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National Electrical Manufacturers Association
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PROPOSED, NEW AND REVISED STANDARDS

TO ALL REPRESENTATIVES OF MEMBER COMPANIES
IN THE SWITCH SECTION

Subject: Revision No. 1 to NEMA Standards Publication on *Enclosed Switches*, KS 1-1983

Dear Representative:

At its meeting on March 8, 1985, the Codes and Standards Committee approved revisions to the subject publication which are reflected on the attached pages. Please insert them in your copy of the book and delete the pages they replace.

Also attached is a new front cover to show that your copy of KS 1-1983 now includes Revision No. 1.

Sincerely yours,

Carol Cross

Carol Cross
Standards Publications Editor

Enc: revised pages
cc: all known holders of KS 1-1983

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STANDARDS PUBLICATION / NO. KS 1-1983

Including: Rev. No. 1—March 1985

nema

Enclosed Switches

NEMA

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TABLE OF CONTENTS

		Page
	FOREWORD	i
	SCOPE	ii
Section 1	REFERENCED STANDARDS	1
Section 2	DEFINITIONS	2
Section 3	CLASSIFICATIONS OF ENCLOSED SWITCHES	
	General Duty (GD)	5
	Heavy Duty (HD)	5
Section 4	CHARACTERISTICS OF ENCLOSED SWITCHES	
	Ratings	6
	Accessories	10
	Enclosures	10
	Service Equipment	11
	Fusible Switches	13
	Number of Switching Poles and Wires	13
Section 5	MARKING	
	General	14
	Enclosure Exterior	14
	Other Markings	14
	Warning Information	15
Section 6	APPLICATION INFORMATION	
	Environmental Conditions	17
	Selection and User Information	17
	Maintenance	19
Section 7	CONSTRUCTION	
	Mechanical Design	21
	Enclosures	22
	Spacings	22
	Terminals	23
	Fuseholders	26
Section 8	TESTS	
	Design and Verification Tests	34
	Design Tests	34
	Verification Testing	44
	Test Circuits and Calibration of Circuits and Instruments	44

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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 switches for their particular application. This Standards Publication provides such a basis by serving as a compendium, as related to enclosed switches, of:

1. Referenced Standards
2. Standard Definitions
3. Standard Classifications
4. Standard Characteristics
5. Standard Markings
6. Applications Information
7. Construction (Manufacturing) Requirements
8. Performance Verification Tests

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:

Manager, Engineering Department
National Electrical Manufacturers Association
2101 L Street, N.W., Suite 300
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Scope

This Standards Publication covers enclosed air-break switches that are:

1. Rated at not more than 600 volts and 1200 amperes with or without a horsepower rating.
2. With or without provision for plug or cartridge fuses.
3. With current-carrying parts and mechanisms enclosed in metallic or nonmetallic cases.
4. Manually operable by means of external handles, including hinged-door-type disconnects.

This Standards Publication does not cover:

1. The common form of snap switches.
2. Switching devices having features intended primarily for the starting and running protection of electric motors.
3. Circuit-breaker-type power circuit protectors.
4. Devices in which the complete removal of a pull-out member accomplishes the switching operation.
5. Molded case switches.
6. Devices which are automatically operable by means of shunt trips, ground fault devices, or similar mechanisms.

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.

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Section 1
REFERENCED STANDARDS

National Electrical Manufacturers Association
2101 L Street, N.W.
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250-1979 *Enclosures for Electrical Equipment (1000 Volts Maximum)*

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

NFPA 70-1984 *National Electrical Code*
NFPA 70B-1983 *Electrical Equipment Maintenance*

American National Standards Institute
1430 Broadway
New York, NY 10017

ANSI/UL 512-1982 *Fuseholders*

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Section 2
DEFINITIONS

An *accessory* is 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.

An *air switch* is a switching device designed to close and open one or more electric circuits by means of guided separable contacts that separate in air.

An *ambient temperature* is the temperature of the surrounding medium which comes in contact with the exterior of the switch enclosure.

An *auxiliary switch* is a switch mechanically operated by the main switching device for switching, signaling, interlocking, or other purposes.

NEMA Standard 9-15-1983.

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

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

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

Authorized Engineering Information 9-15-1983.

An *available fault current* is the maximum current that a power system can deliver through a given circuit point to any negligible impedance short-circuit applied at that point.

An *available fault current withstand rating* is 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.

A *cartridge fuse* is a fuse consisting of a current-responsive element inside a fuse tube with terminals on both ends.

Clearance is the shortest distance through air between two conductors or between a conductor and a grounded part.

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

The *clearing time (of a fuse)* is 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.

A *conducting part* is a part which is capable of conducting current.

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

A *current-limiting fuse (ac)* is a fuse which 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.

The *current-limiting fuse range (ac)* is 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.

A *current rating* is the designated maximum direct or alternating operating current in rms amperes at rated frequency for which the switch qualifies under specified test conditions.

A *dependent manual operation (of a mechanical switching device)* is 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 are those 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.

NEMA Standard 9-15-1983.

Generally, design tests are 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

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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 design, where appropriate.

Authorized Engineering Information 9-15-1983.

A *double-throw switch* is 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.

A *dummy fuse* 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 which it is intended to simulate.

An *enclosed switch* is a switch with or without fuseholders, having all current carrying parts completely enclosed, which is operable without opening the enclosure.

An *enclosure* 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.

A *fuse* is a protective device with a current sensitive fusible part which, during a continuous overcurrent condition, will melt open and interrupt the circuit. A fuse may or may not be the complete device necessary to connect into an electric circuit.

Fuse clips are the contacts of the fuseholder which support the fuse and connect the fuse terminals with the circuit.

A *fuseholder* is an assembly of base, fuse clips, and necessary insulation for the mounting or connecting of a fuse into a circuit.

A *fuse interrupting rating* is the highest direct or rms alternating-current which the fuse is capable of interrupting safely under specified conditions.

A *fusible switch* is a switch in which one or more poles have a fuse in series in a composite unit. NOTE: The International Electrotechnical Commission refers to this type of a device as a switch-fuse.

A *ground (earth) (electric system)* is 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).

Hazardous materials are those gases, vapors, combustible dusts, fibers, or flyings which are explosive under certain conditions.

Hazardous locations are those areas which contain hazardous materials in sufficient quantity to create an explosion (see article 500 in the 1984 *National Electrical Code* (see Section 1).

An *independent manual operation (of a mechanical switching device)* is 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.

An *interlock (mechanical)* is a mechanism which limits the operations of a switch to a specified sequence.

An *isolating switch* is 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.

Jogging (inching) is 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.

A *knockout* is a portion of the wall of an enclosure so fashioned that it can be removed readily by a hammer, screw-driver, 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 are those parts that are designed to operate at a voltage different from that of the earth.

The *locked-rotor current of a motor* is the steady-state current taken from the line with the motor

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locked and with rated voltage (and rated frequency in the case of alternating-current motors) applied to the motor.

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

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

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

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

Overload tests are those 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.

The *peak let-through current, Ip (ac)* is the maximum instantaneous current during the total clearing time.

A *plug fuse* is a fuse consisting of a current-responsive element inside of a housing with coaxial terminals on one end, one terminal being a threaded metal ring or shell on the outside of the housing.

Plugging is a control function that provides braking by reversing the motor line voltage polarity or phase sequence so that the motor develops a countertorque that exerts a retarding force.

A *pole of a switching device* is that 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.

A switching device 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, etc.) provided the poles are or coupled in such a manner as to operate together.

A *pressure wire connector* is a reusable connector into which the conductor is secured by mechanical pressure applied by integral screw, cone, or other mechanical parts.

A *rating* is a designated limit of operating characteristics based on specified conditions of current, voltage, frequency, etc.

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

Service equipment is 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.

A *single-throw switch* is a switch which has only one open and one closed circuit position.

A *switch* is a device, manually operated, unless otherwise designated, for opening and closing or for changing the connection of a circuit.

The term *ventilated* 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 3
CLASSIFICATIONS OF ENCLOSED SWITCHES

3.1 GENERAL DUTY (GD)

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

Fusible switches of this type shall be used with Class H, Class K, or Class R cartridge fuses or Type S plug fuses (see 5.3, item 24). General duty switches shall be fusible or nonfusible and are intended for use on circuits having available short-circuit currents of 10,000 rms symmetrical amperes or less.

General duty switch enclosures shall be Type 1 or 3R as defined by NEMA Standards Publication 250-1979, *Enclosures for Electrical Equipment (1000 Volts Maximum)*, (see Section 1).

NEMA Standard 9-15-1983.

3.2 HEAVY DUTY (HD)

Heavy duty enclosed switches, fused or nonfused, shall be ampere rated or ampere and horsepower rated. The voltage, ampere, and horsepower ratings at 60 hertz are up to and including 600 volts, 1200 amperes, and 500 horsepower. The dc ratings shall be up to and including 600 volts, 1200 amperes, and 50 horsepower.

They shall be permitted to have short-circuit current ratings up through 200,000 rms symmetrical amperes.

Heavy duty switch enclosures shall be type 1, 3, 3R, 4, 4X, 5, 7, 9, 12, 12K, or 13 as defined by NEMA Standards Publication 250-1979 (see Section 1).

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Section 4
CHARACTERISTICS OF ENCLOSED SWITCHES

4.1 RATINGS

The rating of an enclosed switch shall include the following items:

Voltage rating .....See 4.1.1
Frequency rating.....See 4.1.2
Current rating .....See 4.1.3
Horsepower rating, Fusible switches..See 4.1.4
Horsepower rating, Non-Fusible switches.....See 4.1.5
Available Fault current rating.....See 4.1.6

NEMA Standard 9-15-1983.

4.1.1 Voltage Rating

The voltage rating of enclosed switches shall be in accordance with Table 4-1.

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 alternating- or direct-current system having a grounded neutral.

Authorized Engineering Information 9-15-1983.

4.1.2 Frequency Rating

The frequency rating of alternating-current enclosed switches shall be 60 hertz unless the switch is otherwise marked. Switches having a direct-current rating shall be marked dc (see 5.2, item 3).

4.1.3 Current Rating

General duty switches shall be rated 30, 60, 100, 200, 400, or 600 amps. Heavy duty switches shall be rated 30, 60, 100, 200, 400, 600, 800, or 1200 amps.

4.1.4 Fusible Switch Horsepower Ratings

4.1.4.1 Horsepower Rating—Standard

Standard horsepower ratings of both general duty and heavy duty fusible enclosed switches shall be in accordance with Table 4-2. 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.

NEMA Standard 9-15-1983.

For the purpose of assigning these ratings, an alternating-current motor is assumed to have less than 5.0 locked-rotor kVA per horsepower (corresponding to locked-rotor indicating code letters A through E*). The full-load current should be approximately in accordance with Tables 430-148, 430-149, or 430-150 of the 1984 *National Electrical Code.* Fuse current ratings should be in accordance with Table 430-152 of the 1984 *National Electrical Code* (see Section 1).

The maximum operating overload for direct-current 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 rated full-load current.

Authorized Engineering Information 9-15-1983.

4.1.4.2 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 4-3.

NEMA Standard 9-15-1983.

For the purpose of assigning these ratings, an alternating-current motor is assumed to have locked rotor kVA per horsepower less than 6.3 (corresponding to locked-rotor indicating code letters A through G*) for general-duty switches, or less than 8.0 (corresponding to locked-rotor indicating code letters A through J*) for heavy-duty switches which are rated 50 horsepower and below.

The maximum operating overload for direct-current 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 rated full-load current.

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4.1.5 Nonfusible Switch Horsepower Ratings

The horsepower rating for a nonfusible switch shall be in accordance with Table 4-3.

4.1.6 Available Fault Current Withstand Rating

General duty switches shall have a minimum available fault current withstand rating of 10,000 rms symmetrical amperes. Heavy duty switches shall have

*As listed in Table 430-7(b) of the 1984 *National Electrical Code*.

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Table 4-1
VOLTAGE RATINGS OF ENCLOSED 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

*These ratings shall not be applicable to switches having plug fuses.
**Shaded area ratings apply to general duty switches.
†A switch having one of the direct-current ratings shall also be considered to be suitable for use on alternating current.
‡A switch having one of the alternating-current ratings shall not have one of the direct-current ratings unless it is so marked.

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Table 4-2
STANDARD HORSEPOWER RATINGS*

Size of Fuseholder Amperes	Volts	Rating of Enclosed Switch — Horsepower			
		Two-Pole Single-Phase	Two-Pole Direct Current	Three-Pole Three-Phase	Four-Pole Two-Phase
30	120 ac	½	...	1½	2
60		1½	...	3	3
30	125 dc	...	2	...	...
60		...	5	...	...
30	240 ac	1½	...	3	3
60		3	...	7½	7½
100		7½	...	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	7½
60		5	...	15	15
100		10	...	25	25
200		25	...	50	50
400		...	...	100	...
600		...	...	150	...
800		...	...	200	...
30	600 ac	3	...	7½	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	...	...

*All ratings apply to heavy duty switches. Shaded area ratings apply to general duty switches.

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Table 4-3
MAXIMUM HORSEPOWER RATINGS*

Size of Fuseholder In Amps or Ampere Rating of Nonfused Switch	Volts	Rating of Enclosed Switch — Horsepower			
		Two-Pole Single-Phase	Two-Pole Direct Current	Three-Pole Three-Phase	Four-Pole Two-Phase
30	120 ac	2	...	3	3
60		3	...	7½	10
30	125 dc	...	3	...	...
60		...	...	...	...
30	240 ac	3	...	7½	10
60		10	...	15	20
100		15	...	30	30
200		...	...	60	50
400		...	...	125	...
600		...	...	200	...
800		...	...	250	...
30	250 dc	...	5	...	...
60		...	10	...	...
100		...	20	...	...
200		...	40	...	...
400		...	50	...	...
30	480 ac	7½	...	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	600 dc	...	15	...	...
60		...	30	...	...
100		...	50	...	...
200		...	...	...	...

*All ratings apply to heavy duty switches. Shaded area ratings apply to general duty switches.

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one or more of the following available fault current withstand ratings:

10,000
25,000
50,000
100,000
200,000

NEMA Standard 9-15-1983.

4.2 ACCESSORIES

Enclosed switches may have provisions for a number of supplementary items to provide additional features or functions. In some cases, the equipment is supplied in the form of field installed kits with instructions and mounting material. In other cases, it may only be available as a factory installed item. Only accessories recommended by the switch manufacturer should be used to assure 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.

4.2.1 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:

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

4.2.2 Interlocked Receptacle Switches

An interlocked receptacle switch is an enclosed switch which has a receptacle wired to the load end of the switch, which is interlocked with the switch operating mechanism 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.

4.2.3 Fuse Adaptors and Rejectors

Fuse adaptors 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 which will apply after the modification.

4.2.4 Wire Connectors

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

4.2.5 Hubs

Hubs are available for various types of switch enclosures (such as Type 3R, 4, and 12) which after proper installation, allow the conductor entry opening to maintain the environmental capability indicated by the enclosure Type No. 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 must be added in the field.

4.2.6 Neutral or Ground Lugs

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

4.3 ENCLOSURES

Refer to NEMA Standards Publication No. 250-1979 (see Section 1) for more detailed descriptions of enclosures.

Authorized Engineering Information 9-15-1983.

4.3.1 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.

4.3.2 Conductor Entry

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

4.3.3 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. 250-1979 unless otherwise specified. (See Section 1).

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4.3.4 Materials

Enclosures shall be made of materials which 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 enamelling, painting, galvanizing, plating, or other equivalent means. Consult the manufacturer if application conditions are more severe than those represented by the applicable design test.

NEMA Standard 9-15-1983.

4.3.5 Applications

Refer to clause 6.2.6 for application purposes.

Authorized Engineering Information 9-15-1983.

4.3.6 Type Designations

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

Enclosures shall be classified as follows. Refer to NEMA Standards Publication No. 250-1979 (see Section 1) for more detailed description of enclosures. General duty switch enclosures shall be type 1 or 3R and heavy duty switch enclosures shall be type 1, 3, 3R, 4, 4X, 5, 7, 9, 12, 12K, or 13.

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

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

TYPE 4- 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- The 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- Type 5 enclosures are intended for indoor use primarily to provide a degree of protection against dust and falling dirt.

TYPE 7- Type 7 enclosures are for use indoors in locations classified as Class 1, Groups A, B, C, or D as defined in the *National Electrical Code*, Art. 501.

TYPE 9- Type 9 enclosures are for use in indoor locations classified in Class II, Groups E, F, or G as defined in the *National Electrical Code*, Art. 502.

TYPE 12- 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- 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- Type 13 enclosures are intended for indoor use primarily to provide a degree of protection against dust, spraying of water, oil, and non-corrosive coolant.

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4.4 SERVICE EQUIPMENT

General duty and heavy duty enclosed switches intended for use as service equipment shall meet the requirements of this section.

NEMA Standard 9-15-1983.

4.4.1 Service Equipment Rated Less Than 1,000 Amperes

4.4.1.1 Provisions for Grounded Service Conductor

An enclosed switch which 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 for 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. 10AWG 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. 10AWG

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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.

An enclosed 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:

1. Accommodate a conductor of the same size as the grounding electrode conductor specified in Table 4-4,
2. Be bounded to the enclosure, and
3. Be directly connected to the grounding electrode conductor terminal.

Exception: When the terminals are omitted the enclosed 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.

4.4.1.2 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 4-4. A soldering lug or other connection means that depends upon solder is not acceptable.

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4.4.2 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

Table 4-4
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 (Square Centimeters) (Minimum)‡, #				Size of Grounding Electrode Conductor (Minimum)	
	Copper	Aluminum	Copper		Aluminum		Copper	Aluminum
60	8 AWG	6 AWG	0.013*	(0.084)	0.021*	(0.135)	8 AWG	6 AWG
100	6	4	0.021*	(0.135)	0.033*	(0.213)	6	4
200	4	2	0.033**	(0.213)	0.052**	(0.335)	4	2
400	0††	3/0††	0.083†,††	(0.535)	0.132†,††	(0.852)	0††	3/0††
600	2/0	4/0	0.105	(0.677)	0.166	(1.07)	2/0	4/0
800	2/0	4/0	0.105	(0.677)	0.166	(1.07)	2/0	4/0
1200	250 MCM	250	0.177	(1.14)	0.196	(1.26)	3/0	250

*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.

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

‡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.

††When the ampere rating is 400 and the wire terminal connectors for the main service conductors are acceptable for two No. 3/0 AWG copper or No. 250 MCM aluminum conductor but will not accept a 600 MCM 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.

#For equipment that is rated 1200 amperes and that has wiring terminals intended to connect service conductor wires sized larger than 600 MCM copper or 650 MCM aluminum, the cross section of the main bonding jumper shall be at least 12.5 percent of the total cross section of the largest main service conductor(s) of the same material (copper or aluminum) for any phase.

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means in the presence of a ground fault. Since the Scope of this publication excludes devices which are automatically operable, ground fault protection is not provided on these devices. Therefore, heavy duty enclosed switches having ratings of 1,200 amps, 480V, or 600V, as defined in the Scope of this publication, are not used as service equipment, where ground fault protection is required.

There is an exception in the *National Electrical Code* to 230-95 for continuous industrial processes. Installations which meet the exception and the other ratings included in this publication are suitable for use as service equipment when the requirements in 4.4.1 are met.

Authorized Engineering Information 9-15-1983.

4.4.3 Provisions for Bonding

When an insulated neutral is provided, a main bonding jumper consisting of a separate screw, strap, or other means shall be provided to bond the enclosure of an enclosed switch that is intended for use as service equipment to the insulated grounded circuit conductor (the insulated neutral) of an alternating-current circuit. The bonding means shall be of copper or aluminum, except as noted in the footnotes to Table 4-4, and shall have a cross-sectional area as indicated in Table 4-4.

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

4.4.4 Service Disconnect Marking

(See 5.2, items 7 and 8, and 5.3, items 14 and 15.)

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4.5 FUSIBLE SWITCHES

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

General Duty Switches (see 6.2.1.1)

0–30A—Type S plug fuse or Type S plug fuse with adapter. See 7.5.1 and 7.5.2 for specifications.

0–600A—Class H, K, or R cartridge fuses. See 6.2.4.1 and 7.5.3 for specifications.

Heavy Duty Switches (see 6.2.1.2 and 6.2.4.1)

0–600A—Class G, H, J, K, R, or T cartridge fuses. See 7.5.3 for specifications.

601–1200A—Class L fuses. See 7.5.3 for specifications.

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4.6 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 by means of the operating handle 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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Section 5
MARKING

5.1 GENERAL

Enclosed 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 clauses 5.2, 5.3, and 5.4 as applicable.

NEMA Standard 9-15-1983.

5.2 ENCLOSURE EXTERIOR

1. Maximum voltage rating.
2. Current rating in amperes. An alternating current rating shall be indicated by the letters ac if the frequency or phase rating is not given.
3. Frequency rating if other than 60 Hz, or the indication dc.
4. Warning information (see 5.4.1).
5. An enclosed switch shall be marked plainly outside the enclosure to indicate ON/OFF and any other functional positions of the switch.
6. Unless an 800- or 1200-ampere switch rated at more than 250 volts performs acceptably when subjected to the overload test described in Section 8, it shall be conspicuously marked on the outside of the enclosure: FOR ISOLATING USE ONLY—DO NOT OPEN UNDER LOAD.
7. An enclosed switch marked "Suitable For Use As Service Equipment" shall be provided with a marking "Service Disconnect" in the form of a pressure sensitive label in an envelope or on a card, with instructions to apply near the disconnect handle if the equipment is used as service equipment. See 5.3, item 14.
8. If an enclosed 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 5.3, item 15).

NEMA Standard 9-15-1983.

5.3 OTHER MARKINGS

1. Manufacturer's name or trademark.
2. Catalog number of switch or equivalent.
3. 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 so indicate.
4. Codes allowing determination of the month, year, and place of manufacture.
5. "Heavy Duty" or "General Duty".
6. Available fault current withstand, rating in rms symmetrical amperes.
7. Warning information (see 5.4.2).
8. A fusible enclosed switch shall be marked, as a part of the electrical rating, "Continuous Load Current Not to Exceed 80% of the Rating of Fuses Employed in Other Than Motor Circuits".
9. Standard and maximum horsepower ratings where applicable.
10. 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 4.1.4. 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."
11. 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".
12. 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".
13. If a switch is marked with the voltage and/or horsepower rating 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 incidate the proper circuit arrangement for these ratings.
14. An enclosed switch that is intended for use as service equipment and does not have the neutral bonded to the enclosure at the factory, shall be marked "Suitable For Use As Service Equipment".
15. An enclosed 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 s Service Equipment".
16. A switch designed to accept only Class G, J, L, R, or T fuses and having a high available fault current rating indicated in clause 4.1.6 shall be marked with the following statement, "Suitable for

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use on a circuit capable of delivering not more than . . . rms symmetrical amperes, . . . volts maximum; Use Class (G, J, L, R, or T) fuses".

A switch designed for field conversion to accept only Class J, R, or T fuses, having a short-circuit withstand rating indicated in clause 4.1.6, shall be marked, "when used with class _____ (J Fuses, T Fuses, R Fuses) and Fuse Clip Assembly No. _____ Properly Installed, or R Fuses and Class H Rejectors Properly Installed, this Switch Is Suitable For Use On A Circuit Capable of Delivering Not More Than _____ RMS Symmetrical Amperes, _____ Volts Maximum". 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 Become a Fire and Casualty Hazard If Installed On Circuits Capable of Delivering More Than 10,000 RMS Symmetrical Amperes".

An enclosed 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.

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

18. An enclosed 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.

19. Tightening torques—An enclosed 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.

20. A switch which is equipped with pressure wire connectors suitable for use with aluminum and copper conductors and which 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 of Aluminum Conductors" or "Suitable For Use With Cu/Al Conductors".

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

22. If a switch has any terminals which, 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".

23. When terminals are omitted per 7.4.1, exception 3 , both pieces of equipment are to be marked as follows:

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

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

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

25. 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.

26. When terminals are omitted per clause 7.4.1, Exception 2, the equipment shall be marked stating which pressure terminal connector or component terminal assemblies are suitable for use with the equipment.

NEMA Standard 9-15-1983.

5.4 WARNING INFORMATION

5.4.1 Outside of Enclosure Door

To make the user aware of immediate or potential hazards in their application, installation, use, or maintenance, enclosed switches (with the exception of those units used in panelboards and switchboards) shall be conspicuously marked on the outside of the enclosure door with the following text (or effective equivalent) and symbol, and shall reflect the following format.

DANGER: Hazard of electrical shock or burn. See instructions inside_____.

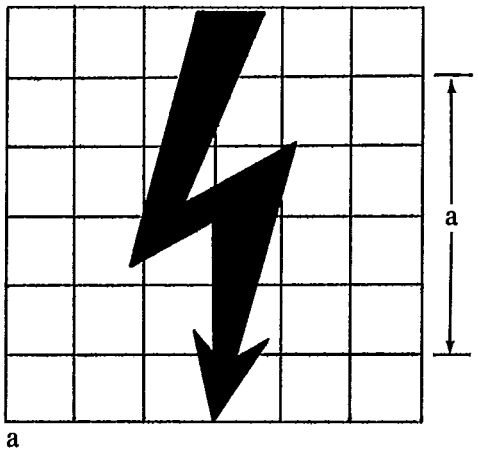
Insert "cover" or "door"

The symbol for danger shall have the proportions shown in Figure 5-1.

Vivid red (ISCC-NBS 11) Munsell Notation 7.5R 4.0/14 shall be the predominant visual color for either the signal word "DANGER" and the symbol, or for the background. Black, white, or metallic may be used for contrast. These colors may be used either for the lettering or the background.

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Real Dimensions
Height = 1.48a
Weight = 0.58a

Figure 5-1

Warning labels on the exterior of 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 which are required to comply with other nationally recognized standards or applicable laws or regulations, such as radiation warnings, or which may be deemed necessary by the manufacturer.

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5.4.2 Inside of Enclosure Door

The warning instructions on the inside of the cover, door, etc., shall be in accordance with Figure 5-2 for fusible switches and Figure 5-3 for nonfusible switches. Any color may be used. The symbol for DANGER is not required. (As an alternative, warning instructions may be located on a label on the outside of the cover, door, etc.)

NEMA Standard 9-15-1983.

> TURN OFF SWITCH before removing or installing fuse(s).
> TURN OFF POWER ahead of switch before doing other work inside.
> (a) Replace all parts and close cover before turning ON
> (b) Close cover before turning power ON

Use (a) or (b), whichever is more appropriate

Figure 5-2
FUSIBLE SWITCHES

> TURN OFF POWER ahead of switch before doing work inside.
> (a) Replace all parts and close cover before turning power ON
> (b) Close cover before turning power ON

Use (a) or (b), whichever is more appropriate

Figure 5-3
NONFUSIBLE SWITCHES

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Section 6
APPLICATION INFORMATION

6.1 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.

6.1.1 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.

6.1.1.1 Ambient Air Temperature

The ambient air temperature is between −30°C and +40°C. When the expected range of ambient air temperature is lower than −30°C or higher than +40°C, the user should consult the manufacturer.

6.1.1.2 Altitude

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

6.1.2 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 which can lead to internal condensation.
>
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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.

Authorized Engineering Information 9-15-1983.

6.2 SELECTION AND USER INFORMATION

6.2.1 General Duty and Heavy Duty Switches

6.2.1.1 General Duty Switches

General duty 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.

General duty switches are intended for use on supply circuits having a maximum available fault current of 10,000 rms symmetrical amperes at a maximum of 240 volts alternating current (see 4.5).

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

6.2.1.2 Heavy Duty Switches

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

They may have fault current ratings up through 200,000 rms symmetrical amperes 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.

6.2.2 Ampere and 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.

6.2.2.1 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:

1. Connecting and disconnecting circuits under no load conditions.
2. Switching of resistive loads.

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3. Switching of mixed resistive and light inductive loads.

6.2.2.2 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 4.1.4 and 4.1.5 for horsepower ratings.)

Enclosed switches covered in this standard should not be used as motor controllers in applications subject to jogging or plugging.

6.2.3 Fusible and Nonfusible Switches

6.2.3.1 Fusible Switches

Fusible switches may be used where overcurrent protection is required for main, feeder, or branch circuits. Fusible switches with horsepower ratings may 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.

6.2.3.2 Nonfusible Switches

Nonfusible switches may 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.

6.2.4 Available Fault Withstand Current Rating

6.2.4.1 Fusible Switches

The available fault current withstand 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 rms symmetrical amperes requires the use of the fuses designated on the switch marking (classes G, J, L, R, or T). However, use of these fuses which have interrupting ratings in excess of 10,000 rms amps, 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 maufacturer may result in a fire or casualty hazard.

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

6.2.4.2 Nonfusible Switches

Nonfusible switches may have either one or both of the following types of available fault current withstand ratings:

1. An available fault current withstand 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.

2. An available fault current withstand 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 which 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 than the rating of the switch.

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

If a nonfusible switch is marked for use with overcurrent protective devices which 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 8.

6.2.5 Termination Information

See clause 5.3 for marking and clause 7.4 for standard conditions for construction.

1. 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.

2. 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.

3. 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.

4. 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

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Table 6-1
COMPARISON OF SPECIFIC APPLICATIONS OF ENCLOSURES FOR INDOOR NONHAZARDOUS LOCATIONS

Provides a Degree of Protection Against the Following Environmental Conditions	Type of Enclosure						
	1	4	4X	5	12	12K	13
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X
Falling dirt	X	X	X	X	X	X	X
Falling liquids and light splashing	...	X	X	...	X	X	X
Dust, lint, fibers, and flyings*	...	X	X	X	X	X	X
Hosedown and splashing water	...	X	X	...	...	...	...
Oil and coolant seepage	...	...	...	...	X	X	X
Oil or coolant spraying and splashing	...	...	...	...	...	...	X
Corrosive agents	...	...	X	...	...	...	...

*Fibers and flyings are nonhazardous materials and are not considered the Class II Type ignitable fibers or combustible flyings. See footnote at bottom of Table 6-3.

the stripped portion and, when required, an oxide inhibiting compound should be applied.

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

6. All lugs should be tightened. Torque values given in the manufacturers' instructions or markings provided with the equipment should be used.

7. 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 manufacturers' instructions or markings provided with the equipment.

8. 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.

6.2.6 Enclosure Applications

Tables 6-1, 6-2, and 6-3 may be used as a guide in selecting enclosures for specific environments. It is possible that, because of local code requirements of unusual operating conditions, a different or modified type of enclosure may be required, in which case the manufacturer should be consulted.

Special care should be used in selecting enclosures for hazardous locations, and the advice of competent authorities should be solicited.

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 6-1, 6-2, and 6-3.

Authorized Engineering Information 9-15-1983.

6.3 MAINTENANCE

6.3.1 General

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

Maintenance of enclosed switches should be in accordance with the instructions supplied by the manufacturer of the enclosed switch. Also see NFPA 70B *Electrical Equipment Maintenance-1977* (see Section 1).

Table 6-2
COMPARISON OF SPECIFIC APPLICATIONS OF ENCLOSURES FOR OUTDOOR NONHAZARDOUS LOCATIONS

Provides a Degree of Protection Against the Following Environmental Conditions	Type of Enclosure			
	3	3R	4	4X
Incidental contact with the enclosed equipment	X	X	X	X
Rain, snow, and sleet*	X	X	X	X
Windblown dust	X	...	X	X
Hosedown	...	...	X	X
Corrosive agents	...	...	...	X

*External operating mechanisms are not required to be operable when the enclosure is ice covered.

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Table 6-3
COMPARISON OF SPECIFIC APPLICATIONS OF ENCLOSURES FOR INDOOR HAZARDOUS LOCATIONS

Provides a Degree of Protection Against Atmospheres Typically Containing	Class	Type of Enclosure						
		7 Class I Groups				9 Class II Groups		
		A	B	C	D	E	F	G
Acetylene	I	x	...	...	...	...	...	...
Hydrogen, manufacturing gas	I	x	x	...	...	...	...	...
Diethel ether, ethylene, cyclopropane	I	x	x	x	...	...	...	...
Gasoline, hexane, butane, naphtha, propane, acetone, toluene, isoprene	I	x	x	x	x	...	...	...
Metal dust	II	x	x	x	x	x	...	...
Carbon black, coal dust, coke dust	II	x	x	x	x	...	x	...
Flour, starch, grain dust	II	x	x	x	x	x	x	x
Fibers, flying*	III	x	x	x	x	x	x	x

*A Class III, Division 1 location in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured, or used. See Section 500–6(a) of the *National Electrical Code* (see Section 1).

6.3.2 Specific Parts

6.3.2.1 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.

6.3.2.2 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 which could also be caused by arcing should be replaced.

6.3.2.3 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.

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Section 7
CONSTRUCTION

7.1 MECHANICAL DESIGN

7.1.1 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.

7.1.2 Operating Handle

A suitable handle shall be provided for safe 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.

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 8.2. If handle movement is vertical, the upper position shall be ON.

A handle or other member which 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.

7.1.3 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 person 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.

7.1.4 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 provided with an interlock release by which a person (1) can open the main or auxiliary cover to inspect the switch in the ON position, using a tool, (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.

7.1.5 Padlocking

Means shall be provided for padlocking enclosure doors shut.

Means shall be provided to positively lock a switch with the contacts of 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.

7.1.6 Accessibility of Fuses

The design and construction of an enclosed single throw switch and the location of fuses shall be such that fuses will be readily accessible when the switch contacts are open so that they can be replaced with-

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Table 7-1
MINIMUM SPACING (IN,M)

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	¾ (19.05)	½ (12.7)	½ (12.7)	½ (12.7)
126–250	1¼ (31.75)	¾ (19.05)	½ (12.7)	½ (12.7)
251–600	2 (50.8)	1 (25.4)	1 (25.4)	½ (12.7)

out 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.

If double throw switches are installed as transfer devices between two sources of power and a common load, the fuses may be energized even if the switch is in the middle (OFF) position. The switch should be disconnected from both sources before changing fuses. The switch shall be marked in accordance with 5.3, item 25.

NEMA Standard 9-15-1983.

7.2 ENCLOSURES

Switch enclosures shall be in accordance with NEMA Standards Publication No. 250-1979 (see Section 1).

NEMA Standard 9-15-1983.

7.3 SPACINGS

7.3.1 General

Except as otherwise noted in this clause, the spacings in an enclosed switch shall be as indicated in Table 7-1. "Grounded Metal" includes the enclosures and any metal which is in electrical connection with the enclosure.

The spacings between screw shells of plug fuseholders which are protected by surrounding walls of insulating material and between such screw shells and a metal cover plate may be less than those indicated in 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 ¾ in (1.905 cm). However, such spacings shall not be less than ¼ in (.635 cm) 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 is in the OFF position and the blades are not energized, but such spacing shall be not less than ⅛ in (.3175 cm).

There shall be a spacing of not less than ⅛ inch (.3175 cm) between line and load terminals of the same polarity.

Compression lugs or pressure wire connectors shall be prevented from turning to the extent that spacing would be reduced to less than those in the foregoing table; 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 be provided.

7.3.2 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 7.3.1. For the purpose of measurement, it shall be assumed that required bushings having the dimensions shown in Table 7-2 are in place and that

Table 7-2
BUSHING DIMENSIONS

Trade Size of Conduit (Inches)	Bushing Dimensions, in (mm)	
	Overall Diameter	Height
½	1 (25.4)	⅜ (9.5)
¾	1 15/64 (31.4)	27/64 (10.7)
1	1 19/32 (40.5)	33/64 (13.1)
1¼	1 15/16 (49.2)	9/16 (14.3)
1½	2 13/64 (56.0)	19/32 (15.1)
2	2 45/64 (68.7)	⅝ (15.9)
2½	3 7/32 (81.8)	¾ (19.1)
3	3⅞ (98.4)	13/16 (20.6)
3½	4 7/16 (112.7)	15/16 (23.8)
4	4 31/32 (126.2)	1 (25.4)
4½	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 (183.4)	1¼ (31.8)

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no 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 7-3 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.

NEMA Standard 9-15-1983

7.4 TERMINALS

7.4.1 General

An enclosed 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 Table 7-4.

It shall be assumed that field installed conductors will be:

1. Wire rated at 75°C (167°F) in size 1/0 AWG and larger.
2. 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.

Aluminum wire at any terminal identified as being suitable for use with such wire.

Exceptions:

1. A wire binding screw may 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 bending 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 connector.
2. Pressure terminal connectors for field connection (line or load) need not be provided if the following conditions are met:

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

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

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

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

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

f. The equipment shall be marked in accordance with clause 5.3, item 26.

3. A terminal may be omitted if:

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

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

c. Both pieces of equipment are marked in accordance with 5.3, item 23.

Suggested Standard for Future Design 9-15-1983.

7.4.2 Wire Bending Space

Minimum wire bending spaces for enclosed switches are given in Table 7-4.

Suggested Standard for Future Design 9-15-1983.

7.4.3 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 parts of the switching mechanism, shall be not less in width and depth than the values given in Table 7-5 and shall be not less in cross-sectional area than 250 percent of the total cross-sectional area of the maximum number of wires which 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 7-5.

NEMA Standard 9-15-1983.

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Table 7-3

TRADE SIZE OF METALLIC CONDUIT OR TUBING BASED ON NEC CHAPTER 9, TABLE 1 FOR 40% FILL AND TABLES 3A, 3B, 3C, & 4—NEW WORK OR REWIRING. REFER TO NEC CHAPTER 9 FOR MAXIMUM NUMBER OF CONDUCTORS IN TRADE SIZES OF METALLIC CONDUIT OR TUBING. PROPERTIES OF CONDUCTORS MUST AGREE WITH NEC CHAPTER 9, TABLE 8.

Table 310-16 Ampacity Insulated Copper ‡	Table 310-16 Ampacity Insulated Aluminum & Copper Clad Aluminum ‡	60°C (140°F) TW UF (14-4/0)			75°C (167°F) *THWN, *XHHW			75°C (167°F) *THW *RHW-USE Without Outer Covering		
		Wire Size	Conduit 3W	‡Conduit 3Ø 4W	Wire Size	Conduit 3W	‡Conduit 3Ø 4W	Wire Size	Conduit 3W	‡Conduit 3Ø 4W
15	...	#14†	½	½	#14†	½	½	■14†	½	½
15	...	...	...	...	...	...	...	...	...	...
20	15	‡12†	½	½	#12†	½	½	■12†	½	½
20	20	...	...	...	...	...	...	...	...	...
30	25	‡10	½	½	‡10†	½	½	■10†	½	½
40	30	‡8	¾	¾	...	...	...	...	...	...
40	35	...	...	...	...	...	...	...	...	...
50	40	...	...	...	‡8	½●	¼	■8	¾	1
55	40	#6	1	1	...	...	...	...	...	...
55	45	...	...	...	...	...	...	...	...	...
65	50	...	...	...	#6	¾	¾◆	#6	1	1
70	55	#4	1	1¼	...	...	...	...	...	...
75	60	...	...	...	...	...	...	...	...	...
85	65	#3	1¼	1¼	...	...	...	...	...	...
85 (100°)	65	...	...	...	#4	1	1	#4	1	1¼
95	75	#2	1¼	1¼	...	...	...	...	...	...
95 (100°)	75	...	...	...	...	...	...	...	...	...
100 (110°)	75	...	...	...	#3	1	1¼	#3	1¼	1¼
110	85	#1	1¼	1½	...	...	...	...	...	...
110 (110°)	85	...	...	...	...	...	...	...	...	...
115 (125°)	90 (100°)	...	...	...	#2	1	1¼	#2	1¼	1¼
125	100	0	1½	2	...	...	...	...	...	...
130 (125°)	100 (100°)	...	...	...	...	...	...	...	...	...
130 (150°)	100 (110°)	...	...	...	#1	1¼	1½	#1	1¼	1½
145	115	00	1½	2	...	...	...	...	...	...
150 (150°)	115 (110°)	...	...	...	...	...	...	...	...	...
150 (175°)	120 (125°)	...	...	...	0	1¼	1½	0	1½	2
165	130	000	2	2	...	...	...	...	...	...
170 (175°)	135 (125°)	...	...	...	...	...	...	...	...	...
175 (200°)	135 (150°)	...	...	...	00	1½	2	00	1½	2
195	150	0000	2	2½	...	...	...	...	...	...
195 (200°)	150 (150°)	...	...	...	...	...	...	...	...	...
200	155 (175°)	...	...	...	000	1½	2	000	2	2
215	170	250M	2½	2½	...	...	...	...	...	...
225	175 (175°)	...	...	...	...	...	...	...	...	...
230	180 (200°)	...	...	...	0000	2	2	0000	2	2½
240	190	300M	2½	3	...	...	...	...	...	...
255	205	...	...	...	250M	2	2½	250M	2½	2½
260	205 (200°)	...	...	...	...	...	...	...	...	...
260	210	350M	2½	3	...	...	...	...	...	...
280	225	400M	3	3	...	...	...	...	...	...
285	230	...	...	...	300M	2	2½	300M	2½	3
290	230	...	...	...	...	...	...	...	...	...
310	250	...	...	...	350M	2½	3	350M	2½	3
320	255	...	...	...	...	...	...	...	...	...
320	260	500M	3	3½	...	...	...	...	...	...
335	270	...	...	...	400M	2½	3	400M	3	3
350	280	...	...	...	...	...	...	...	...	...
355	285	600M	3	3½	...	...	...	...	...	...
380	305	...	...	...	...	...	...	...	...	...
380	310	...	...	...	500M	3	3	500M	3	3½
385	310	700M	3½	4	...	...	...	...	...	...
400	320	750M	3½	4	...	...	...	...	...	...
420	340	...	...	...	600M	3	3½	600M	3	3½
430	350	...	...	...	...	...	...	...	...	...
460	375	...	...	...	700M	3	3½	700M	3½	4
475	385	...	...	...	750M	3½	4	750M	3½	4
520	420	...	...	...	...	...	...	...	...	...
535	435	...	...	...	...	...	...	...	...	...

● 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 RHW-THW-THWN-XHHW.)

‡ 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% per notes 8 & 10 to NEC Table 310-16.

◆ #6 XHHW requires 1" conduit for 3Ø 4W.

● #8 XHHW requires ¾" 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.

† The overcurrent protection for conductor types marked with an obelisk (†) shall not exceed 15 amperes for 14 AWG, 20 amperes for 12 AWG, and 30 amperes for 10 AWG copper; or 15 amperes for 12 AWG and 25 amperes for 10 AWG aluminum and copper-clad aluminum after any correction factors for ambient temperatures and number of conductors have been applied. (These are the values shown in this table.)

NEC 220-2 (a) Continuous Loads.
The continuous load supplied by a branch circuit shall not exceed 80 percent of the branch circuit rating. (See Exceptions in NEC.)

NEC 220-10 (b) Continuous and Noncontinuous Loads.
Where a feeder supplies continuous loads or any combination of continuous and noncontinuous loads, neither the ampere rating of the overcurrent device nor the ampacity of the feeder conductors shall 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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Table 7-4
MINIMUM WIRE BENDING SPACE FOR ENCLOSED SWITCHES
(Based on the 1984 NEC)

Switch Nameplate Rating, Amperes	Copper Wire 60°C Wire	Copper Wire 75°C Wire	Copper Wire Ampacity	Copper Wire Wire Bending Space Inches	Aluminum Wire 60°C Wire	Aluminum Wire 75°C Wire	Aluminum Wire Ampacity	Aluminum Wire Wire Bending Space Inches	Switch Nameplate Rating, Amperes
30 *	1-#10	...	30	Not specified except as noted	1-#8	...	30	1½	30 *
30	...	1-#10	35	Not specified except as noted	...	1-#8	40	1½	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	4½	1-1/0	...	100	5½	100
100	...	1-#3	100	3	...	1-#1	100	4½	100
200	...	1-3/0	200	6½ [½]***	...	1-250MCM	205	8½ [2]***	200
400**	...	2-4/0	460	7½ [1½]***	...	2-300MCM	460	10 [2]***	400
600	...	2-350MCM	620	12 [3]***	...	2-500MCM	620	14 [3]***	600
800	...	3-300MCM	855	11 [1]***	...	3-400MCM	810	14 [3]***	800
1200	...	4-350MCM	1240	14 [2]***	...	4-500MCM	1240	16 [3]***	1200

* Wire bending space and terminals for line connections for 30 ampere switches marked suitable for use as service equipment shall be 1½" for No. 8 copper or 2" for No. 6 aluminum.

** For ampere rated 400-ampere switches (with no horsepower rating) wire bending space shall be permitted to be 6½ inches for (2) 3/0 copper conductors or 8½ inches for (2) 250MCM aluminum conductors.

Should the conditions of note *** apply, the wire bending space for (2) 3/0 copper conductors shall be permitted to be 6 inches and for (2) 250 MCM aluminum, the space shall be permitted to be 6½ inches.

*** For removable wire terminals intended for only one wire, bending space shall be permitted to be reduced by the number of inches indicated in brackets.

NOTE: To obtain metric values (mm) multiply inches × 25.4.

NEMA Standard 3-8-1985.

Table 7-5
WIRING SPACE

Maximum Size of Wire or Cable Involved	Minimum Width and Depth of Wiring Space in In (mm)	Minimum Areas in Square Inches (Square Centimeters) Required for Multiple Wires—Based on Factor of 2.5 Two Wires	Three Wires	Four Wires	Five Wires	Six Wires
10 AWG	⅜*(9.5)	0.23 (1.5)	0.34 (2.2)	0.46 (3.0)	0.57 (3.7)	0.68 (4.4)
8	½(12.7)	0.43 (2.8)	0.64 (4.1)	0.85 (5.5)	1.07 (6.9)	1.28 (8.3)
6	⅝(15.9)	0.62 (4.0)	0.93 (6.0)	1.24 (8.0)	1.55 (10.0)	1.86 (12.0)
4	¾(19.1)	0.80 (5.2)	1.20 (7.7)	1.60 (10.3)	2.00 (12.9)	2.40 (15.5)
2	⅞(22.2)	1.03 (6.6)	1.55 (10.0)	2.06 (13.3)	2.58 (16.6)	3.10 (20.0)
1	1 (25.4)	1.36 (8.8)	2.04 (13.2)	2.72 (17.6)	3.40 (22.0)	4.08 (26.3)
1/0	1 (25.4)	1.55 (10.0)	2.33 (15.0)	3.10 (20.0)	3.88 (25.0)	4.66 (30.1)
2/0	1 (25.4)	1.79 (11.5)	2.68 (17.3)	3.58 (23.1)	4.47 (28.8)	5.36 (34.6)
3/0	1⅛(28.6)	2.08 (13.4)	3.11 (20.1)	4.16 (26.8)	5.19 (33.5)	6.22 (40.1)
4/0	1¼(31.6)	2.42 (15.6)	3.63 (23.4)	4.84 (31.2)	6.05 (39.0)	7.26 (46.8)
250 MCM	1⅜(34.9)	2.96 (19.1)	4.44 (28.6)	5.92 (38.2)	7.40 (47.7)	8.88 (57.3)
300	1½(38.1)	3.42 (22.1)	5.13 (33.1)	6.84 (44.1)	8.55 (55.2)	10.26 (66.2)
350	1½(38.1)	3.81 (24.6)	5.72 (36.9)	7.62 (49.2)	9.53 (61.5)	11.44 (73.8)
400	1⅝(41.3)	4.18 (27.0)	6.27 (40.5)	8.36 (53.9)	10.45 (67.4)	12.54 (80.9)
500	1¾(44.5)	4.92 (31.7)	7.38 (47.6)	9.84 (63.5)	12.30 (79.4)	14.76 (95.2)

*The minimum clear width and depth of a wiring space in an enclosed switch marked as acceptable for use as service equipment is to be ½ inch (12.7 mm) in any case.

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7.5 FUSEHOLDERS

7.5.1 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.

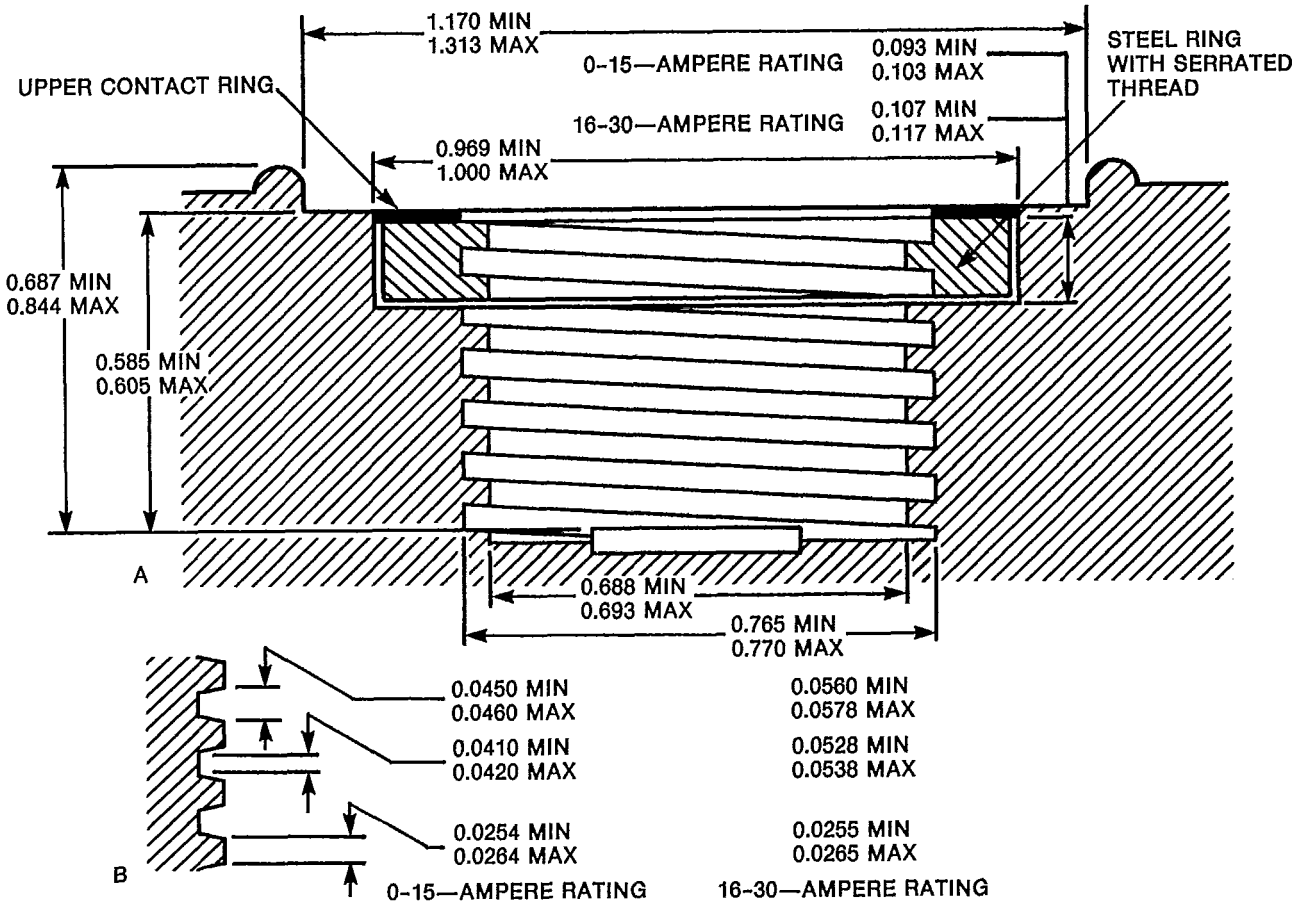
There shall be no live parts exposed when a Type S fuse and fuseholder are installed and assembled together.

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

Just below the upper contact ring of a Type S fuseholder there shall be a hardened steel ring, as illustrated in Figure 7-1 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 7-1.

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 7-1 with reference to this feature,



A = FUSEHOLDER
B = DETAILS OF THREADS

Figure 7-1
DIMENSIONS OF A TYPE S FUSEHOLDER, In (mm)*

* Conversion Factor: 1 inch = 25.4 mm

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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 7-1, go and not as applicable.

The marked current rating of a Type S fuseholder shall be located so that it will be plainly visible after installation.

7.5.2 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 in (.2032 mm) thick.

*Drawings of those gauges are available from Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, Illinois.

Exception: A screw shall formed from metal nominally 0.008 in (.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 in (.1651 mm).

The male screw shell shall be of the medium base size and shall, when tested with gauges made in conformity with the ANSI/UL Standard on *Fuseholders,* go and not 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 plus 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 $\frac{7}{16} \pm \frac{1}{32}$ in ($11.11 \pm .79$ 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 7-2 that is protected against corro-

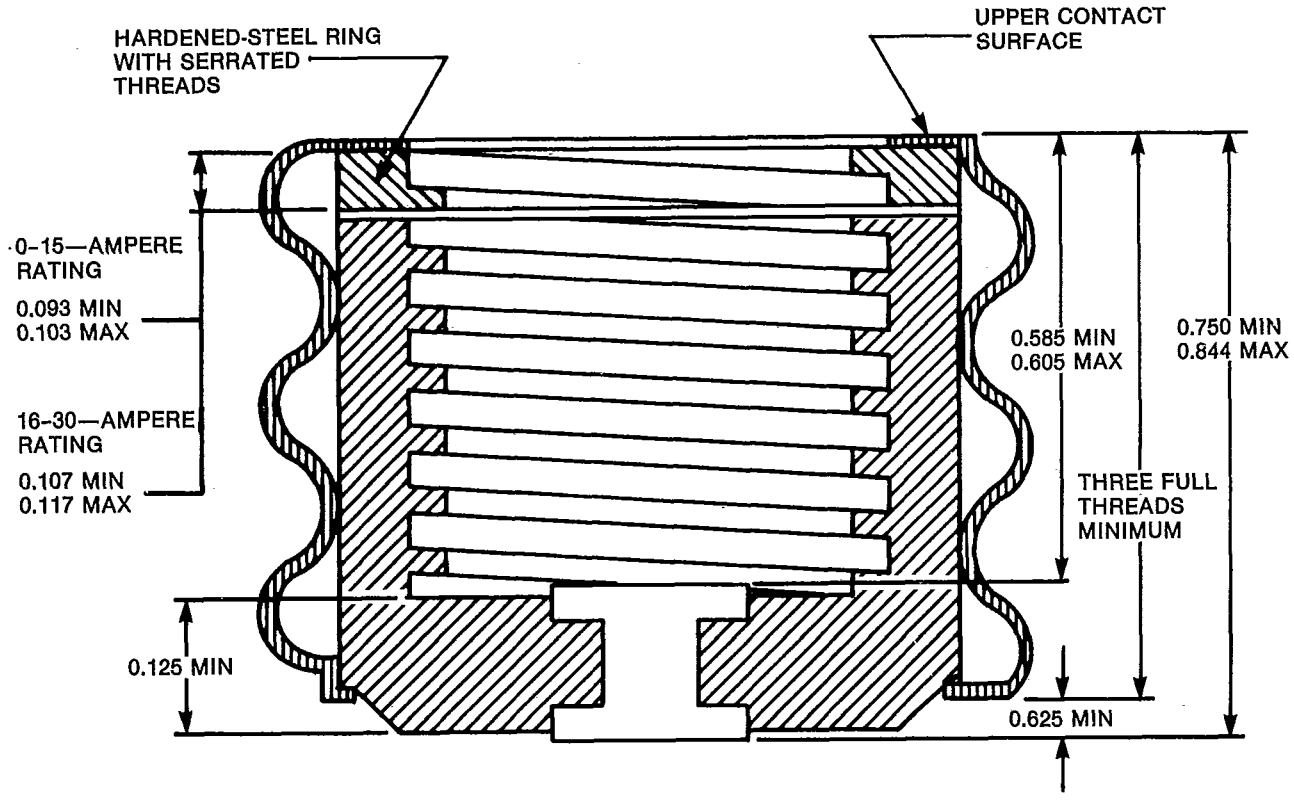


Figure 7-2
DIMENSIONS OF A TYPE S ADAPTER, In (mm)*

* Conversion Factor: 1 inch = 25.4 mm

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sion by a suitable metallic-planted 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 7-2.

A Type S adapter shall be so constructed that the female threaded portion will, when tested with gauges* made in conformance with the ANSI/UL Standard on *Fuseholders,* (see Section 1), go and not go as applicable.

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 7-3 with reference to this feature, and the cup or spacer shall be secured by suitable means that will prevent it from being readily removed.

*Drawings of these gauges are available from Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, Illinois.

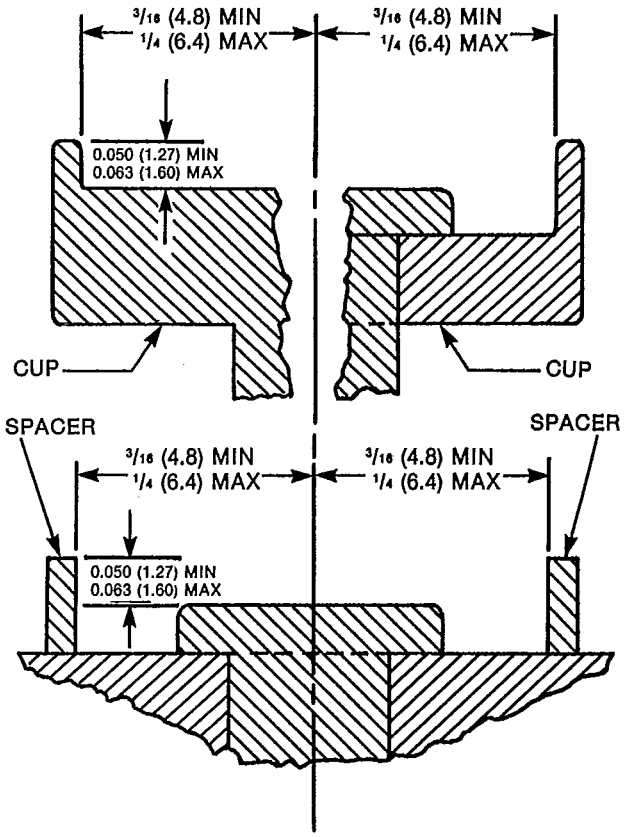


Figure 7-3
CONTACT-REJECTION CUP AND SPACER, In (mm)

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.

7.5.3 Cartridge Fuseholders—Class 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 assure that these conditions will be met.

A fuseholder designed for a Class R 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 may consist of a pin, a bolt, or lancing of the clips. Other methods may be used if shown to be suitable for the purpose.

A fuseholder for a Class R fuse shall be designed so that removal of the rejection member by using ordinary tools and methods causes obvious damage to the fuseholder.

The methods and tools referred to are outlined in 7.5.3.1 and 7.5.3.2.

7.5.3.1 METHODS

1. Bending, twisting, reshaping or breaking apart, and
2. Addition, removal, or substitution of a standard available part, common hardware, screws, etc.

Exception: A part retained by standard head screws, nut, or bolts that are accessible for release only from the rear of the fuseholder or that are retained by rivets or one-way screws.

7.5.3.2 TOOLS

A hand screwdriver, pliers, diagonal cutter, wrench (excluding a pipe wrench), and a tool specifically designed to alter the rejection member that is readily available in the field.

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

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Table 7-6
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	200	889.6
600	250/600	200	889.6

7-6. The force shall be applied using a Class H fuse or a dummy fuse.

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 shall also be secured with one or more rivets or screws.

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, shall be as specified in Tables 7-7, 7-9, and Figures 7-4, 7-5, 7-6, and 7-7, whichever are applicable.

Exception: A fuseholder with other constructions may 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 a Class R fuse shall be the same as specified in Table 7-8. All other dimensions shall be the same as for Class H fuses.

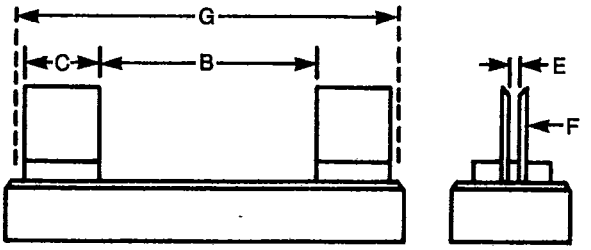


Figure 7-5
CARTRIDGE FUSEHOLDER—KNIFE-BLADE TYPE (EXCEPT CLASS R)

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

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 7-7.

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 7-7).

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 7-4) is 3¾ inches and for (2) a 30-ampere, Class J fuseholder if that distance is one inch.

NEMA Standard 9-15-1983.

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

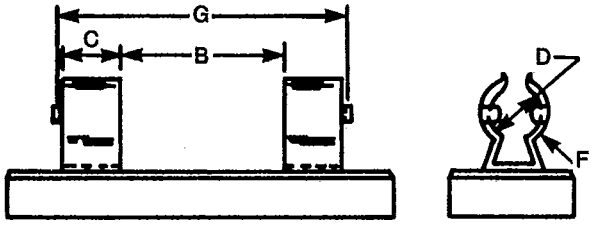


Figure 7-4
CARTRIDGE FUSEHOLDER—FERRULE-CONTACT TYPE (EXCEPT CLASS R)

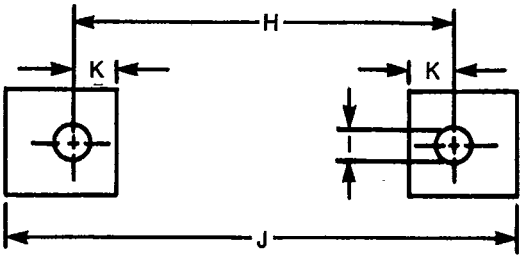


Figure 7-6
FUSEHOLDER—FUSE BOLTED IN PLACE

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Table 7-7
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)	½ (12.7)	9/16 (14.29)	...	0.028 (.71)	2 1/32 (51.59)	2 1/8 (53.975)
		60	1 3/4* (44.45)	5/8 (15.87)	13/16 (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)	½ (12.7)	13/16 (20.63)	...	0.028 (.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)	...
G	300	15	3/4* (19.05)	0.305 (7.75)	13/32 (10.32)	...	0.017 (.43)	1.345 (34.16)	1.365 (34.67)
		20†	27/32*,‡ (21.43)	0.305 (7.75)	13/32 (10.32)	...	0.017 (.43)	1.440 (36.58)	1.460 (37.08)
		30	1 1/16* (26.99)	0.305 (7.75)	13/32 (10.32)	...	0.017 (.43)	1.660 (42.16)	1.700 (43.18)
		60	1 1/4* (31.75)	0.500 (12.7)	13/32 (10.32)	...	0.040 (1.106)	2.281 (57.94)	2.375 (60.325)
J	600	30	1 1/4*,** (31.75)	½ (12.7)	13/16 (20.64)	...	0.028 (.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 (63.5)
		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 1/32 (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 (.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 (1.52)	2.176 (55.27)	2.398 (60.91)
		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 (.7112)	1.540 (39.12)	1.580 (40.132)
		60	0.740†† (18.79)	0.390 (9.906)	0.812 (20.62)	...	0.040 (1.016)	1.600# (40.64)	1.630# (41.40)

* Tolerances for the B dimensions are: 60 amperes or less: +1/32 inch (.793) and −1/16 inch (1.59); 100 and 200 amperes: +1/16 inch (1.59) and −1/32 inch (.793); 400 and 600 amperes: +3/32 inch (2.38).

** See 7.5.3

† Minus tolerance may be 5/32 inch (3.97)

‡ Tolerance ±0.020 inch (.508)

†† Tolerance ±0.050 inch (1.27)

‡‡ Tolerance ±0.030 inch (.762)

Minimum of 0.070 inch (1.778) clearance at one end shall be provided for plate. Distance may be 1.670–1.700 (42.42–43.18) with clearance at each end for plate.

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Table 7-8
DIMENSIONS OF A CARTRIDGE FUSEHOLDER FOR CLASS R FUSES HAVING A REJECTION MEMBER In (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	I‡‡ 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 (16.637)	...
	60	5.298 (134.57)	0.260 (6.60)	0.081†† (2.06)	...	0.080 (2.03)	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 (22.07–23.44)
	600	12.375 (314.33)	1.156 (29.36)	0.505 (12.83)	0.781 (19.84)	...	...	...	1.056–1.110 (26.82–28.19)

* Column K tolerance: +0.031(.7874),–dimension E in Table 7-7 multiplied by 0.5.

** Column L tolerance: –0.016(.406), +0.000 applicable when rejection member is integral part of fuse clip.

† Column N tolerance: –0.000, +0.060(1.524) applicable when rejection member is not integral part of fuse clip.

‡ Assumes rectangular cross-section, may be 0.127(3.23) inch(mm) if portion in contact with fuse has 0.031(.7874) inch(mm) radius on each side.

†† Assumes rectangular cross-section, may be 0.143(3.63) inch(mm) if portion in contact with fuse has 0.031(.7874) inch(mm) radius on each side.

‡‡ 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.

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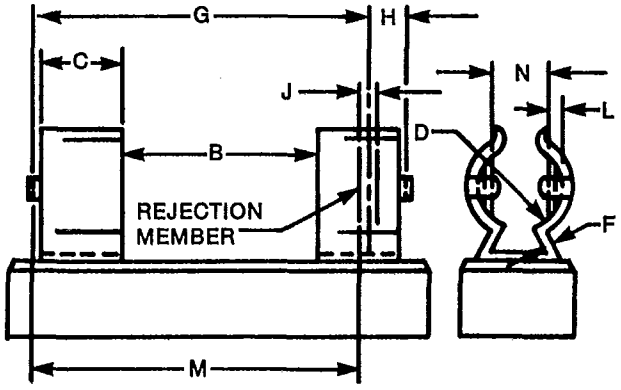


Figure 7-7
CLASS R FUSEHOLDER FERRULE CONTACT TYPE WITH REJECTION MEMBER

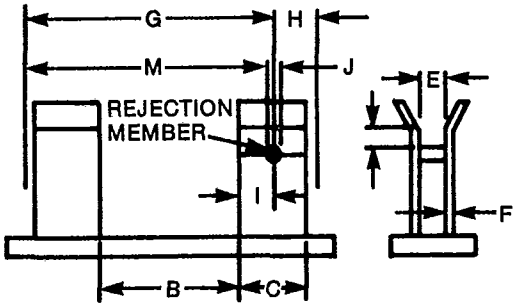


Figure 7-8
CLASS R FUSEHOLDER BLADE TYPE WITH REJECTION MEMBER

Table 7-9
DIMENSIONS OF A CLASS J FUSEHOLDER—FUSES BOLTED IN PLACE

	Dimensions, In (mm)				
	H		I	J	K
Current Rating of Fuse, Amperes	Center-to-Center of Studs or Clearance Holes*	Diameter of Stud	Diameter of Clearance Hole	Minimum Obstructed Clearance	End of Terminal to Center of Stud or Clearance Hole Maximum
100	3⅝ (92.075)	¼	9/32 (7.14)	4 23/32 (102.32)	⅜ (9.53)
200	4⅜ (111.125)	¼	9/32 (7.14)	5 27/32 (148.43)	9/16 (14.29)
400	5¼ (133.35)	⅜	13/32 (10.32)	7 7/32 (178.02)	51/64 (20.24)
600	6 (152.4)	½	17/32 (13.49)	8 3/32 (205.58)	63/64 (25.0)

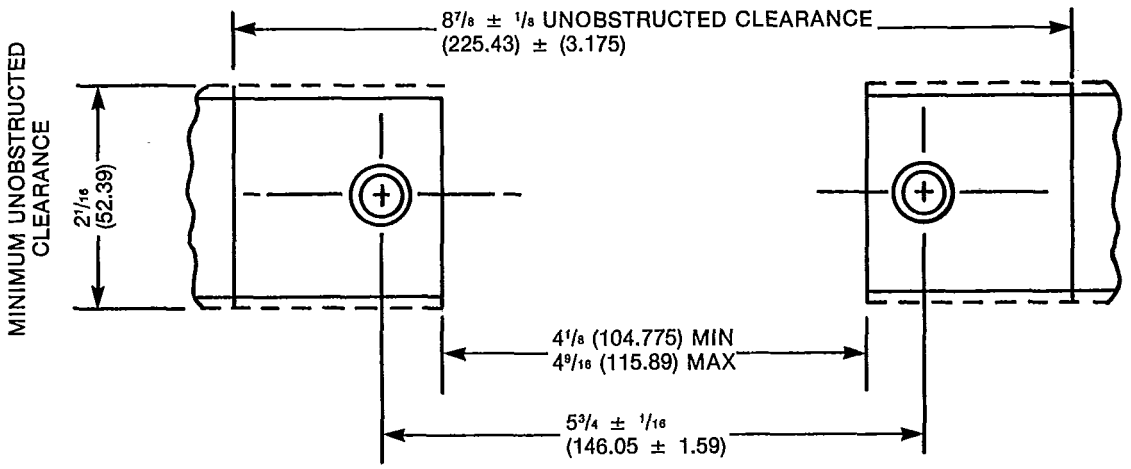
*Tolerance ± 1/16 in (1.5875 mm).

Table 7-10
DIMENSIONS OF A CLASS T FUSEHOLDER—FUSES BOLTED IN PLACE

		Dimensions, In (mm)				
		H	I	J		K
Potential Rating of Fuse, Volts	Current Rating of Fuse, Amperes	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)	¼	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)	⅜	2.790 (70.87)	3.003 (76.28)	0.480 (12.19)
	600	2.031 (51.59)	7/16	3.103 (78.82)	...	0.560 (14.22)
600	100	2.352 (59.74)	¼	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)
	400	2.719 (69.06)	⅜	3.665 (93.09)	3.924 (99.67)	0.480 (12.19)
	600	2.953 (75.01)	7/16	4.024 (102.21)	...	0.560 (14.22)

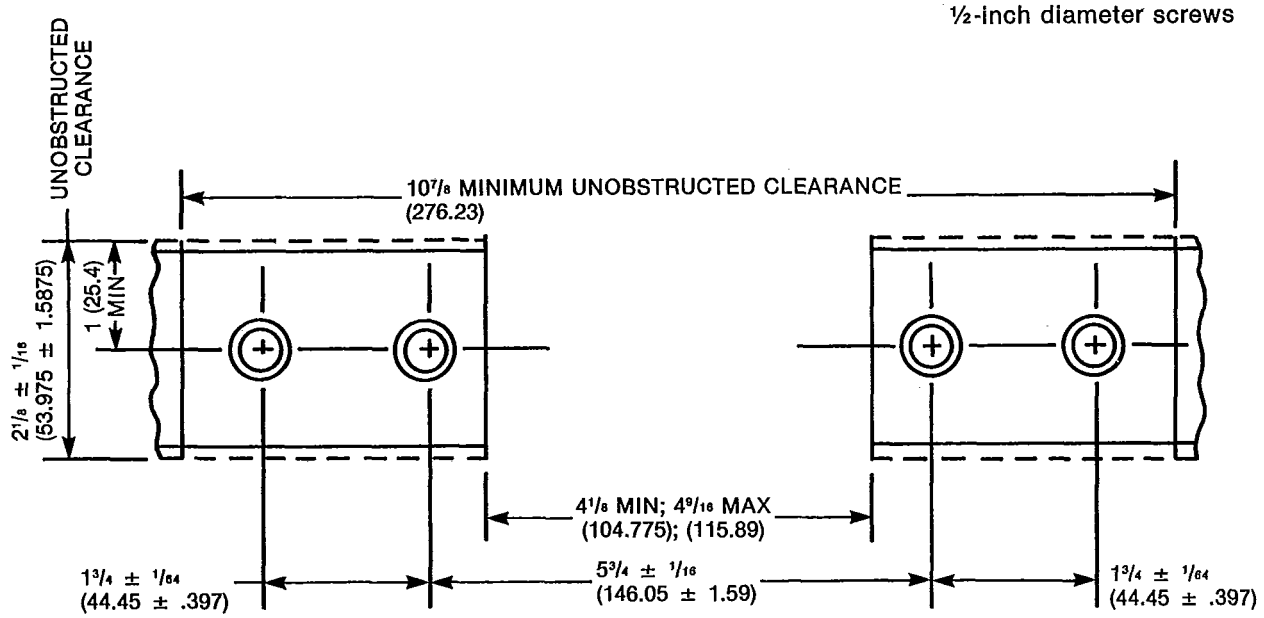
* Tolerance ± 0.015 in (.381 mm) where specified rigid stud or threaded hole.
**End stops required when captive stud floats in fuseholder or when stud or threaded hole 1/16 in (1.5875 mm) or smaller size to prevent insertion of larger case size fuse in smaller fuseholder.

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800-AMPERE FUSE MOUNTING

½-inch diameter studs or tapped holes, or clearance holes for ½-inch diameter screws



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 7-9
MOUNTING MEANS FOR 800- AND 1200-AMPERE CLASS "L" FUSES

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 of by the spacing between the contact clips, for other than Class T fuses. See Table 7-10, double-asterisk footnote, for use of maximum spacing between end stops.

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Section 8
TESTS

8.1 DESIGN AND VERIFICATION TESTS

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

8.1.1 Design Tests for Enclosed Switches are as Follows:

(See definition of Design Tests, Section 2)

1. Heating Tests.....Clause 8.2.1
2. Overload Tests (ampere-rated).....Clause 8.2.2.2
3. Overload Tests (horsepower-rated).....Clause 8.2.2.3
4. Endurance Test.....Clause 8.2.3
5. Dielectric Test.....Clause 8.2.4
6. High Available Fault Current Tests.....Clause 8.2.5
7. Enclosure Test.....Clause 8.2.6

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

1. Construction.....Clause 8.3.1
2. Performance.....Clause 8.3.2

NEMA Standard 9-15-1983.

8.2 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 heating, overload, endurance, and dielectric withstand tests mentioned and in the order shown in 8.1.1 except separate samples shall be permitted to be used as indicated in Table 8-1. 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 8-1 is a list of the design tests (referred to by clause number) for a given classification of equipment.

8.2.1 Heating Test

8.2.1.1 Sample Preparation

The switch shall be mounted as in actual service, with the door and other openings closed. Except as noted below, dummy fuses 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 feet (1.22 meters) of wire per terminal, the wire size corresponding to the ampere rating of the switch. See Table 7-4. A switch employing Class L or T fuses or 400 or 600 ampere Class J fuses shall be tested with fuses in place.

8.2.1.2 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 lead wire shall be securely held in good thermal contact with the surface of the material whose temperature 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°–40°C (50°–104°F).

8.2.1.3 Method

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

1. Ampere rated switch (except as noted in (3) below)—rated current.

2. Ampere and Horsepower rated switch (except as noted in (3) below)—rated current, or 115 percent of current corresponding to the horsepower rating, whichever is greater.

3. A switch employing Class L or T fuses or 400

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Table 8-1
DESIGN TESTS

Test	Clause	Classification			
		General Duty		Heavy Duty	
		Rating Category			
		Amp	Amp and HP	Amp	Amp and HP
Heating	8.2.1	x ①	x ①	x ①	x ①
Overload (ampere-rated)	8.2.2.2	x ②	x	x ②	x
Overload (Horsepower-rated)	8.2.2.3	...	x ①	...	x ①
Endurance	8.2.3	... ③	x	... ③	x
Dielectric	8.2.4	x	x	x	x
High Available Fault Current	8.2.5	...	...	x	x
Enclosure (Environmental)	8.2.6	x	x	x	x

① Separate switch may be used.
② Isolating switches may be run at reduced current values; see conditions under paragraph 8.2.2.2.
③ Isolating switches may be run on endurance test without current under certain conditions; see Table 8-9 double-asterisk note.

or 600 ampere Class J fuses—80 percent of its rated current.

A temperature is considered to be constant when three successive readings taken at 15-minute intervals indicate no change.

8.2.1.4 EVALUATION

The switch shall not show a temperature rise greater than that indicated in Table 8-2 nor shall any fuse link melt when tests are performed with fuses.

8.2.2 Overload Test

Switches shall be subjected to overload tests as follows:

1. Ampere Rated..... 8.2.2.2
2. Ampere and Horsepower Rated..... 8.2.2.2, 8.2.2.3

Except as noted in the footnote to Table 8-3, an overload or endurance test at any voltage rating shown in Table 8-3 shall be considered to be representative of an overload or endurance test at any

Table 8-2
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 with dummy fuses	30	54
Fused switches for use with 75°C (167°F) wire and tested with dummy fuses*	45	81
Class T fused switches rated 100 A or less for use with 60°C wire	50	90
Class T fused switches rated 100 A or less for use with 75°C wire*	65	117
Class J (rated more than 200 A), Class T (rated more than 100 A), and Class L fused switches	60	108
All other current carrying parts:		
Unfused switches	50	90
Fused switches for use with 60°C (140°F) wire and tested with dummy fuses	30	54
Fused switches for use with 75°C (167°F) wire and tested with dummy fuses	50	90
Class T, Class J (rated more than 200 A), and Class L fused switches	85	153

*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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Table 8-3
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	0.75–0.80
5	600*	1	0.75–0.80
6	480	3	0.40–0.50
7	480*	1	0.40–0.50
8	480	3	0.75–0.80
9	480	1	0.75–0.80
10	250*	dc	...
11	240	3	0.40–0.50
12	240*	1	0.40–0.50
13	240*	3	0.75–0.80
14	125–250*	dc	...
15	240	1	0.75–0.80
16	120–240	1	0.75–0.80
17	125	dc	...
18	120	3	0.40–0.50
19	120*	1	0.40–0.50
20	120	3	0.75–0.80
21	120	1	0.75–0.80

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

voltage rating given below it in the table, where the same current or a smaller current is involved.

This table applies to devices having an interrupted 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 or endurance test at the highest voltage is considered to be representative of performance at any lower voltage. A motor-circuit switch or any switch having a horsepower rating greater than 100 horsepower is to be tested at the maximum voltage and also at the maximum current. An overload or endurance test on a 3-phase circuit is considered to be representative of performance on a 2-phase circuit of the same voltage for the same horsepower rating.

8.2.2.1 Sample Preparation

An enclosed switch shall be mounted as in actual service with the door cover and any other openings closed. The line terminals shall be connected to a supply circuit as described in 8.4.2 and the load terminals shall be connected to the necessary resistance or impedance.

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 may be used, if the interior finish is scraped off, scratched, or abraded through to the base metal, in those areas where arcing of 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, the endurance test with current, or the endurance test without current; but switch blades and break jaws which are readily accessible may be put in good operating condition before starting each of these tests. Parts other than switch blades and break jaws shall not be adjusted. A switch shall not be conditioned between the endurance and dielectric voltage withstand tests.

8.2.2.2 Overload Test, Ampere Rated Switch

A switch shall perform succesfully when operated for 50 cycles. The rate of speed shall be the number of cycles per minute given in Table 8-4. The making and breaking of current once each, shall constitute a cycle.

8.2.2.3 Overload Test-Ampere and Horsepower Rated Switches

8.2.2.3.1 100 Horsepower and Less

1. *General Duty*—A general duty switch shall perform successfully when operated for 50 cycles,

Table 8-4
TEST PARAMETERS

Switch Rating, Amperes	Number of Cycles of Operation Per Minute
30–100	6
200	5
400	4
600	3
800	2
1200	1

Voltage	in accordance with 8.4.1
Amperage	150% of rated current*
Power Factor	0.75–0.80
Frequency	60 hertz

*A switch marked for isolating use only and rated at more than 600 amperes at more than 250 volts may be subjected to the overload test with current of 900 amperes.

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making and breaking the current given in Table 8-5. The rate of speed shall be the number of cycles per minute given in Table 8-4, the switch rating in amperes being assumed to be equal to 60 percent of the required overload test current.

2. *Heavy Duty*—A heavy duty switch shall perform successfully where operated for 50 cycles, making and breaking the current given in Tables 8-5 or 8-6, 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 1.67 times the value given in Table 8-5, followed by forty operations at the specified current in the same table for the specified horsepower rating.

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 8-4. Dc overload tests shall be run with a noninductive resistance load, at the rate shown in Table 8-4.

8.2.2.3.2 Over 100 Horsepower

Switches having ratings of more than 100 horsepower shall perform successfully for ten cycles, making and breaking the currents shown in Table 8-5. Tests shall be run at a power factor of 40 percent to 50 percent the rate of operation shall be one cycle per minute. This shall be followed by either:

1. An additional 40 operations at the values given in Table 8-4 for ampere rated switches, in which case the switch shall be marked per 5.3, item 11; or

Table 8-5
OVERLOAD-TEST CURRENTS IN AMPERES FOR ALTERNATING-CURRENT SWITCHES

Switch Rating in Horsepower	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
½	58.8	...	...	...	...	...	...	...	...	...	...	...
¾	82.8	28.8	33.6	41.4	14.4	16.8	21.0	7.2	8.4	16.8	6	6.6
1	96	38.4	43.2	48	19.2	21.6	24.0	9.6	10.8	19.2	7.8	8.4
1½	120	54.0	62.4	60	27.0	31.2	30.0	13.8	15.6	24	10.8	12.6
2	144	70.8	81.6	72	35.4	40.8	36	18.0	20.4	28.8	14.4	16.2
3	204	99.6	115	102	49.8	57.6	51	25.2	28.8	40.8	19.8	23.4
5	336	158	182	168	79.2	91.2	84	39.6	45.6	67.2	31.8	36.6
7½	480	228	264	240	114	132	126	54	66	96	48	54
10	600	288	336	300	144	168	156	72	84	120	60	66
15	810	432	504	408	216	252	204	108	126	162	84	102
20	...	564	648	528	282	324	264	138	162	210	114	132
25	...	708	816	660	354	408	330	174	204	264	144	162
30	...	824	960	816	414	480	408	210	240	324	168	192
40	...	1080	1250	1060	540	624	528	270	312	420	216	246
50	...	1360	1560	1300	678	780	648	336	390	516	270	312
60	...	...	...	...	...	924	...	...	462	...	...	372
75	...	...	...	...	...	1150	...	...	576	...	...	462
100	...	...	...	...	...	1490	...	...	744	...	...	594
125	...	...	...	...	...	1870	...	...	936	...	...	750
150	...	...	...	...	...	2160	...	...	1080	...	...	864
200	...	...	...	...	...	2880	...	...	1440	...	...	1152
250	...	...	...	...	...	3610	...	...	1810	...	...	1450
300	...	...	...	...	...	...	...	...	2170	...	...	1730
350	...	...	...	...	...	...	...	...	2480	...	...	2020
400	...	...	...	...	...	...	...	...	2860	...	...	2290
500	...	...	...	...	...	...	...	...	3540	...	...	2830

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Table 8-6
OVERLOAD-TEST CURRENTS IN AMPERES FOR DIRECT-CURRENT SWITCHES

Switch Rating in Horsepower	125 Volts	250 Volts	600 Volts
1	38	19	7
1½	53	26	10
2	68	34	14
3	100	49	20
5	160	80	33
7½	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

2. An additional 40 operations at 100 horsepower, 40 percent to 50 percent power factor, at the rate given in Table 8-4 in which case the switch shall be marked per 5.3, item 12.

8.2.2.4 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 8.4.2.7 shall not have opened.

8.2.3 Endurance Test

8.2.3.1 TEST SAMPLE PREPARATION

An enclosed switch shall be mounted as in actual service with the door or cover and any other openings closed. Dummy fuses, 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 8.4.2.

The endurance test of a double-throw switch shall be made with the connections which are shown by the overload test to be the most severe.

8.2.3.2 METHOD

8.2.3.2.1 VOLTAGE

The endurance test shall be performed at a test voltage in accordance with 8.4.1, at a power factor of 0.75 to 0.80 (ac test only) and a frequency of 60 hertz (ac test only).

8.2.3.2.2 AMPERAGE

1. For ampere-rated switches, the endurance test is to be made with the rated current of the device.

2. For horsepower-rated switches, full-load motor-running currents are given in Tables 8-7 and 8-8. The endurance test is to be made with whichever is greater—the rated current of the device or the current selected from the appropriate table, except that a fused horsepower rated switch is to be tested at 125 percent of the current value shown in Tables 8-7 or 8-8. The current for the common wire of a 2-phase, three-wire system is 1.414 times the value in Table 8-7 for a 2-phase, four-wire system.

The endurance tests outlined above, for both general duty and heavy duty switches, shall be performed at an ambient temperature in the range of 25 ± 5°C (77 ± 9°F).

8.2.3.2.3 GENERAL DUTY SWITCHES

General duty enclosed switches shall perform successfully when operated for the required number of cycles shown in Columns 3 and 4 of Table 8-9.

8.2.3.2.4 HEAVY DUTY SWITCHES

A single test sample of a heavy duty enclosed switch shall perform successfully during the following test sequence:

1. *Accelerated Aging Period*—The heating period shall consist of maintaining the switch at an ambient temperature of 100°C (212° F) for 24 hours. For the purpose of this test, sealing compound may be omitted or special high-temperature compound used.

2. *Cycling Under Load*—Operation shall be at noted current for one-half the number of operations shown in Column 5 of Table 8-9, at the rate shown in Column 2.

3. *Humidity Conditioning*—The humidity period shall consist of maintaining the switch with its cover open at room temperature of 27°C ± 7°C (80.6°F ± 12.6°F) in a sealed airtight chamber containing an open pool of water for one week. Excess water can be wiped off before further operations.

4. *Cycling Under Load*—Operation shall be at noted current for one-half the number of operations shown in Column 5 of Table 8-9, at the rate shown in Column 2.

5. *Cycling Without Load*—Operation shall be without current for the number of operations shown in Column 6 of Table 8-9.

8.2.3.3 EVALUATION

The switch shall be considered to be acceptable if no undue pitting, burning, or welding of the con-

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Table 8-7
ENDURANCE-TEST CURRENTS IN AMPERES FOR ALTERNATING-CURRENT SWITCHES

Switch Rating in Horsepower	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
½	9.8	...	...	...	...	...	...	...	...	...	...	...
¾	13.8	4.8	5.6	6.9	2.4	2.8	3.5	1.2	1.4	2.8	1.0	1.1
1	16	6.4	7.2	8	3.2	3.6	4.0	1.6	1.8	3.2	1.3	1.4
1½	20	9.0	10.4	10	4.5	5.2	5.0	2.3	2.6	4.0	1.8	2.1
2	24	11.8	13.6	12	5.9	6.8	6	3.0	3.4	4.8	2.4	2.7
3	34	16.6	19.2	17	8.3	9.6	8.5	4.2	4.8	6.8	3.3	3.9
5	56	26.4	30.4	28	13.2	15.2	14.0	6.6	7.6	11.2	5.3	6.1
7½	80	38	44	40	19	22	21	9	11	16	8	9
10	100	48	56	50	24	28	26	12	14	20	10	11
15	135	72	84	68	36	42	34	18	21	27	14	17
20	...	94	108	88	47	54	44	23	27	35	19	22
25	...	118	136	110	59	68	55	29	34	44	24	27
30	...	138	160	136	69	80	68	35	40	54	28	32
40	...	180	208	176	90	104	88	45	52	70	36	41
50	...	226	260	216	113	130	108	56	65	86	45	52
60	...	...	...	...	...	154	...	...	77	...	...	62
75	...	...	...	...	...	192	...	...	96	...	...	77
100	...	...	...	...	...	248	...	...	124	...	...	99
125	...	...	...	...	...	312	...	...	156	...	...	125
150	...	...	...	...	...	360	...	...	180	...	...	144
200	...	...	...	...	...	480	...	...	240	...	...	192
250	...	...	...	...	...	602	...	...	302	...	...	242
300	...	...	...	...	...	...	...	...	361	...	...	289
350	...	...	...	...	...	...	...	...	414	...	...	336
400	...	...	...	...	...	...	...	...	477	...	...	382
500	...	...	...	...	...	...	...	...	590	...	...	472

tracts or electrical or mechanical breakdown has occurred. The enclosure fuse referred to in 8.4.2.7 shall not have opened.

8.2.4 Dielectric Voltage Withstand Test

8.2.4.1 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 one minute. The increase in the applied voltage shall be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by the voltmeter.

A switch (with fuses, if any, in place) shall withstand for one minute the required test potential of 2 times maximum rated voltage plus 1000 volts, at a frequency of 60 hertz, essentially sinusoidal, as follows:

1. Between live parts and the enclosure with the switch closed,
2. Between terminals of opposite polarity with the switch closed, and
3. Between the line and load terminals with the switch open.

8.2.4.2 EVALUATION

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

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Table 8-8
ENDURANCE-TEST CURRENTS IN AMPERES FOR DIRECT-CURRENT SWITCHES

Switch Rating in Horsepower	125 Volts	250 Volts	600 Volts
1	9.4	4.7	1.8
1½	13.2	6.6	2.6
2	17	8.5	3.4
3	25	12.2	5.0
5	40	20	8.3
7½	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

8.2.5 High Available Fault Current Tests

These requirements specify the additional performance requirements with which switches shall comply if they are to be acceptable for use on high available fault current circuits as evidenced by marking.

High available fault current tests involve a sequence of tests on one or more samples, as outlined below, and consist of:

Close-open test .....See 8.2.5.1
Dielectric test .....See 8.2.5.2
Withstand test.....See 8.2.5.3
Dielectric test .....See 8.2.5.4
Closing test .....See 8.2.5.5
Dielectric test .....See 8.2.5.6

8.2.5.1 Close-Open Test

8.2.5.1.1 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 8.4.2.1 and 8.4.2.7 and the load terminals of the switch are to be connected to an inductive load.

8.2.5.1.2 Method

An enclosed switch shall perform successfully when actuated for the number of close-open operations indicated in Table 8-10, 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, etc. No disassembly of the sample is permitted to accomplish the servicing. Servicing shall not include replacement of any part.

8.2.5.1.3 Evaluation

At the conclusion of this test, the switch shall be in operating condition. The fuse described in 8.4.2.7 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 8.2.5.2.

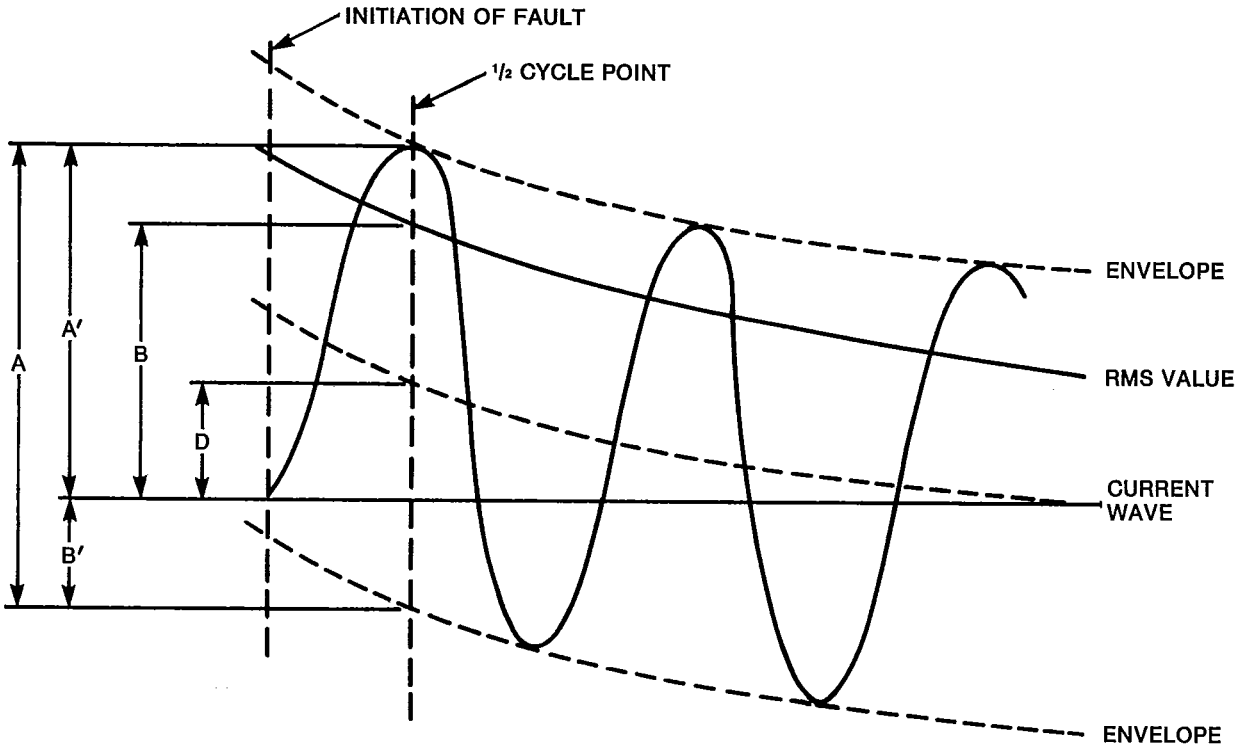
Table 8-9
ENDURANCE TEST CYCLES

Switch Rating in Amperes (1)	Number of Cycles of Operation per Minute* (2)	Number of Cycles of Operation			
		GD Switches		HD Switches	
		With Current (3)	Without Current (4)	With Current (5)	Without Current (6)
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**	3500
1200	1	...	...	600**	2500

* 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 may be operated at any convenient speed.

**Switches rated at more than 600 amperes at more than 250 volts may be operated without current, if the switch is marked "FOR ISOLATING USE ONLY—DO NOT OPEN UNDER LOAD".

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MEASUREMENT OF THE RMS VALUE OF AN ASYMMETRICAL WAVE

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 = DC COMPONENT = $A' - \frac{A}{2}$
B = RMS ASYMMETRICAL CURRENT

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

Figure 8-1

Table 8-10
CLOSE-OPEN TEST OPERATION

Type of Switch	Number of Operations
Polyphase	3
Single Phase	5

Voltage	–in accordance with 8.4.1
Current	–6 times rated current
Frequency	–60 hertz
Power Factor	–0.45–0.50 except a lower power factor may be used if agreeable to those concerned.

8.2.5.2 Dielectric Test

The test sample shall be subjected to the dielectric test as described in 8.2.4. Upon completion of the dielectric test, the test sample shall be subjected to the test referenced in 8.2.5.3.

8.2.5.3 Withstand Test

8.2.5.3.1 Test Sample Preparation

1. The test sample from 8.2.5.2 shall be used for this test. The sample shall be permitted to be serviced before testing.

2. The line and load terminals of the switch shall be connected to the corresponding test-circuit terminals by copper wire leads no longer than 4 feet (1.22 meters) per

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terminal*, each of which has an ampacity not less than the current rating of the switch. For a switch rated 60 or 100A, the wire size shall also be based on the temperature rating of the wire as indicated by the marking on the switch. Where marked for use with 60° or 75°C wire the test shall be conducted with 60°C wire. A copper bus or tube, having a cross sectional area 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 shall be permitted to be individually reinforced to enable it to withstand the short-circuit forces. The bar or tube shall be secured in place in the same manner as are the fuses in normal service.

3. Fuses, having characteristics representing the peak let-through current (I_p) and maximum I^2t values associated with the maximum rated fuses that the device is designed to accept, shall be installed on the load side of the device as shown in Figure 8-2 with dummy fuses mounted in the device. Each of these fuses shall be of such characteristics that, when tested on a single-phase circuit, it will permit a peak let-through current and a maximum clearing of I^2t 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 shall be permitted to be used. Special test fuses of the same physical dimensions as the fuse the enclosed switch is intended to accommodate shall be permitted to be used in place of the dummy fuses in the switch.

NEMA Standard 9-15-1983.

(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 may be a different class.)

Authorized Engineering Information 9-15-1983.

4. Fuses used for tests shall be selected from a lot from which two samples have been selected if the fuses are of Classes G, J, R, or T and one sample if the fuse is Class L and which have been calibrated to determine their I^2t and I_p characteristics comply with the prescribed values called for in item 3 above.

NEMA Standard 9-15-1983.

Special calibrated and certified fuses for use in the noted tests are commercially available. These are identified as "test limiters".

Authorized Engineering Information 9-15-1983.

*The physical arrangement in the test laboratory may require longer leads to switches rated 400 amperes and larger, but such leads shall in no case exceed 8 ft (2.44 m) in length.

8.2.5.3.2 METHOD

With the switch in the full closed position, the test circuit providing maximum fault current for which the switch is rated shall be closed on that sample by a means external to the switch. Test circuit specifications appear as follows:

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

Amperage—The available fault current in rms symmetrical amperes shall not be less than the marked fault current rating of the switch.

Frequency—60 hertz

Power Factor—0.20 or less

The current available and other circuit characteristics shall be determined as indicated in 8.4.4. The requirements of 8.4.3, items 1 through 3 shall apply concerning the supply circuit.

8.2.5.3.3 EVALUATION

Upon completion of this test and opening of the circuit, the meeting of the following conditions shall indicate a successful test:

1. The fuse connected to the enclosure shall not have opened.
2. There shall be no breakage to the extent that the integrity of the mounting of live parts is impaired.
3. The door shall be prevented by its latch, without bolt or lock installed therein, from opening during the test (deformation of the case alone is acceptable).
4. Neither end of a bar or tube as described in clause 8.2.5.3.1, item 2, 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, and the switch shall be capable of being opened manually with the operating handle.

8.2.5.4 DIELECTRIC TEST (LOW LEVEL)

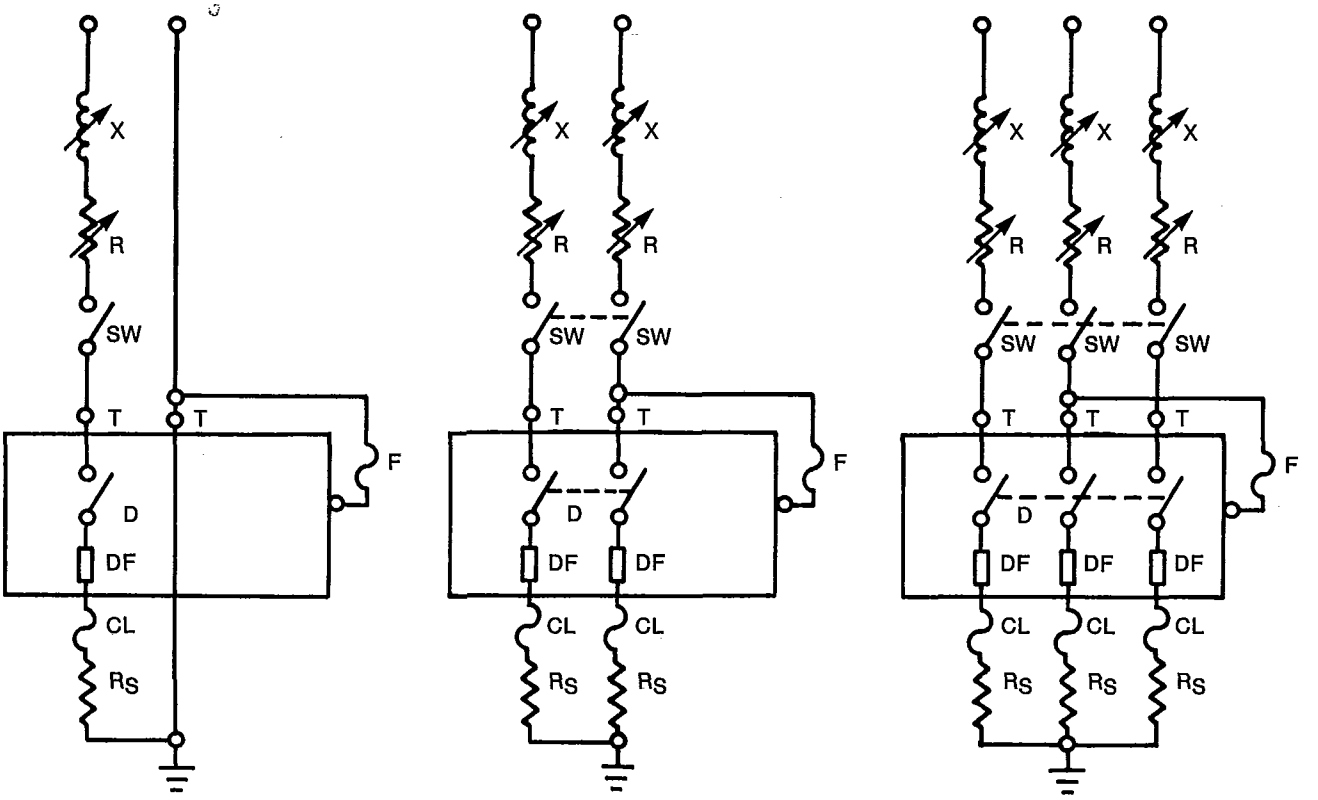
Unless the same sample is to be subjected to the closing test, a switch that has been subjected to the short-circuit withstand test from 8.2.5.3 shall be subjected to the dielectric test as decribed in 8.2.4 except that the test potential is to be twice the rated voltage of the switch but not less than 900 volts.

8.2.5.5 CLOSING TEST

8.2.5.5.1 TEST SAMPLE PREPARATION (CLOSING TEST)

The switch used for the short-circuit withstand test or, at the option of the manufacturer, a previously unused sample switch shall be connected in the open position to the test circuit. The requirements of 8.2.5.3.1, items 2 through 4 shall apply.

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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 8-2
CIRCUIT FOR WITHSTAND AND CLOSING TESTS

8.2.5.5.2 Method

The switch shall be closed on a circuit providing the maximum fault current for which the switch is rated. Complete physical closure of the switch contacts need not be established.

The requirements of 8.2.5.3.2 shall apply concerning voltage, amperage, frequency, and power factor.

The requirements of 8.4.3, items 1 through 3 shall apply, concerning the supply circuit.

8.2.5.5.3 Evaluation

After the fault has cleared, the switch shall comply with the requirements of 8.2.5.3.3.

8.2.5.6 Dielectric Test (Low Level)

The dielectric voltage-withstand test described in 8.2.4 shall be repeated following the closing test, except that the test potential shall be twice the rated voltage of the switch but not less than 900 volts.

8.2.6 Enclosure Tests

New switches shall meet the requirements of NEMA Standards Publication No. 250-1979 (see Section 1) with switch mechanisms installed in the appropriate enclosure.

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

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1. 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.

2. 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 the most detrimental position is not obvious, tests shall be run in both the ON and OFF positions.

The design tests are described in NEMA Standards Publication No. 250-1979 with the reference paragraph as indicated below.

Rod Entry Test (Par. 250-5.02)
Drip Test (Par. 250-5.03)
Rain Test (Par. 250-5.04)
Dust Test (Par. 250-5.05)
External Icing Test (Par. 250-5.06)
Hosedown Test (Par. 250-5.07)
Rust Resistance Test (Par. 250-5.08)
Corrosion Resistance Test (Par. 250-5.09)
Oil Exclusion Test (Par. 250-5.12)

NEMA Standard 9-15-1983.

8.3 VERIFICATION TESTING

8.3.1 Construction

Inspection of enclosed 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:

1. ON/OFF operation.
2. Cover and mechanism interlock operation, if applicable.
3. Fuse spacing.

The dielectric voltage test decribed in 8.2.4 shall be performed on representative production samples.

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

8.3.2 Performance

Testing shall be performed on representative samples of enclosed switches as described in Table 8-11 in order to verify their performance.

NEMA Standard 9-15-1983.

8.4 TEST CIRCUITS AND CALIBRATION OF CIRCUIT AND INSTRUMENTS

8.4.1 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.

Table 8-11
PERFORMANCE TESTS

Test	Clause
Heating	8.2.1
Overload	8.2.2
Endurance	8.2.3
Dielectric	8.2.4
High Available Fault Current	8.2.5

Exceptions:

1. For the overload and endurance tests on a switch rated at more than 100 amperes and greater than 25 hp, the closed-circuit voltage may be as much as 10 percent less than the rated voltage on the switch if the open-circuit voltage is not less than the rating of the switch and more than 110 percent of the rated voltage of the switch.

2. For the close-open 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.

3. The test voltage for a direct-current-rated device shall be within 5 percent of the rated voltage of the switch for the endurance test.

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8.4.2 Supply Circuits

8.4.2.1 Alternating Current (AC) Switches

An enclosed switch intended for alternating-current 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 hertz, 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:

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

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

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8.4.2.2 Direct-Current (DC) Switches

An enclosed switch intended for use on direct-current 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.

8.4.2.3 Two- and Three-Wire Switch With Solid Neutral

A two- and a three-wire enclosed switch intended for use on either three-wire direct-current or single-phase, alternating-current circuits with grounded neutral shall be tested on a three-wire, direct-current circuit with grounded neutral, with the switch connected to the outside conductors of the circuit, and with the enclosure grounded as indicated in clause 8.4.2.7. 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 clause 8.4.2.1

8.4.2.4 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 alternating-current circuits other than that described in 8.4.2.3 and a four-wire enclosed switch having a solid neutral shall be tested on a three-phase circuit with a three-phase balanced load.

8.4.2.5 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.

8.4.2.6 Double-Throw Switches

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.

8.4.2.7 Enclosure Fuse

An enclosed switch designed for use on circuits having one conductor grounded shall be tested with the enclosure connected through a 30-ampere cartridge fuse to 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.

8.4.3 Supply Circuit (Withstand Test)

1. The circuit shall be as indicated in Figure 8-2 and shall include the necessary measuring equipment and the fuse mounting means. It shall be evaluated for instrumentation and calibration in accordance with clauses 8.4.4 and 8.4.5.
2. The enclosure of the device shall be connected through a 30-ampere 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 laod side of the limiting impedance by a No. 10 AWG copper wire having a length of 4-6 feet (1.22–1.83 meters).
3. For two-pole devices tested on a single-phase circuit, synchronous closing shall be employed so that maximum current flow (I_p) is obtained.

8.4.4 Calibration of Fault Current Test Circuit

The test circuit shall be calibrated in accordance with the following clause. 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 8-3.

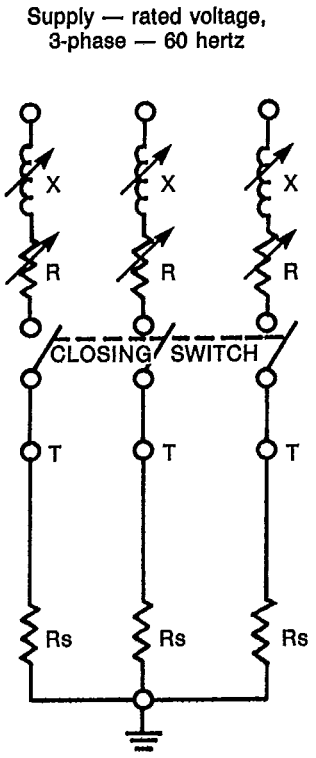
8.4.4.1 Current

The rms symmetrical current shall be determined with the test terminals short-circuited by a shunt of negligible impedance by measuring the alternating-current component of the wave at an instant ½ cycle (on the basis of a 60 hertz timing wave) after the initiation of the short circuit. The current shall be calculated in accordance with Figure 8-1.

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.

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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 8-3
TEST CIRCUIT VERIFICATION

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

8.4.4.2 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.

8.4.4.3 POWER FACTOR

The power factor shall be determined at an instant one-half cycle (on the basis of a 60-hertz timing wave) after the short-circuit occurs. Both the total asymmetrical rms amperes and the symmetrical rms amperes shall be measured in accordance with 8.4.4.1 and the ratio M_A or M_M calculated as follows:

Ratio M_A (for three-phase tests)

$$= \frac{\text{(Average of 3 phases) Asymmetrical rms amperes}}{\text{(Average of 3 phases) Symmetrical rms amperes}}$$

Ratio M_M (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 8-4. For more accurate determination of the power factor, see Table 8-12.

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.

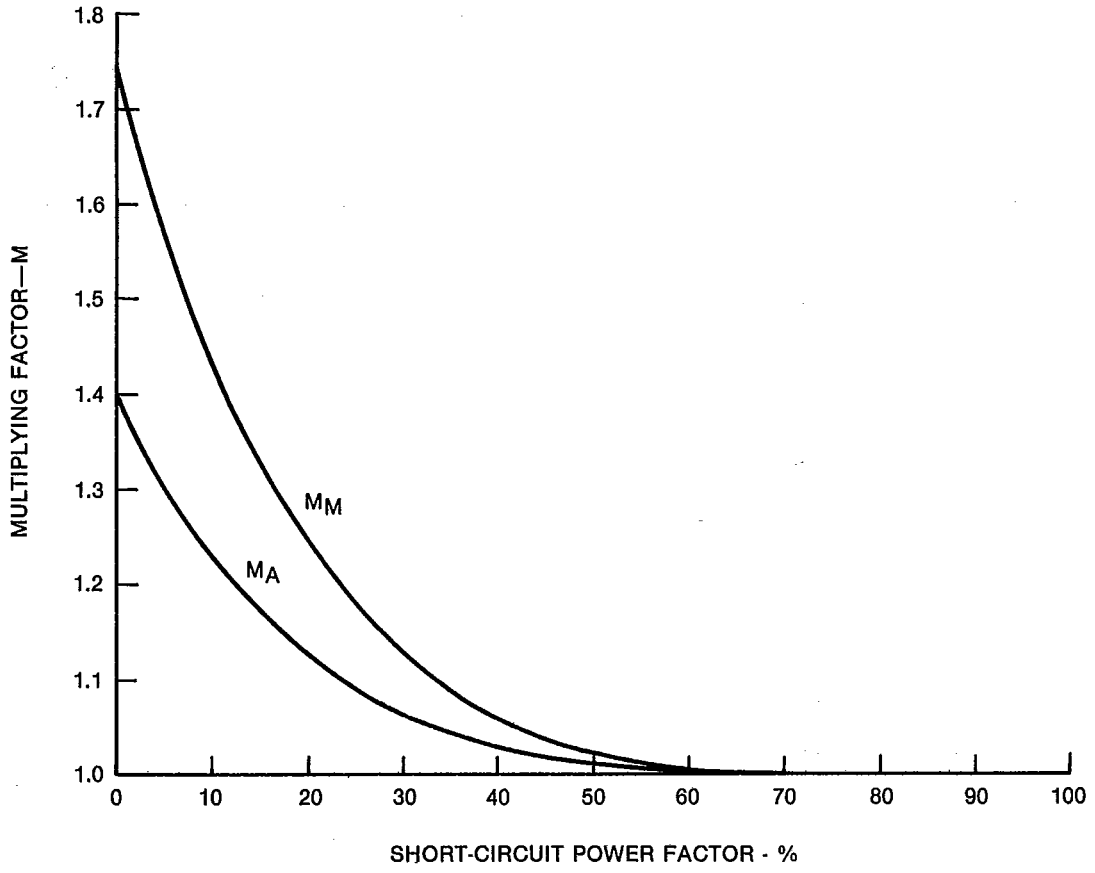
If, in a circuit which employs secondary closing, there is no attenuation or phase displacement of the first full cycle of he recovery voltage wave when compared with the open circuit secondary voltage wave before current flow, the detailed measurement of recovery voltage characteristics as indicated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

NEMA Standard 9-15-1983.

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 detemined for each of the phases.

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

Figure 8-4

8.4.5 Instrument Calibration

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

8.4.5.1 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 from 50 to 1200 hertz 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 millimeters.

8.4.5.2 Calibration

1. When a shunt is used to determine the circuit characteristics, a direct-current 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

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Table 8-12

Short Circuit Power Factor, Percent	Short Circuit X/R Ratio	Multiplying Factor: Maximum 1 Phase Rms Amperes at ½ Cycle (Curve M_M)	Multiplying Factor: Average 3 Phase Rms Amperes at ½ Cycle (Curve M_A)	Short Circuit Power Factor, Percent	Short Circuit X/R Ratio	Multiplying Factor: Maximum 1 Phase Rms Amperes at ½ Cycle (Curve M_M)	Multiplying Factor: Average 3 Phase Rms Amperes at ½ Cycle (Curve M_A)
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	1.568	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	2.1608	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	10.41	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	1.7321	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

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.

2. A 60-hertz sinusoidal potential may be used for calibrating the galvanometer circuit, using the same general method described in item 1. The resulting factor shall be multiplied by 1.414.

3. 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

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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 sensivity 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.

8.4.5.3 DISPLACEMENT DIFFERENCES

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

8.4.5.4 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 be not less than 60 inches per second, and higher speeds are recommended.

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NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status are set forth in certain clauses of the NEMA Bylaws, which are quoted below:

Purpose of Standards

National Electrical Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for its particular need. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard.

(Bylaw—Art. V, Sec. 1)

Definition of a Standard

A standard of the National Electrical Manufacturers Association defines a product, process or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Bylaw—Art. V, Sec. 2, Subsection A)

Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the standards publication may be capable of otherwise equivalent performance.

(NEMA Policy Memorandum 84-2, dated June 7, 1984)

Classes of Standards

National Electrical Manufacturers Association Standards are of two classes:

1. NEMA Standard, which relates to a product commercially standardized and subject to repetitive manufacture, which standard has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon;
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote thereon.

(Bylaw—Art. V, Sec. 2, Subsection B)

Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard or Suggested Standard for Future Design.

(Bylaw—Art. V, Sec. 6, 1st Sentence)

Official Standards Proposal

An Official Standards Proposal is an official draft of a proposed standard which is formally recommended to an outside organization(s) for consideration, comment and/or approval.

(Bylaw—Art. V, Sec. 4, Subsection A)

Identification of Status

Standards in NEMA Standards Publications are identified in the foreword or following each standard as "NEMA Standard" or "Suggested Standard for Future Design." These indicate the status of the standard. These words are followed by a date which indicates when the standard was adopted in its present form by the Association.

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