmetrically closed single-phase circuit, any other suitable calibration point shall be chosen. The sensitivity of the galvanometer circuit in rms amperes per inch (or millimeter) shall be determined in each case and the results averaged. The average sensitivity shall be multiplied by the current-transformer ratio and by 1.414 to obtain peak amperes per inch (or millimeter). This constant shall be used for the determination of the rms current.

3.4.5.3 Displacement Differences

All of the galvanometer elements shall line up properly in the oscillograph, or the displacement differences shall be noted and used as needed.

3.4.5.4 Sensitivity and Recording Speed

The sensitivity of the galvanometer and the recording speed shall be sufficient to provide a record from which values of voltage, current, and power factor can be measured accurately. The recording speed shall not be less than 60 inches per second, and higher speeds are recommended.

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Table 3-17
POWER FACTOR DETERMINATION

Short-Circuit Power Factor, Percent	Short-Circuit X/R Ratio	Multiplying Factor: Maximum 1 Phase rms Amperes at 1/2 Cycle (Curve MM)	Multiplying Factor: Average 3-Phase rms Amperes at 1/2 Cycle (Curve MA)	Short-Circuit Power Factor, Percent	Short-Circuit X/R Ratio	Multiplying Factor: Maximum 1 Phase rms Amperes at 1/2 Cycle (Curve MM)	Multiplying Factor: Average 3-Phase rms Amperes at 1/2 Cycle (Curve MA)
0	...	1.732	1.394	29	3.3001	1.139	1.070
1	99.995	1.696	1.374	30	3.1798	1.130	1.066
2	49.990	1.665	1.355	31	3.0669	1.121	1.062
3	33.318	1.630	1.336	32	2.9607	1.113	1.057
4	24.980	1.598	1.318	33	2.8605	1.105	1.053
5	19.975	1.5668	1.301	34	2.7660	1.098	1.049
6	16.637	1.540	1.285	35	2.6764	1.091	1.046
7	14.251	1.511	1.270	36	2.5915	1.084	1.043
8	12.460	1.485	1.256	37	2.5109	1.078	1.039
8.5	11.723	1.473	1.248	38	2.4342	1.073	1.036
9	11.065	1.460	1.241	39	2.3611	1.068	1.033
10	9.9499	1.436	1.229	40	2.2913	1.062	1.031
11	9.0357	1.413	1.216	41	2.2246	1.057	1.028
12	8.2731	1.391	1.204	42	2.16008	1.053	1.026
13	7.6270	1.372	1.193	43	2.0996	1.049	1.024
14	7.0725	1.350	1.182	44	2.0409	1.045	1.022
15	6.5912	1.330	1.171	45	1.9845	1.041	1.020
16	6.1695	1.312	1.161	46	1.9303	1.038	1.019
17	5.7967	1.294	1.152	47	1.8780	1.034	1.017
18	5.4648	1.277	1.143	48	1.8276	1.031	1.016
19	5.1673	1.262	1.135	49	1.7790	1.029	1.014
20	4.8990	1.247	1.127	50	1.73321	1.026	1.013
21	4.6557	1.232	1.119	55	1.5185	1.015	1.008
22	4.4341	1.218	1.112	60	1.3333	1.009	1.004
23	4.2313	1.205	1.106	65	1.1691	1.004	1.002
24	4.0449	1.192	1.099	70	1.0202	1.002	1.001
25	3.8730	1.181	1.093	75	0.8819	1.0008	1.0004
26	3.7139	1.170	1.087	80	0.7500	1.0002	1.00005
27	3.5661	1.159	1.081	85	0.6197	1.00004	1.00002
28	3.4286	1.149	1.075	100	0.0000	1.00000	1.00000

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3.5 ADDITIONAL PULLOUT SWITCH TESTS

3.5.1 Heating with Fuses Test (Class H or K)

30 A and 60 A pullout switch intended for use with Class H or K fuses shall be subjected to this test with non renewable time delay Class R or K fuses. Where the construction is essentially the same, a test of a 60 A shall represent the 30 A.

Sample Preparation—The pullout switch shall be mounted in a metal enclosure as described in 3.2.1.1. Class R or K fuses shall be used in place of test links. Class R fuses when used, shall be other than the time-delay type.

Method—The selected fuses shall be subjected to a heating test in free air in open-type fuseholders at 110 percent of rated current in accordance with the temperature test procedure in UL 198B. The fuse ferrule and body temperatures shall be measured using thermocouples.

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

The same fuses shall then be placed in the pullout switch and the switch subjected to a temperature test with current adjusted to 80 percent of the switch rating. Except for using Class R or K fuses in place of the test links and the current, the test conditions shall be as described in 3.2.1.1. The fuse thermocouples shall be located at the same points as when tested in free air.

Evaluation—The temperature rise on the fuse ferrule and on the body when tested at 80 percent in the pullout switch shall not exceed the temperature rise on the same fuse recorded during the test in free air at 110 percent. The temperature rise on insulating or sealing materials of the switch shall be at least 40°C (72°F) less than the maximum temperature in °C (°F) for which they have been found acceptable. The temperature rise at field wiring terminals shall not be more than 50°C (90°F) for terminals identified for use with 60°C (140°F) wire and 65°C (117°F) for terminals identified for use with 75°C (167°F) wire.*

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

3.5.2 Heating with Fuses Test (Class CC, G, J, or R)

30 A or 60 A pullout switch intended for use with Class CC, G, J or R fuses shall be subjected to this test with actual fuses in place. Where the construction is essentially the same, a test of a 60 A shall represent the 30 A.

Sample Preparation—The pullout switch shall be mounted in a metal enclosure as described in 3.2.1.1. Class CC, G, J, or R fuses shall be used in place of test links. Class R fuses when used shall be of other than the dual-element type.

Method—The current for the test shall be adjusted to 80 percent of the switch rating. Except for fuses being used in place of test links and the current, the test conditions shall be as described in 3.2.1.1.

Evaluation—During this test, the temperature rise on the line and load terminal shall not be more than 50°C (90°F) for terminals identified for use with 60°C (140°F) wire and 65°C (117°F) for terminals identified for use with 75°C (167°F) wire*, and on other current-carrying parts shall not be more than 35°C (63°F) above the values given in Table 3-2. No fuse link shall open during the test. The temperature rise on insulating or sealing materials of the switch shall be at least 40°C (72°F) less than the maximum temperature in degrees Celsius (degrees Farenheit) for which the materials have been found acceptable.

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

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3.5.3 Pullout Switch Overload-Cycle Heating Test

Pullout switches are to be additionally evaluated for the effects of heating at fuse terminals by means of an overload-cycle-heating test.

Sample Preparation—The pullout switch shall be mounted in a metal enclosure with the door and other openings closed as described in 3.2.1.1. The test wire used shall be in accordance with 3.2.1.1.

Method—Test links shall be used that are reduced in cross section or are made of material that will produce the required results. The test links may also be heated internally or externally by a resistance energized from a separate source to produce the required results. The surfaces of the ferrule or blade of each dummy fuse that makes electrical contact with the clip of the fuseholder shall be made of uniplated copper or copper alloy and shall be cleaned and reconditioned as necessary. These surfaces shall then be allowed to oxidize at room ambient for at least 30 days before being inserted in the fuseholders. The current shall be adjusted to 100 + 10 percent of the rating of the switch so as to produce a temperature rise not less than that noted in Table 3-18 on all fuse clips. The switch is then to be cycled at the above mentioned current at a rate of 8 hours on and 4 hours off for 24 hours. During the second on period, the current shall be readjusted if necessary to bring the temperatures on the fuse clips back to the required temperatures, and actual temperatures shall be recorded after conditions are constant. The switch shall then be cycled for 60 operations at the rate of 8 hours on and 4 hours off. The temperature rises shall be recorded at the end of every sixth cycle.

Evaluation—No temperature rise recorded shall differ more than 10°C (18°F) from the average of all temperature rises measured at that point.

Table 3-18
ADJUSTED TEMPERATURE RISE

Switch Rating, Amperes	Temperature Rise Above Room Ambient*
30–100	30°C (54°F) plus T
101–200	40°C (72°F) plus T

* T is the temperature rise obtained in the heating test, 3.2.1.

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Section 4
CLASSIFICATIONS OF SWITCHES

4.1 GENERAL DUTY ENCLOSED SWITCHES (GD)

General duty enclosed switches, fusible or non-fusible shall be ampere rated or ampere and horsepower rated. The voltage, ampere, and horsepower ratings of general duty switches at 60 Hz shall be up to and including 240 volts, 600 amperes, and 200 horsepower.

General duty enclosed switch enclosures shall be Type 1 or 3R as defined by NEMA Standards Publication 250. (See Section 1.)

4.1.1 Fusible Switches

Fusible general duty enclosed switches shall have provisions for one or more of the following fuses:

a. 0-30A-Type S plug fuse or Type S plug fuse with adapter (see 2.10.1 and 2.10.2 for fuseholder specifications)

b. 0-600A-Class H, K, R, or T cartridge fuses (See 5.2.4.1 and 2.10.3 for fuseholder specifications)

4.1.2 Horsepower Rating Standard

Standard horsepower ratings of general duty enclosed switches shall be in accordance with Table 2-2. These are based on the ability to start typical single-speed motors under normal service conditions using fuses that have been selected without regard to their time-delay characteristics.

Standard horsepower ratings are assigned assuming that for an ac motor, the lock rotor currents are as shown in Table 3-7 for single phase motors and for Design B, C and D multi-phase motors. The full load currents are approximately in accordance with Table 3-9.

4.1.3 Horsepower Rating Maximum

Maximum horsepower ratings of fusible enclosed switches used with fuses having time delay characteristics suitable for the starting characteristics of the motor shall be in accordance with Table 2-3.

Maximum horsepower ratings are assigned assuming that for an ac motor, the lock rotor currents are as shown in Table 3-7 for single phase motors and for Design B, C and D multi-phase motors. The full load currents are approximately in accordance with Table 3-9.

4.2 HEAVY DUTY ENCLOSED SWITCHES (HD)

Heavy duty enclosed switches, fusible or non-fusible shall be ampere rated or ampere and horsepower rated. The voltage, ampere, and horsepower ratings at 60 Hz are up to and including 600 volts, 6000 amperes, and 500 horsepower. The dc ratings shall be up to and including 600 volts, 1200 amperes, and 50 horsepower.

Heavy duty enclosed switches shall be Type 1, 3, 3R, 4, 4X, 5, 7, 9, 12, 12K, or 13 as defined by NEMA Standards Publication 250.

4.2.1 Fusible Switches

Fusible heavy duty enclosed switches shall have provisions for one or more of the following fuses.

a. 0-600A-Class CC, G, H, J, K, T, and R cartridge fuses (See 2.10.3 for fuseholder specifications)
b. 0-1200A-Class T cartridge fuses (see 2.10.3 for fuseholder specifications)
c. 601-6000A-Class L fuses (see 2.10.3 for fuseholder specifications)

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4.2.2 Horsepower Rating Standard

Standard horsepower ratings of heavy duty, enclosed switches shall be in accordance with Table 2-2. These are based on the ability to start typical single-speed motors under normal service conditions using fuses which have been selected without regard to their time-delay characteristics.

Standard horsepower ratings are assigned assuming that for an ac motor, the lock rotor currents are as shown in Table 3-7 for single phase motors and for Design B, C, D and E multi-phase motors. The full load currents are approximately in accordance with Table 3-9.

4.2.3 Horsepower Rating Maximum

Maximum horsepower ratings of heavy duty, fusible enclosed switches used with fuses having time delay characteristics suitable for the starting characteristics of the motor shall be in accordance with Table 2-3.

Maximum horsepower ratings are assigned assuming that for an ac motor, the lock rotor currents are as shown in Table 3-7 for single phase motors and for Design B, C, D and E multi-phase motors. The full load currents are approximately in accordance with Table 3-9.

The maximum operating overload for dc motors is assumed to be four times the rated full load current. Reduced voltage starting may be required to avoid starting currents higher than four times the full load current.

4.3 DEADFRONT AND OPEN SWITCHES

These switches (often classified miscellaneous switches or fused power circuit devices) are switches with enclosures that are incomplete when sold but are completed when the deadfront switch is installed in a larger unit such as a panelboard or switchboard; or in the case of an open switch, when installed in an enclosure built for that purpose.

4.3.1 Deadfront Switches Ratings

The voltage, ampere, and horsepower ratings of deadfront switches at 60 Hz or dc shall be up to and including 600 volts, 6000 amperes, and 500 horsepower (50 horsepower dc).

4.3.2 Open Switches Ratings

The voltage, ampere, and horsepower ratings of open switches at 60 Hz or dc shall be up to and including 600 volts, 6000 amperes, and 500 horsepower (50 horsepower dc).

4.4 PULLOUT SWITCHES

These switches open or close a circuit by manually separating or reconnecting the movable contact and the stationary contact.

Pullout switch enclosures shall be Type 1, 2, 3, 3R, 3S, 4, 4X, 5, 7, 9, 10, 12, 12K, or 13 as defined by NEMA Standards Publication 250.

4.4.1 Hinged Pullouts

These devices have the stationary contact mounted to a support base. The movable contact (along with its mounting means) is attached to a hinged cover of the device, such that when the cover is opened or closed, the circuit is also opened or closed.

Hinged pullout switches, fusible or non-fusible, shall be ampere rated or ampere and horsepower rated. The voltage, ampere, and horsepower ratings of hinged pullout switches at 60 Hz shall be up to and including 600 volts, 800 amperes, and 500 horsepower, respectively.

These switches shall be permitted to be enclosed or deadfront types.

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4.4.2 Detachable Pullouts

These switches have stationary contact mounted to a support base. The movable contact (along with its mounting means) is attached to a pullout member such that when the pullout member is physically removed from the unit, the circuit is opened and, when the pullout member is reinserted, the circuit is closed.

Detachable pullout switches, fusible or non-fusible, shall be ampere rated or ampere and horsepower rated. The voltage, amperes and horsepower ratings of detachable pullout switches at 60 Hz shall be up to and including 600 volts, 200 amperes, and 150 horsepower respectively.

These switches shall be permitted to be enclosed, deadfront, or open type.

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Section 5
APPLICATION INFORMATION

5.1 ENVIRONMENTAL CONDITIONS

The environmental conditions under which the enclosed switch is used can have a major influence on the performance and life of the switch. These conditions shall be categorized as usual and unusual service conditions.

5.1.1 Usual Service Conditions

Usual service conditions shall be considered to be conditions for which the enclosed switch has been designed and is intended.

The following shall be considered to be usual service conditions for all types of enclosed switches:

5.1.1.1 Ambient Air Temperature

The ambient air temperature is between -30°C (-22°F) and 40°C (104°F).

When the expected range of ambient air temperature is lower than -30°C (-22°F) or higher than 40°C (104°F), the user should consult the manufacturer.

5.1.1.2 Altitude

The altitude of the site of installation does not exceed 6,600 ft. (2000 m). The user should consult the manufacturer regarding product application at higher altitudes.

5.1.2 Unusual Service Conditions

Unusual service conditions shall be considered to be those beyond the limits of those defined in 6.1.1 and include, but are not limited to: nuclear radiation, vibration, shock, corrosive agents, and conditions that can lead to internal condensation.

Enclosed switches for use under unusual service conditions may require additional construction, protective features, or special enclosures.

When enclosed switches are to be applied under unusual service conditions, the manufacturer should be consulted.

5.2 SELECTION AND USER INFORMATION

The information in 5.2 applies to enclosed switches; it also applies to deadfront and open switches after they have been properly installed in an enclosure or a larger unit such as a panelboard or switchboard for which they are intended.

5.2.1 Types of Switches

5.2.1.1 General Duty Enclosed Switches

General duty enclosed switches are intended for applications where reliable performance and continuity of service are needed. They are suitable for motor circuit use when marked with horsepower ratings.

A general duty enclosed switch may meet the requirements for service entrance disconnecting applications and can be used for such a purpose when marked accordingly.

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5.2.1.2 Heavy Duty Enclosed Switches

Heavy duty enclosed switches are intended for applications where reliable performance, continuity of service, rugged construction, and ease of maintenance are needed.

They shall be permitted to have fault current ratings up through 200,000 amperes, rms symmetrical and maximum voltage ratings of 600 volts ac or dc.

They are suitable for motor circuit use when marked with horsepower ratings.

This type of switch may meet the requirements for service entrance disconnecting applications and can be used for such a purpose when marked accordingly.

Applications requiring the need for accessories such as auxiliary switches, interlocked receptacles, fuse adapters, or rejectors or alternate wiring terminals may be available for factory or field assembly to heavy duty switches.

Facilities such as manufacturing plants, mass production industries, commercial and industrial buildings that may be served by network systems, or transformers of higher capacities are typical examples of uses.

5.2.1.3 Pullout Switches

Pullout switches are intended for applications where reliable performance and continuity of service is needed. They are suitable for motor circuit use when marked with horsepower ratings.

This type of switch may meet the requirements for service entrance disconnecting applications and can be used for such a purpose when so marked.

5.2.1.4 Fused Power Circuit Devices

Fused power circuit devices are intended primarily for use as service entrance and distribution switches. They will accept either Class L or T fuses.

This type of switch shall be suitable for use up to 100% of its rating. Ratings shall be 800 through 6000 amperes and a maximum voltage rating of 600 volts ac or dc. The fault current rating shall be up to 200,000 rms symmetrical amperes or 100,000 amperes dc.

These switches shall have either bolted pressure contact or high pressure butt contact design, and means of operation may be either manual, shunt trip or motor operated.

Common accessories for these devices are ground fault components, phase monitoring devices, auxiliary switches and key interlocks. Key interlocks can provide reliable means for these devices to be used on multiple source equipment.

5.2.1.5 Open Switches

An open switch is a switch that is provided without an enclosure.

5.2.2 Ampere or Ampere and Horsepower Ratings

Switches may be ampere rated or ampere and horsepower rated. Therefore, care should be exercised to ensure the proper selection of a switch for a particular application.

5.2.2.1 Ampere Rated

Ampere rated switches are not suitable for the switching of motors or other highly inductive loads. Typical applications of ampere rated switches are:

a. Connecting and disconnecting circuits under no load conditions
b. Switching of resistive loads
c. Switching of mixed resistive and light inductive loads

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5.2.2.2 Ampere and Horsepower Rated

Ampere and horsepower rated switches are suitable for switching of motor loads or other highly inductive loads, in addition to those uses specified for ampere rated switches. (Refer to 2.1.4 and 2.1.5 for horsepower ratings.)

Switches covered in this standard are not intended for use as motor controllers in applications subject to jogging or plugging.

5.2.3 Fusible and Nonfusible Switches

5.2.3.1 Fusible Switches

Fusible switches should be used where overcurrent protection is required for main, feeder, or branch circuits. Fusible switches with horsepower ratings should be used on motor circuits when they are equipped with appropriate fuses.

The selection of fuses shall include consideration of the available fault current as well as characteristics of the intended load.

5.2.3.2 Nonfusible Switches

Nonfusible switches should be used where overcurrent protection is provided external to the switch. When used on motor circuits, these switches must have the appropriate horsepower ratings unless used as isolating switches only.

5.2.4 Available Fault Current Rating

5.2.4.1 Fusible Switches

The available fault current rating of a fusible switch is the maximum fault current capability of a circuit on which the switch can be used with designated fuses installed.

A fusible switch with an available fault current rating higher than 10,000 amperes, rms symmetrical requires the use of the fuses designated on the switch marking (Classes CC, G, J, L, R, or T). However, use of these fuses that have interrupting ratings in excess of 10,000 amps, rms does not automatically mean that the switch is suitable for use at those fault levels unless it has been tested in combination with the fuses and is so marked.

Use of fuses other than those specified in the marking by the manufacturer may result in a fire or casualty hazard.

Fusible switches not marked with an available fault current rating are assumed to have a rating of 10,000 amps, rms symmetrical maximum when used with fuses for which the switch is designed.

5.2.4.2 Nonfusible Switches

Nonfusible switches shall be permitted to have either one or both of the following types of available fault current ratings:

a. An available fault current rating for which the switch marking specifies the overcurrent protective device that must be used on the supply side of the switch. For this type of rating, the switch has been tested in combination with only those overcurrent devices marked on the switch. An acceptable installation requires that the available fault current capability of the circuit on the supply side of the marked combination of devices be less than the rating of the switch.

b. An available fault current rating for which the switch marking does not specify a particular overcurrent device. For this type of rating, the switch has been tested in such a way that any installation that follows the *National Electrical Code* requirements for overcurrent protection will be acceptable if the available fault current capability of the circuit on the supply side of the switch is less

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than the rating of the switch. Nonfusible switches not marked with a fault current rating are assumed to have a rating of 10,000 amperes, rms symmetrical.

If a nonfusible switch is marked for use with overcurrent protection devices that have a continuous current rating above the current rating of the switch, then the switch must be tested in combination with those devices as provided for in Section 3.

5.2.5 Termination Information

See 5.4 for marking and 2.9 for standard conditions for construction.

a. The cable that is connected to the switch should be suitable and approved for use with the lugs provided. Aluminum cable should be used only with lugs approved for termination of aluminum or copper and aluminum conductors. Copper cable may be used with lugs approved for termination of copper or copper and aluminum conductors.

b. Conductor lengths should be kept to a minimum within the wiring gutter. Excessive cable lengths may result in overheating. However, cables should be long enough to reach the terminal location in a manner that avoids strain on the connecting lug.

c. Care should be exercised to maintain the largest practical bending radius of conductors; otherwise, the insulation may be damaged and terminal connections may become loosened.

d. Care should be used in stripping insulation from conductors so as not to nick or ring the conductor. For aluminum, all oxide should be cleaned from the stripped portion and, when required, an oxide inhibiting compound should be applied.

e. In enclosures constructed of ferro-magnetic materials, conductors should be arranged and routed so as to reduce the effects of inductive heating.

f. All lugs should be tightened. Torque values given in the manufacturer's instructions or markings provided with the equipment should be used.

g. Before energizing the equipment, the wire clamping members of all accessible mechanical (pressure wire) type connectors should be tightened to the torque value (pounds-inches) given in the manufacturer's instructions or markings provided with the equipment.

h. Before energizing the equipment, checks should be made to determine that all grounding connections are properly made. If the switch is used as service equipment, the neutral should be properly bonded to the enclosure.

5.2.6 Enclosure Applications

Tables 5-1 and 5-2 may be used as a guide in selecting enclosures for specific environments. It is possible that, because of local code requirements or unusual operating conditions, a different or modified type of enclosure may be required, in which case the manufacturer should be consulted. (See NEMA Standards Publication 250.)

Special care should be used in selecting enclosures for hazardous locations, and the advice of competent authorities should be solicited. For further information, see NEMA Standards Publication 250 and Section 500 of the *National Electrical Code*.

General duty switches may be provided in Types 1 and 3R enclosures. Heavy duty switches may be provided in any NEMA type of enclosure shown in Tables 5-1 and 5-2.

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Table 5-1
COMPARISON OF SPECIFIC APPLICATIONS OF ENCLOSURES FOR INDOOR NONHAZARDOUS LOCATION

Provides a Degree of Protection Against the Following Environmental Conditions	Types of Enclosure									
	1*	2*	4	4X	5	6	6P	12	12K	13
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X
Falling dirt	X	X	X	X	X	X	X	X	X	X
Falling liquids and light splashing	...	X	X	X	...	X	X	X	X	X
Circulating dust, lint, fibers, and flyings†	...	...	X	X	...	X	X	X	X	X
Settling airborne dust, lint, fibers, and flyings †	...	...	X	X	X	X	X	X	X	X
Hosedown and splashing water	...	...	X	X	...	X	X	...	...	...
Oil and coolant seepage	...	...	...	...	...	...	...	X	X	X
Oil or coolant spraying and splashing	...	...	...	..	...	...	...	...	...	X
Corrosive agents	...	...	...	X	...	...	X	...	...	...
Occasional temporary submersion	...	...	...	...	...	X	X	...	...	...
Occasional prolonged submersion	...	...	...	...	...	...	X	...	...	...

* These enclosures may be ventilated. However, Type 1 may not provide protection against small particles of falling dirt when ventilation is provided in the enclosure top. Consult the manufacturer.
† These fibers and flyings are nonhazardous materials and are not considered the Class III type ignitable fibers or combustible flyings. For Class III type ignitable fibers or combustible flyings see the *National Electrical Code*, Section 500-6(a).

Table 5-2
COMPARISON OF SPECIFIC APPLICATIONS OF ENCLOSURES FOR OUTDOOR NONHAZARDOUS LOCATION

Provides a Degree of Protection Against the Falling Environmental Conditions	Type of Enclosure						
	3	3R†	3S	4	4X	6	6P
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X
Rain, snow, and sleet*	X	X	X	X	X	X	X
Sleet**	...	...	X	...	...	...	...
Windblown dust	X	...	X	X	X	X	X
Hosedown	...	...	...	X	X	X	X
Corrosive agents	...	...	...	...	X	...	X
Occasional temporary submersion	...	...	...	...	...	X	X
Occasional prolonged submersion	...	...	...	...	...	...	X

* External operating mechanisms are not required to be operable when the enclosure is ice covered.
** External operating mechanisms are operable when the enclosure is ice covered. See 2.3.3.
† These enclosures may be ventilated.

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5.3 MAINTENANCE

5.3.1 General

The electrical circuit should be deenergized prior to any cleaning or maintenance.

Maintenance of switches should be in accordance with the instructions supplied by the manufacturer of the switch. Also see NFPA 70B.

5.3.2 Specific Parts

5.3.2.1 Enclosures

Enclosures located in clean, dry, and noncorrosive atmospheres do not normally require maintenance. However, they should be inspected periodically for dust and dirt accumulation as well as corrosive conditions and cleaned as necessary. The required frequency of inspections and cleaning should be determined by the amount of contamination.

5.3.2.2 Current Carrying Parts

The electrical circuit should be deenergized and the terminal and cable connections should be examined and tightened as required using the manufacturer's torque requirements. Any device having evidence of overheated conductors and carbonized insulation that could also be caused by arcing should be replaced.

5.3.2.3 Operating Mechanisms

The operating mechanism and mechanical interlock (when provided) should be manually operated periodically, so as to assure proper operation and lubricated if so specified by the manufacturer.

5.4 MARKING

5.4.1 General

Switches shall be marked in a durable manner. The markings shall be on the equipment itself or on nameplates or labels attached to the equipment, and shall be located in a place such that they are visible and legible after the equipment is installed. Nameplates and labels on the exterior or equipment shall be resistant to fading under the influence of sunlight, water, or other normal environmental conditions. The markings shall include the markings given in 5.4.2, 5.4.3, and 5.5.5 as applicable.

Markings, labels, or labeling instructions, or a combination of the above, for use in conjunction with open switches shall be permitted to be provided with the switch for installation on the equipment in which the switch is to be installed.

5.4.2 Enclosure Markings

With the switch installed as intended for use, with the enclosure door closed, the following markings shall be visible. For a pullout switch, the installation of labels inside a door, the opening of which does not expose live parts, meets the intent of this requirement. In the case of an open switch, markings 18 shall be applied to the switch so that they are visible from the front when the switch is installed as is intended for use.

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a. Maximum voltage rating

b. Current rating in amperes. An alternating current rating shall be indicated by the letters ac if the frequency or phase rating is not given

c. Frequency rating if other than 60 Hz, or the indication dc

d. Warning information (see 5.5)

e. The outside of a switch enclosure shall be plainly marked to indicate on/off and any other functional positions of the switch. The outside of a switch enclosure may have on/off indicating symbols in accordance with IEC Publication 417:

417-I E C-5007  On (power)

417-I E C-5008  Off (power)

g. Switches tested to the requirements of Section 3 (see Tables 3-6 and 3-11) for isolating use only shall be conspicuously marked on the outside of the enclosure: FOR ISOLATING USE ONLY DO NOT OPEN UNDER LOAD.

h. A 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. (See 5.4.3, item n.)

i. If a switch is marked Suitable Only For Use As Service Equipment, the service disconnecting means shall be marked Service Disconnect on or adjacent to the switch handle. (See 5.4.3, item o.)

5.4.3 Other Markings

The following markings shall be used when applicable:

a. Manufacturer's name or trademark.

b. Catalog number of switch or equivalent.

c. If provided, the enclosure shall be marked with the NEMA enclosure type. If an enclosure suitable for Class I and II hazardous locations as described in Article 500 of the *National Electrical Code* (see Section 1) is provided, the marking shall be indicated.

d. Codes allowing determination of the month, year, and place of manufacture.

e. Heavy Duty or General Duty (applicable to enclosed switches only).

f. Available fault current withstand rating in rms symmetrical amperes.

g. Warning information (see 5.5).

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h. The fusible switch shall be marked as a part of the electrical rating: Continuous Load Current Not to Exceed 80 percent of the Rating of Fuses Employed in Other Than Motor Circuits, unless the fusible switch employs Class L fuses or Class T fuses above 600 amps, and has been tested for use at 100 percent of its rating.

i. Standard and maximum horsepower ratings where applicable.

j. Fusible switches with horsepower ratings shall include the word Standard (or Std) or Maximum (or Max), or both, whichever is appropriate for that rating as shown in 2.1.4.1. and 2.1.4.2. A switch shall be marked plainly with the statement, The starting current of motors of more than the standard horsepower ratings may require the use of fuses with appropriate time-delay characteristics.

k. A switch marked with a horsepower rating greater than 100 horsepower but not tested for a rating of 100 horsepower shall also be marked with the following or equivalent statement: Not for Use as Motor Controller.

l. A switch marked with a horsepower rating greater than 100 horsepower and tested for a rating of 100 horsepower shall be marked: Not for Use as Motor Controller for Motors Over 100 Horsepower.

m. If a switch is marked with the voltage or horsepower rating, or both, applicable only to a switch having fewer poles than those provided in the switch, the switch shall be marked in a conspicuous manner to clearly indicate the proper circuit arrangement for these ratings.

n. A switch that has been found to be acceptable for service equipment use and does not have the neutral bonded to the enclosure at the factory, shall be marked: Suitable For Use As Service Equipment.

o. A switch that has been found to be acceptable for service equipment use and that has the neutral bonded at the factory shall be marked: Suitable Only For Use As Service Equipment.

p. On a switch with ground fault protection, the following or equivalent marking shall be located on or adjacent to the load neutral terminal: "WARNING—Do not connect grounding conductors to these or any other neutral load terminal; to do so will defeat ground fault protection."

q. If a control voltage component is connected to the line side of the switch, the switch shall be marked: "DANGER—Operation of the switch does not disconnect control and instrument circuits."

r. A switch intended to accept Class K or Class H fuses shall be marked: Suitable for use on a circuit capable of delivering not more than 10,000 amperes rms symmetrical_volts maximum or the equivalent.

s. An unfused switch shall be marked: This switch is suitable for use on a circuit capable of delivering not more than_amperes, rms symmetrical_volts maximum when protected by Class_fuses (type_circuit breaker) rated_amperes maximum or with an equivalent marking.

Exception No. 1: If the short-circuit rating is 10,000 A, the class of fuse may be omitted but the current rating shall be provided.

Exception No. 2: If the short-circuit rating is 5,000, 7,500, or 10,000 A and the continuous current rating of the circuit breaker does not exceed that of the switch, the type designation and manufacturer of the circuit breaker may be omitted.

Exception No. 3: If the short-circuit rating is 5,000, 7,500, or 10,000 A, the continuous current rating of the circuit breaker exceeds that of the switch, and the switch was tested for three cycles

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as indicated in 3.2.7.1.2, the type designation and manufacturing of the circuit breaker may be omitted.

Exception No. 4: If the tests mentioned in 3.2.7.1 and 3.2.7.2 are conducted with the overcurrent protection means on the line side of the unfused switch, the marking shall also specify that the fuses (or circuit breakers) shall be installed ahead of the switch.

The markings may be repeated for several different types of protection.

t. A switch constructed to accept only Class CC, G, J, R, or T fuses shall be marked with the following statement: Suitable for use on a circuit capable of delivering not more than_amperes, rms symmetrical_volts maximum; use Class_fuses.

u. A switch constructed to accept Class H or K fuses, but field convertible to restrict accommodation to Class J, R, or T fuses, shall be marked: When used with Class K or H fuses, suitable for use on a circuit capable of delivering not more than 10,000 amperes, rms symmetrical_volts, maximum. When used with Class J fuses (when used with Class R or T fuses and fuse clip assembly No_properly installed), this switch is suitable for use on a circuit capable of delivering not more than_amperes, RMS symmetrical_volts maximum, or equivalent wording. In addition, the switch shall be marked as follows to indicate that the interrupting rating is only applicable when Class J, R, or T fuses are used: Danger Unless Class J, R, or T fuses are used, this switch may present a risk of a fire and injury to persons if installed on circuit capable of delivering more than 10,000 amperes, rms symmetrical or equivalent wording.

v. A switch designed to accept only Class J or T fuses by repositioning load fuse base on fuse clip assemblies shall be provided with instructions for repositioning the load base fuseholder or fuse clips and associated barriers so that it will accept only Class J or T fuses.

w. A switch designed for the addition of accessories (such as fuse clips, rejectors, neutrals, and such) in the field shall be marked with instructions for ordering the accessory. Instructions for installation of the accessory shall be marked on the switch or provided with the accessory.

x. A switch shall be marked to indicate clearly the line and load terminals. This marking shall be visible when the switch interior, accessories, and field wiring are installed.

y. Tightening torques: a switch shall be marked to show a range of values or a nominal value of tightening torque to be applied to the clamping screws of all terminal connectors for field wiring.

z. A switch that is equipped with pressure wire connectors suitable for use with aluminum and copper conductors and that has wiring space and wiring gutters sufficient for the size of the conductors appropriate for the ratings of the switch shall be marked as: Suitable For Use With Copper or Aluminum Conductors or Suitable For Use With Cu/Al Conductors.

aa. A switch shall be marked to indicate the required temperature rating for all field-installed conductors.

bb. If a switch has any terminals that, because of wiring space or other factors, are suitable for use with copper conductors only, they shall be marked to indicate that those terminals are: Suitable For Copper Conductors Only.

cc. When terminals are omitted per 2.9.1, Exception 3, both pieces of equipment are to be marked as follows:

1. The switch and the equipment intended to be connected to it shall be marked to indicate that one is to be used with the other.

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2. Both pieces of equipment shall also identify, by suitable marking or the equivalent, the means by which connections between them should be made.

dd. An enclosed switch with Edison base fuseholders shall be marked to require use of Type S fuse adapters.

ee. 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.

ff. When terminals are omitted per 2.9.1, Exception 2, the equipment shall be marked stating which pressure terminal connect or component terminal assemblies are suitable for use with the equipment.

gg. In regard to exception of 3.5, unless overcurrent protection is provided in the pullout switch, the pullout switch shall be marked: Caution Does Not Contain Fuses, or an equivalent wording. The marking shall be a minimum of 3/16 inch (4.8 mm) high letters and visible without removing any cover.

hh. A pullout switch that is required to be marked or is optionally marked to show intended use in Class CTL assemblies shall be marked: CTL or Class CTL. This marking is not required to be visible after installation.

ii. If the electrical safety features, including performance and spacing to grounded metal parts of a pullout switch, are dependent upon the proper connection of line and load conductors, the marking shall indicate plainly the proper connections.

jj. An open type device shall have a marking to indicate the ventilating openings required, and the minimum spacings required between live parts and grounded metal when mounted, or it shall refer to a specific drawing, an information sheet, or installation instructions supplied by the manufacturer.

kk. If a power circuit device and its enclosure are to be shipped separately, the enclosure shall be marked to indicate what power circuit device it is intended to receive.

ll. If a switch is provided with a transformer or other circuit component providing control voltage, connected to the line side of the switch, the switch shall be marked: "DANGER—Operation of the switch does not disconnect control and instrument circuits."

mm. A double-throw switch investigated for use in accordance with Article 702 of the *National Electrical Code* shall be marked: "Manually-operated switch suitable for use in accordance with Article 702 of the *National Electrical Code*." 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.

nn. A switch suitable for use with Design E motors shall be marked accordingly

5.5 PRODUCT WARNING INFORMATION

5.5.1 Outside of Enclosure

To make the user aware of immediate or potential hazards in their application, installation, use, or maintenance, switches shall be conspicuously marked on the outside of the enclosure with information that complies with ANSI Z535. The panel information shown in Figures 5-1 and 5-2 complies with ANSI Z535. The words, symbols, and messages may vary by manufacturer.

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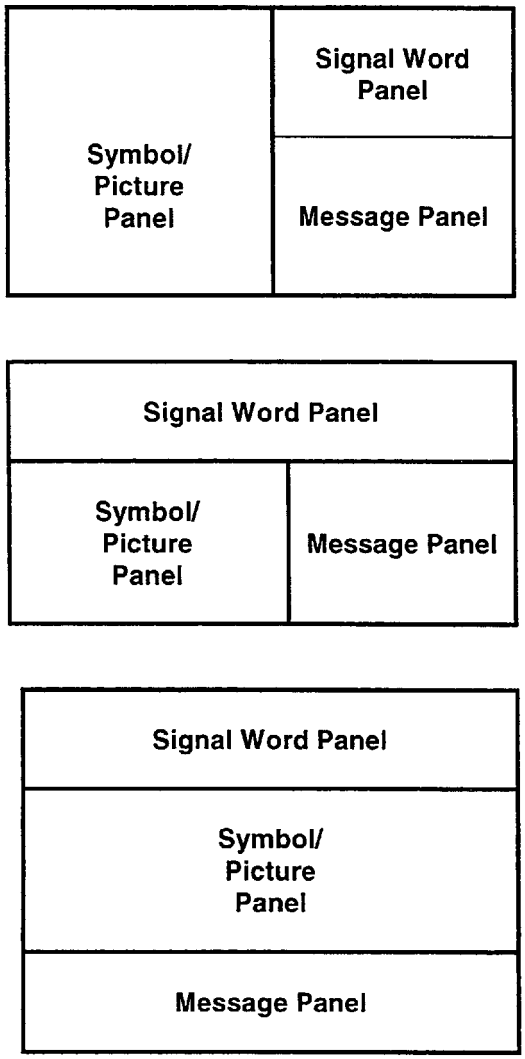


Figure 5-1
THREE PANEL INFORMATION

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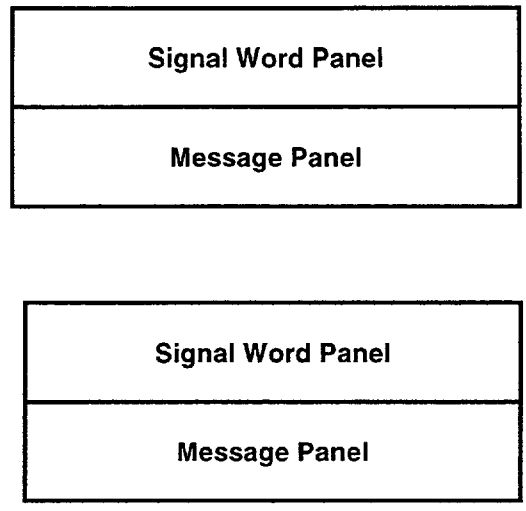


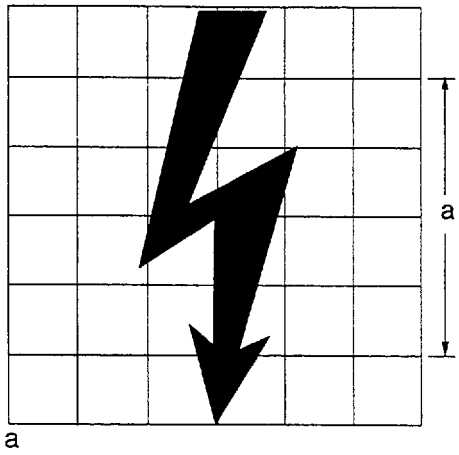
Figure 5-2
TWO PANEL INFORMATION

When the "lighting bolt" is used as the symbol/pictorial it shall have the proportions shown in Figure 5-3. The safety alert symbol shall have the proportions shown in Figure 5-4.

Information on the exterior of the equipment shall be resistant to fading under the influence of sunlight, water or other normal environmental conditions.

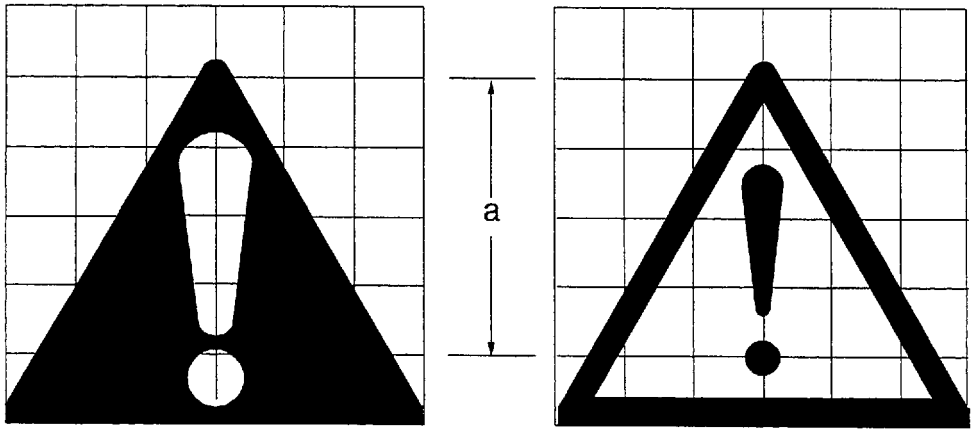
This requirement is not intended to rule out the use of other labels or markings that are required to comply with other nationally recognized standards or applicable laws or regulations, such as radiation warnings, or that may be deemed necessary by the manufacturer.

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Real Dimensions
Height = 1.48a
Width = 0.58a

Figure 5-3
LIGHTNING BOLT SYMBOL/PICTORIAL



Symbol Proportion
Height = 1.3a
Width = 1.5a

Figure 5-4
SAFETY ALERT SYMBOL

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5.5.2 Inside of Enclosure

Other information shall be as appropriate to alert the user to potential hazards involved when testing, changing fuses, or performing maintenance on the switch. These labels shall comply with ANSI Z535. These labels shall include the statements (or equivalent determined by the manufacturer) as shown in Figure 5-5 for fusible switches and Figure 5-6 for non-fusible switches.

HAZARDOUS VOLTAGE; WILL CAUSE DEATH, SERIOUS INJURY OR BURN

- Never operate switch with door (or cover) open.
- Turn off switch before removing or installing fuses.
- Always use a properly rated voltage sensing device at all line and load side fuse clips to confirm switch is off.
- Turn off power supplying the switch before doing other work inside.
  a. Reinstall all parts and close cover before turning on power ahead of switch and turning switch on.
  b. Close cover before turning power on.

Figure 5-5
FUSIBLE SWITCHES

HAZARDOUS VOLTAGE; WILL CAUSE DEATH, SERIOUS INJURY OR BURN

- Never operate switch with door (or cover) open.
- Always use a properly rated voltage sensing device at all load side terminals to confirm switch is off.
- Turn off power supplying the switch before doing other work inside.
  a. Reinstall all parts and close cover before turning on power ahead of switch and turning switch on.
  b. Close cover before turning power on.

Figure 5-6
NON-FUSIBLE SWITCHES

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