IEEE Std C37.20.4-2001
(Revision of
IEEE Std C37.20.4-1996)

IEEE Standard for Indoor AC Switches (1 kV–38 kV) for Use in Metal-Enclosed Switchgear

Sponsor

Switchgear Committee
of the
IEEE Power Engineering Society

Approved 17 March 2001

IEEE-SA Standards Board

Abstract: Indoor ac medium-voltage switches for use in enclosures for application in power circuits at voltages above 1 kV through 38 kV are covered. These include stationary or drawout, manual or power operation, fused or unfused.
Keywords: indoor ac switches, metal-enclosed switchgear

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Print: ISBN 0-7381-2838-4 SH94927
PDF: ISBN 0-7381-2839-2 SS94927

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Introduction

(This introduction is not part of IEEE Std C37.20.4-2001, IEEE Standard for Indoor AC Switches (1 kV–38 kV) for Use in Metal-Enclosed Switchgear.)

This standard was first issued as a Trial Use document. It is now being updated to include and reference the base document for Interrupter Switches IEEE Std 1247-1998.[a] This document applies to switches used in metal-enclosed-switchgear as defined in the ANSI/IEEE C37.20 series. It does not apply to devices of similar construction used in other types of medium voltage (1 kV through 38 kV) equipment.

This standard has been revised to reflect needed technical changes that have been suggested since the original document was published. There have been three substantive changes in this revision, as follows:

a) The asymmetrical factor for momentary rating has been changed from 1.6 to 1.55.

b) The impulse test requirements have been defined as 3 by 9. This requires that nine additional tests be run in case of flash-over in the first set of the required three instead of the old requirement of three additional tests.

c) A new rating has been created, "Rated Short-Time Withstand Current Duration."

The above changes reflect a move to harmonize with IEC and to accept current industry practices.

This standard uses ANSI/IEEE Std 4-1978, IEEE Standard Techniques for High Voltage Testing, instead of IEEE Std 4-1995, the current revision of this document. This was done because of the omission of several correction factors and test procedures needed and used by the Switchgear Committee in standards for switchgear and circuit breakers. The Switchgear Committee has requested coordination and revision of the current standard IEEE Std 4-1995 to address these test procedures and correction factors.

This edition was prepared by the Power Switchgear Assemblies Technical Committee of the National Electrical Manufacturers Association (NEMA) and the Switchgear Assemblies Subcommittee of the IEEE Switchgear Committee. NEMA is responsible for Clause 5 and Clause 7. The Switchgear Assemblies Subcommittee of the IEEE Switchgear Committee is responsible for Clause 3, Clause 4, Clause 6, and Clause 8. Through this joint effort over the many years, the switchgear assemblies standards have been of extreme value to the industry. Further suggestion for improvement gained in the use of this standard will be welcome.

[a]Information on references can be found in Clause 2.

This standard is one of a series covering Switchgear Assemblies as follows (see Figure A). Other standards in the series are listed below.

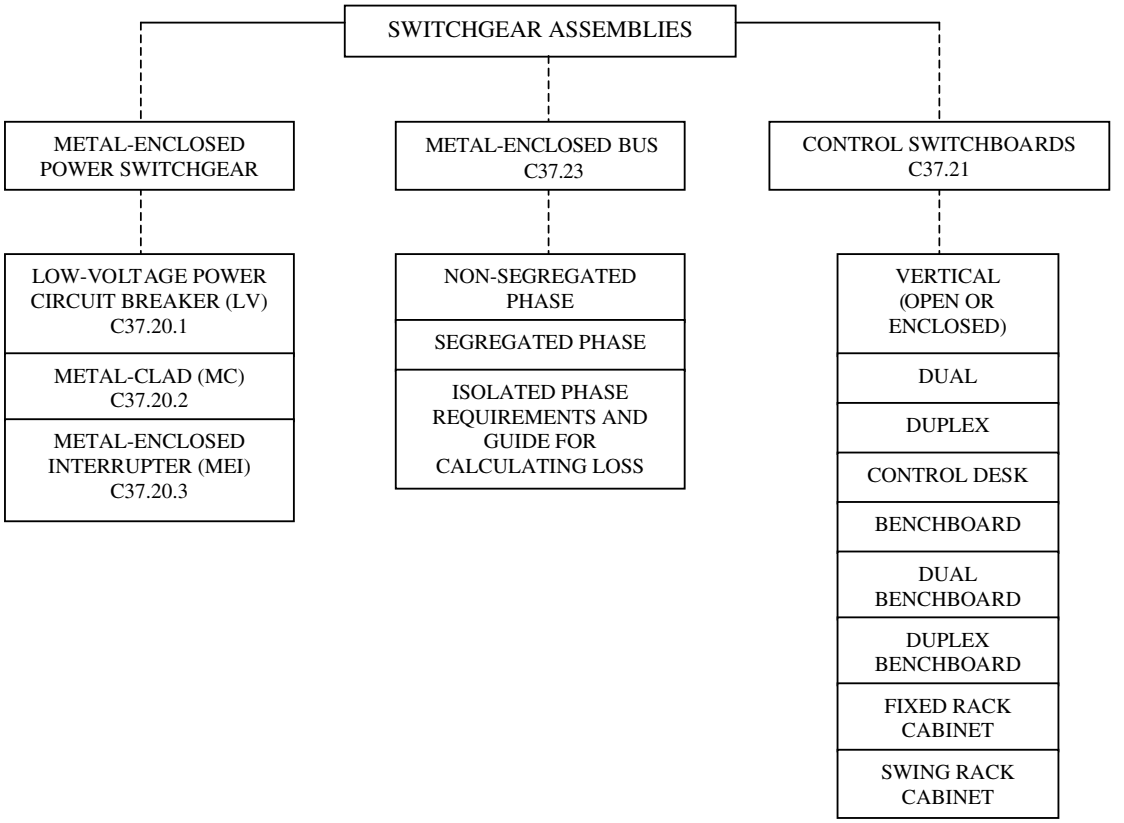

Figure A—Types of switchgear assemblies

ANSI C37.22-1997	American National Standard Preferred Ratings and Related Required Capabilities for Indoor AC Medium Voltage Switches Used in Metal-Enclosed Switchgear
IEEE Std C37.20.1-1993 (R1998)	IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
IEEE Std C37.20.2-1999	IEEE Standard for Metal-Clad and Station-Type Cubicle Switchgear
IEEE Std C37.20.3-2001	IEEE Standard for Metal-Enclosed Interrupter Switchgear
IEEE Std C37.20.4-2001	IEEE Trial-Use Standard for Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear
IEEE Std C37.20.6-1997	IEEE Standard for 4.76 kV to 38 kV Rated Grounding and Testing Devices Used in Enclosures
IEEE Std C37.21-1985	IEEE Standard for Control Switchboards
IEEE Std C37.23-1987 (R1991)	IEEE Standard for Metal-Enclosed Bus and Guide for Calculating Losses in Isolated-Phase Bus

Participants

The Switchgear Assemblies Working Group that prepared and approved this standard had the following personnel:

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IEEE Standard for Indoor AC Switches (1 kV–38 kV) for Use in Metal-Enclosed Switchgear

1. Scope

This standard covers indoor ac switches rated above 1 kV through 38 kV for use in metal-enclosed switchgear as follows:

a) Stationary or drawout
b) Manual or power operation
c) Fused or unfused

The term "indoor" is intended to indicate that the enclosure provides a degree of protection to the switch and the enclosure may be suitable for indoor, outdoor, or other service conditions and complies with the requirements of switchgear assemblies as defined by IEEE C37.20.2-1999 or IEEE C37.20.3-2001

This standard does not apply to subsurface load interrupting switches in IEEE Std C37.71-1984, switches intended for use in padmounted switchgear in ANSI C37.72-1987 and ANSI C37.73-1998, or to high-voltage air switches in ANSI C37.30-1997.

NOTES

1—Within this standard, the words "switch(es)" shall be considered to mean metal-enclosed, indoor, three-phase, ac medium-voltage switch(es) as defined by this scope.

2—There are switch designs that have short-circuit current interrupting capability and these devices are covered by this standard only to the extent of meeting the listed testing requirements. However, due to the additional capability, additional testing is required and the manufacturers should be consulted.

2. References

When the standards referenced in this document are superseded by a revision approved by the issuing authority, the latest revision shall apply, except as noted for ANSI/IEEE Std 4-1978.

ANSI C37.22-1997, American National Standard Preferred Ratings and Related Required Capabilities for Indoor AC Medium Voltage Switches Used in Metal-Enclosed Switchgear.[1]

ANSI C37.57-1990, American National Standard for Switchgear—Metal-Enclosed Interrupter Switchgear Assemblies—Conformance Testing.

ANSI C37.58-1990, American National Standard for Switchgear—Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear—Conformance Test Procedures.

ANSI C37.72-1987, American National Standard for Manually Operated, Dead-Front Padmounted Switchgear with Load Interrupting Switches and Separable Connectors for Alternating-Current Systems.

ANSI/IEEE Std. 1-1986 (R1992), General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation.

ANSI/IEEE Std 4-1978, IEEE Standard Techniques for High-Voltage Testing.[2]

ANSI/NFPA 70-1999, National Electrical Code.[3]

ANSI/NFPA 70B-1998, Electrical Equipment Maintenance.

IEC 60420-1990, High-voltage alternating current switch-fuse combinations.[1]

IEEE Std 1247-1998, IEEE Standard for Interrupter Switches for Alternating Current, Rated above 1000 Volts.

IEEE Std C37.09-1999, IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.[4]

IEEE Std C37.20.2-1999, IEEE Standard for Metal-Clad Switchgear.

IEEE Std C37.20.3-2001, IEEE Standard for Metal-Enclosed Interrupter Switchgear.

IEEE Std C37.30-1997, IEEE Standard Requirements for High-Voltage Switches.

IEEE Std C37.34-1994, IEEE Standard Test Code for High-Voltage Air Switches.

IEEE Std C37.40-1993, IEEE Standard Service Conditions and Definitions for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories.

IEEE Std C37.71-2001, IEEE Standard for Three-Phase, Manually Operated Subsurface Load Interrupting Switches for Alternating Current Systems.

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[1]ANSI and IEC publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13 Floor, New York, NY 10036, USA.

[2]The 1978 standard is used instead of the 1995 revision because the 1995 revision does not include critical test techniques needed for switchgear testing. When the 1995 version of IEEE 4 is suitably revised, it will be officially recognized and will become part of this revision of C37.20.4.

[3]ANSI/NFPA publications are available from the National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269, USA.

[4]ANSI/IEEE and IEEE publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331, USA. Copies are also available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13 Floor, New York, NY 10036, USA.

IEEE Std C37.73-1998, IEEE Standard Requirements for Pad-Mounted, Fused Switchgear.

IEEE Std C37.100-1992, IEEE Standard Definitions for Power Switchgear.

NEMA CC1-1993, Electric Power Connections for Substations.[5]

3. Definitions

The definitions of terms contained in this standard, or in other standards referred to in this standard, are not intended to embrace all legitimate meanings of the terms. They are applicable only to the subject treated in this standard.

If a term is not defined in this standard, the definition in IEEE Std C37.100-1992 applies. An asterisk (*) following a definition indicates that the definition in this standard is not contained in IEEE Std C37.100-1992 while a dagger (†) indicates that the definition differs from that in IEEE Std C37.100-1992. Some terms and definitions given in IEEE Std C37.100-1992 are repeated in this standard for clarity. Some definitions are copied from IEEE Std 1247-1998.

3.1 bypass switch: A non-load break switch used in parallel with another device such that closing the bypass switch will commutate current flow in the parallel device and allow it to be removed from the circuit. Example: this switch is used in switchgear for bypass feeders and in transfer bus schemes.

3.2 conformance tests: Tests made to demonstrate compliance with the applicable standards. The test specimen is normally subjected to all planned production tests prior to initiation of the conformance test program. Reference ANSI C37.58-1990 applies.†

NOTE—The conformance tests may, or may not, be similar to certain design tests. Demonstration of margin (capability) beyond the standards is not required.

3.3 design tests: Tests made by the manufacturer 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 normal service conditions or under special conditions, if specified, and which may be used to demonstrate compliance with applicable industry standards.†

NOTES

1—Design tests are made on representative apparatus or prototypes to verify the design analysis and calculation methods and to substantiate the ratings assigned to all other apparatus of basically the same design. These tests are not intended to be made on every design variation or to be used as part of normal production. The applicable portion of these designs tests may also be used to evaluate modifications of a previous design and to ensure that performance has not been adversely affected. These data from previous similar designs may also be used for current designs, where appropriate. Once made, the tests need not be repeated unless the design is changed so as to modify performance.

2—Design tests are sometimes called "type tests."

3.4 disconnecting switch (or isolating switch): A mechanical switching device used for changing the connections in a circuit, or for isolating a circuit or equipment from the source of power.

NOTE—It is required to carry normal load current continuously, and abnormal or short-circuit currents for short intervals as specified. It is also required to open or close circuits either when negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the switch poles occurs. Synonym: isolating switch [IEEE Std C37.100-1992].

3.5 field tests: Tests made after the switch has been installed at its place of utilization.†

[5]NEMA publications are available from the National Electrical Manufacturers Association, 1300 N. 17th Street, Suite 1847, Rosslyn, VA 22209, USA.

3.6 fused switch: A switch intended to operate with power fuses connected in series, directly attached to, or in close proximity to the switch.*

3.7 grounding switch: A mechanical switching device by means of which a circuit or piece of apparatus may be electrically connected to ground [IEEE Std C37.100-1992].

3.8 integral switch and fuse: A switch and fuse assembly mounted on the same frame.*

3.9 interrupter switch: A switching device, designed for making specified currents and breaking specified steady state currents [IEEE Std 1247-1998].

3.10 production tests: Tests made for quality control by the manufacturer on every device or on representative samples, or on parts or materials as are required to verify during production that the product meets the design specifications and applicable industry standards.†

NOTES

1—Certain quality assurance tests on identified critical parts of repetitive high-production devices may be tested on a planned statistical sampling basis.

2—Production tests are sometimes called "routine tests."

3.11 selector switch: A switch arranged to permit connection of a conductor to any one of a number of other conductors [IEEE Std C37.100-1992].

3.12 service disconnect: A device used in service equipment as defined in ANSI/NFPA 70-1999.

3.13 switch: A device designed to close or open, or both, one or more electric circuits [IEEE Std C37.100-1992].

NOTE—In this standard, the term switch does not imply that the device has interrupting capability. A switch may not be capable of making or breaking current.

3.14 tin-surfaced or equivalent: Metallic materials having satisfactory long-term performance that operate within the limits established for tin-surfaced electrical contact parts and conducting mechanical joints.*

3.15 unfused switch: A switch that has no power fuses directly attached to or in close proximity (series connected) to the switch.*

4. Service conditions

Usual service conditions—Switches conforming to this standard are intended to be used in metal-enclosed switchgear and shall be subject to the normal service conditions in accordance with IEEE Std C37.20.2-1999 or IEEE Std C37.20.3-2001.

5. Ratings

5.1 General

The preferred values for the ratings are listed in ANSI C37.22–1997. These ratings are preferred and are not considered restrictive. The ratings of switches are designations of limits under specified conditions of ambient temperature, temperature rise, etc.

Some of the ratings are repeated in this standard for clarity and ease of reading. Where the rating is the same as that contained in IEEE Std 1247-1998, this has been indicated.

The ratings of a switch, as designated by the manufacturer, shall be marked on the standard nameplate in accordance with 7.2.4.

5.2 Required ratings

The following types of switches shall have the listed ratings. Other ratings are optional as established by the manufacturer.

5.2.1 Load current interrupter switches

a) Rated maximum voltage
b) Rated Lightning impulse withstand voltage
c) Rated power frequency withstand voltage
d) Rated power frequency
e) Rated continuous current
f) Rated load switching current
g) Rated momentary withstand current
h) Rated short-time withstand current
i) Rated short-time withstand current duration
j) Rated fault making current
k) Rated fault making current for integral switch and fuse (optional) (see NOTE below)
l) Rated cable charging switching current (optional)
m) Rated unloaded transformer switching current (optional)

NOTE—An integral switch and fuse short-circuit current rating is different from the fault making current rating of the switch alone. The integral switch and fuse short-circuit current rating is established by a fault making test as specified by 6.2.4. This rating is dependent upon the type of fuse designated and the rated interrupting current of the fuse.

5.2.2 Disconnect, bypass, or selector switches

a) Rated maximum voltage
b) Rated lightning impulse withstand voltage
c) Rated power frequency withstand voltage
d) Rated power frequency
e) Rated continuous current
f) Rated momentary withstand current
g) Rated short-time withstand current
h) Rated short-time current withstand duration
i) Rated fault making current (optional)

5.2.3 Grounding switches

a) Rated maximum voltage
b) Rated lightning impulse withstand voltage
c) Rated power frequency withstand voltage

d) Rated power frequency
e) Rated momentary withstand current
f) Rated short-time withstand current
g) Rated short-time withstand current duration
h) Rated fault making current (optional)

5.3 Rated maximum voltage

The rated maximum voltage of switches is the highest rms three-phase system voltage for which the switch is designed to operate. [IEEE Std 1247-1998].

5.4 Rated lightning impulse withstand voltage

The rated lightning impulse withstand voltage is the peak value of both $1.2 \times 50\,\mu s$ positive and negative impulses that the switch shall be required to withstand [IEEE Std 1247-1998].

5.5 Rated power frequency withstand voltage

The rated power frequency withstand voltage is the maximum rms voltage of sinusoidal waveform at rated power frequency that a switch is required to withstand for a duration of 60 s [IEEE Std 1247-1998].

5.6 Rated power frequency

The rated power frequency is the fundamental steady-state sinusoidal supply voltage frequency at which the switch is designed to operate. (Ratings are based on a frequency of 60 Hz.)

5.7 Rated continuous current

The rated continuous current is the maximum sinusoidal current in rms amperes at rated power frequency that the switch shall be required to carry continuously without exceeding specified temperature rise limits under test conditions as specified by 5.18 [IEEE Std 1247-1998].

5.8 Rated load switching current

The rated load switching current is the maximum rms symmetrical power frequency load current flowing in a circuit that the switch shall be required to make and interrupt at its rated maximum voltage [IEEE Std 1247-1998].

5.9 Rated momentary withstand current

The rated momentary withstand current is the maximum rms total current that the switch shall be required to withstand. The current shall be the rms value, including the dc component, at the major

peak of the maximum cycle as determined from the envelope of the current wave of the maximum offset phase during a test period of at least 10 cycles. The symmetrical current shall be the rated short-time current and the peak current value shall be 2.6 times its rated short-time current at the major peak of the maximum cycle (this is also referred to as the peak withstand current).

NOTE—This rating was previously called the rated momentary current and was an rms asymmetrical current. In other documents this value may also be referred to and can be equated to "peak withstand current." If the peak withstand current rating is 2.6 times the rated short-time symmetrical current and the duration of the test is 10 cycles, then the requirement for "rated momentary withstand current" has been met. The new rated momentary withstand current is equivalent to the historic rated momentary current. The rated momentary withstand current is shown as the "fault-closing and momentary current" in IEEE Std C37.22-1996.

5.10 Rated short-time withstand current

The rated short-time withstand current is the maximum symmetrical rms current at rated power frequency that the switch shall be required to carry for its rated duration. This is a measure of the ability of the switch to withstand the heat and the forces generated by a short circuit current at its rated time duration.

5.11 Rated short-time withstand current duration

The rated short-time withstand current duration is the maximum duration that the switch shall be required to carry rated short-time withstand current while in the closed state.

5.12 Rated fault making current

The rated fault making current is the maximum instantaneous current at the first major peak of an offset rated power frequency current that the switch shall be required to make and carry at its rated maximum voltage for a duration of 10 cycles. This value of current shall be the same as the rated momentary current of the switch.

5.13 Rated fault making current for integral switch and fuse

Switches equipped with fuses may be rated at prospective (available) short-circuit currents different from the unfused switch fault making ratings. The integral switch and fuse short-circuit current rating is the prospective peak current, which has been demonstrated by tests, that the combination switch and fuse can withstand during the fault making test. During the fault making test to demonstrate the integral switch and fuse short-circuit current rating, the current duration is limited by the cleaning time of the fuse. The specific fuse types for which the integral short-circuit current rating has been established shall be specified.

5.14 Rated control voltage

The rated control voltage is the nominal voltage for which a power-operated mechanism is designed to operate when that voltage is applied to the terminals of the operating mechanism [IEEE Std 1247-1998].

5.15 Rated cable-charging switching current (optional)

The rated cable-charging switching current is the maximum charging current flowing into an unloaded cable that the switch shall be required to interrupt at any voltage up to and including rated maximum voltage. The current is expressed in rms symmetrical amperes at rated power frequency [IEEE Std 1247-1998].

5.16 Rated unloaded transformer switching current (optional)

The rated unloaded transformer switching current is the maximum transformer exciting current that the switch shall be required to make and interrupt at its rated maximum voltage. The current is expressed in symmetrical amperes [IEEE Std 1247-1998].

NOTE—This is sometimes known as magnetizing current.

5.17 Rated direct acting fuse tripping current (optional)

The rated direct acting fuse tripping current is the maximum current in rms symmetrical current that a switch can interrupt when tested in accordance with IEC 60420-1990 Test Duties 4 and 5.

5.18 Temperature limitations

5.18.1 Limiting temperature

The limiting temperature for indoor medium voltage switches is the maximum temperature permitted:

a) For any component such as insulation, conducting parts, switching devices, and interrupting devices
b) For any non-current-carrying structural parts
c) For air surrounding switches.

5.18.2 Temperature limits for insulating materials

The temperature to which insulating materials are subjected shall not exceed the values listed in Table 1 for the various classes of insulating materials.

Table 1—Temperature limits for insulating materials used in switches

Class of insulating material	Limit of hottest-spot temperature rise (°C)	Limit of hottest-spot total temperature (°C)
Class 90	50	90
Class 105	65	105
Class 130	90	130
Class 155	115	155
Class 180	140	180
Class 220	180	220

NOTE—For additional information on temperature limits see ANSI/IEEE Std 1-1986.

5.18.3 Temperature limits for switch conducting parts

The temperature of the switch primary current conducting parts shall not exceed the values listed in Table 2.

Table 2—Temperature limits for switch conducting parts

Type of connection	Limit of hottest-spot temperature rise (°C)	Limit of hottest-spot total temperature (°C)
1) Moving or hinge contacts:		
a) With silver or equivalent surfaces on both mating parts	65	105
b) With silver or equivalent surface mating to copper surface parts	50	90
c) With copper surfaces on both mating parts	30	70
2) Connecting joints:		
a) With silver or equivalent surfaces on both mating parts	65	105
b) With tin or equivalent surfaces on both mating parts	65	105
c) With silver, tin, or equivalent surface mating to copper surface parts	50	90
d) With copper surfaces on both mating parts	30	70

NOTES

a) Ambient temperature is measured outside the enclosure.

b) When fuses are used, temperature rise and total temperatures of the fuse assembly shall be in accordance with IEEE Std C37.40-1993.

c) Temperature limits for connecting joints do not apply to brazed or welded connections. Welded or brazed connections are not considered joints.

d) Except as noted in 1-(b) and 2-(c), when dissimilar contact surfaces are connected, the permissible temperatures and temperature rises shall be those of the part having the lower value permitted in Table 2.

6. Tests

6.1 General

This subclause establishes physical and electrical conditions for tests and methods of determining test parameters.

Switch configuration—Switches intended for three-phase electrical systems are usually three-pole group operated. Three-pole group operated switch tests shall be made using a three-phase power source as appropriate or as noted. Other switch configurations (single or two-pole) may be tested using an appropriate test circuit.

Switches that are to be rated for optional switching duties shall undergo a load current switching test before the optional test duties are performed. This requirement conforms to switching test requirements of IEEE Std 1247-1998.

IEEE Std 1247-1998 and IEEE Std C37.34-1994 detail many of the test performance requirements listed in this subclause.

IEEE Std 1247-1998 and IEEE Std C37.34-1994 test conditions, circuits, and criteria will be used unless so noted in each subclause of this standard.

6.2 Design tests

Design tests, as applicable per Table 3, shall be made in accordance with 6.2.1, 6.2.2, 6.2.3, 6.2.4, 6.2.5, 6.2.6, 6.2.7, and 6.2.8. Each test may be performed independently on a new or reconditioned switch with no requirements for pre-conditioning of the switch. The conditions prevailing at the test site shall be within those listed in Clause 4.

All design tests shall be made with the switch in its intended mounting position in a test enclosure. The test enclosure shall be an enclosure with the smallest electrical spacing recommended by the manufacturer. The enclosure normally supplied for production switches may be used as the test enclosure. The manufacturer's test enclosure description shall include:

a) Minimum clearance to ground, and phase to phase
b) Location of ventilation openings and their effective area
c) Total enclosure dimensions
d) Configuration of connections to the switch

Table 3—Design tests

Type of test	Reference paragraph	Switch type a,b		
		LCIS	DIS	GND
Power frequency withstand voltage	6.2.1.1	X	X	X
Lightning impulse withstand voltage	6.2.1.2	X	X	X
Continuous current	6.2.2	X	X	
Momentary withstand current	6.2.3	X	X	X
Short-time withstand current	6.2.3	X	X	X
Fault making current (switch only)	6.2.4	X		Optional
Mechanical endurance	6.2.5	X	X	–
Load switching current	6.2.6	X	–	–
Fault making current (integral switch and fuse)	6.2.4.2.3	Optional	–	–
Cable-charging switching current	IEEE Std 1247-1998, Clause 8.3.2.3	Optional	–	–
Unloaded transformer switching current	IEEE Std 1247-1998, Clause 8.3.2.5	Optional	–	–
Direct acting fuse tripping current	IEC 60420-1990, Duties 4 and 5	Optional	–	–

[a]The presence of an X indicates the types of test required for the switch type shown in Table 3.
[b]Switch type:

LCIS—load current interrupter switches
DIS—disconnect, transfer, selector switches
GRD—Grounding Switch

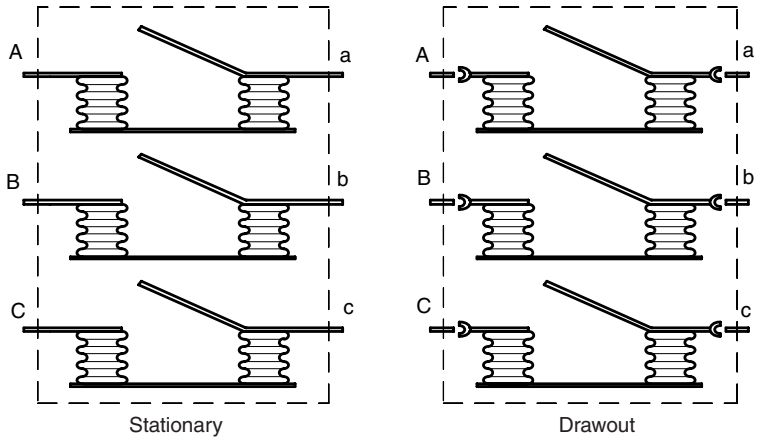
6.2.1 Dielectric tests

Power frequency withstand voltage tests (6.2.1.1) and lightning impulse withstand voltage tests (6.2.1.2) shall be performed on switches to demonstrate the ability of the insulation system to withstand rated voltage levels. The preferred ratings are given in ANSI C37.22-1997.

The tests shall be made under the temperature, pressure, and humidity conditions present at the test site with appropriate correction factors applied as outlined in ANSI/IEEE Std 4-1978. Humidity correction factors shall be based on curves for rod gaps as stated in ANSI/IEEE Std 4-1978, Figure 1.3. The equipment shall be clean and in good condition and tested in an enclosure as specified in 6.1.

NOTE—if not applying correction factor(s) would result in a more severe test, the manufacturer may elect not to apply the factor(s).

Test voltages shall be applied between the primary terminals and ground per Figure 1.



Dielectric test arrangements

Line	Switch terminal energized						Enclosure	Switch	
	A	a	B	b	C	c	Ground or float	Connect or test position	Open or closed
1	V	V	G	G	G	G	G	C	C
2	G	G	V	V	G	G	G	C	C
3	G	G	G	G	V	V	G	C	C
4	V	G	G	G	G	G	G	C	O
5	G	V	G	G	G	G	G	C	O
6	G	G	V	G	G	G	G	C	O
7	G	G	G	V	G	G	G	C	O
8	G	G	G	G	V	G	G	C	O
9	G	G	G	G	G	V	G	C	O
10	V_1	G	V_1	G	V_1	G	F	C	O
11	G	V_1	G	V_1	G	V_1	F	C	O
12[a]	V	G	V	G	V	G	G	T[b]	C
13[a]	G	V	G	V	G	V	G	T[b]	C
14[a]	V_1	G	V_1	G	V_1	G	F	T[b]	O
15[a]	G	V_1	G	V_1	G	V_1	F	T[b]	O

V = Test voltage (for values see ANSI C37.22-1997, Table 1).
V_1 = 1.1 × Test voltage (for values see ANSI C37.22-1997, Table 1).
G = Ground
[a]Lines 12 to 15 are for drawout switches only.
[b]The test position (T) tests need not be performed when the switchgear is fitted with metal shutters for drawout switches.

Figure 1—Dielectric tests

Power frequency withstand voltage tests and lightning impulse withstand voltage tests shall be made as follows. All switches except grounding switches shall pass the 110% requirement (see table in Figure 1, lines 10, 11, 12, 13, 14, and 15) for both lightning impulse and power frequency withstand voltage tests.

6.2.1.1 Power frequency withstand voltage Tests

Power frequency withstand voltage tests shall be made in accordance with IEEE Std C37.34-1994.

6.2.1.2 Lightning impulse withstand voltage tests

Lightning impulse withstand voltage tests shall be made in accordance with IEEE Std C37.34-1994 with the exception that ANSI/IEEE Std 4-1978 shall be used.

NOTES

1—For the test across the open gap at 10% higher voltage, an intermediate point of the voltage source may, if practicable, be connected to ground and to the test enclosure in order that the voltage between any live part and the test enclosure will not exceed the withstand voltage rating. If this is not practicable, the test enclosure may be insulated from ground. The preferred ratings are given in ANSI C37.22-1997.

2—Some insulating materials retain a charge after an impulse test, and for these cases care should be taken when reversing the polarity. To allow the discharge of insulating materials, the use of appropriate methods, such as the application of impulse voltages of the reverse polarity at lower voltage or grounding before the tests, is recommended.

3—Successful completion on the open gap test does not necessarily provide assurance that the switch will always flashover to ground instead of across the open gaps.

6.2.2 Continuous current tests

Continuous current tests shall be conducted in accordance with IEEE Std 1247-1998, except that connections shall be as specified in 6.2.2.1 and temperature limitations shall be as specified in Table 1 and Table 2.

6.2.2.1 Copper conductors for use in continuous current tests

Bus bars or cables utilized for connection to the interrupter switch or fuse terminals and to the main bus shall be per Table 4 or representative of the manufacturer's standard construction. The conductors shall have a minimum external length of 1.2 m (4 ft).

Table 4—Copper conductor sizes for use in continuous current tests

Switch rating (amperes)	Bus bars per terminal		Alternate cables per terminal
	Quantity	Size	
200	1	3 × 25 mm (1/8 in × 1 in)	One #2/0
600	1	6 × 51 mm (1/4 in × 2 in)	Two, 350 kcmil
1200	1	6 × 102 mm (1/4 in × 4 in)	Four, 500 kcmil
2000	2	10 × 102 mm (3/8 in × 4 in)	—
3000	3	10 × 127 mm (3/8 in × 5 in)	—

NOTE—When multiple bars are used, they are to be spaced 10 mm (3/8 in) apart. Vertical or horizontal configurations shall be at the option of the manufacturer.

6.2.2.2 Continuous current test power supply

Three-pole switches may be tested at any convenient voltage using a three-phase source of power. Each individual phase current is to be maintained at no less than the rated continuous current. A single-phase source of power may be used provided all poles are connected in series and the current flow in adjacent poles is in opposite directions.

6.2.2.3 Continuous current testing of fused switches

Fused switches shall be tested with fuses of the highest continuous current rating and having the highest thermal losses intended to be used with the fused switch selected.

NOTE—When fuses are used, temperature rise and total temperatures of the fuse assembly shall be in accordance with IEEE Std C37.40-1993.

6.2.3 Momentary withstand and short-time withstand current tests

Tests shall be performed to verify the momentary withstand, short-time withstand current, and short-time withstand current duration ratings of the switch. The switch shall be tested in accordance with IEEE Std 1247-1998 Clause 8.4, with the following additions and exceptions:

6.2.3.1 Test arrangement

The switch shall be in its test enclosure and in the closed position. The fuse assembly on a fused switch shall be replaced or bypassed with a copper conductor of suitable length and cross-sectional area as specified in Table 4. The enclosure or switch frame shall be grounded with a minimum of 4/0 copper conductor. Where the fused switch is the same as the unfused switch, only the unfused switch need be tested.

6.2.3.2 Momentary withstand current test

For three-phase devices, three-phase tests shall be conducted. The three-phase test current shall have a peak and a total rms value no less than those specified in 5.9. The rms symmetrical current shall be no less than 90% of the required short-time withstand current. The maximum peak current shall occur in an outside pole. The power-frequency test current shall have a minimum duration of 10 cycles. The preferred momentary withstand current ratings are given in ANSI C37.22-1997. The test may be conducted at any convenient voltage.

NOTE—The momentary test requires only a peak and rms total value although the momentary withstand current is defined using the rated short-time withstand current. The test may be at any convenient value of voltage, therefore any X/R ratio for the testing circuit may be used.

6.2.3.3 Short-time withstand current test

Short-time withstand current tests shall be permitted to be performed on three-pole switches using either a three-phase or a single-phase source provided two adjacent poles are connected in series such that current flow in adjacent poles is in opposite directions. The test may be conducted at any convenient voltage.

6.2.3.4 Short-time withstand current duration

The test current shall be applied for a time not less than the rated short-time withstand current duration. The preferred time is given in ANSI C37.22-1997.

For convenience in testing, the current magnitude and current duration may be adjusted together to provide an integrated heating equivalent (I^2t) to that of the rated short-time withstand current for the rated short-time withstand current duration. The duration, however, shall not exceed 1.25 times the rated short-time withstand current duration.

NOTES

1—If the current magnitudes achieved during the short-time withstand current test meet the requirements of 6.2.3.2, then this test may be combined with the momentary withstand current test. The above testing can be combined at the discretion of the manufacturer.

2—The tests conducted in 6.2.3.2 and 6.2.3.3 are to demonstrate the mechanical and thermal capabilities of the switch.

6.2.3.5 Acceptance criteria

Conditions in IEEE Std 1247-1998 Clause 8.6 apply except that, following the tests specified in 6.2.3.2, 6.2.3.3, and 6.2.3.4, the test switch shall be capable of withstanding for one minute a power frequency withstand voltage equal to 75% of the rated power frequency withstand voltage (the 110% test is not required). The preferred rated power frequency withstand voltages are given in ANSI C37.22-1997.

6.2.4 Fault making current test

Tests shall be performed to verify the ability of the switch to make and carry the maximum instantaneous current at the major peak of an offset rated power frequency current at its rated maximum voltage for a duration of 10 cycles.

The equipment qualified by this standard is tested as a grounded system to produce the maximum fault conditions and may be applied on both grounded or ungrounded systems. The switch shall be tested in accordance with IEEE 1247-1998 Clause 8.5 with the following additions and exceptions:

6.2.4.1 Pre-conditioning

Pre-conditioning of the switch is not a requirement.

6.2.4.2 Test arrangement

The switch shall be mounted in a test enclosure. The neutral of the supply system must be connected to the switchgear assembly by either a separate bus or the ground as permitted by the testing laboratory. The frame and all other normally grounded parts (enclosure, drive mechanism, etc.) shall be insulated from ground but connected to ground through a suitable device to indicate any significant current to ground. A 3 A fuse or a 5 cm (2 in) long #38 AWG copper wire is sufficient to detect current to ground. Test conductors must be adequately braced to prevent undue forces on the switch and/or enclosure, but shall not add intentional bracing to the switch.

For the tests specified in 6.2.4, switches which have an electrically operated closing mechanism shall be operated at the rated control voltage. Preferred values are listed in ANSI C37.22-1997.

NOTE—Tests in 6.2.4.2 shall be permitted to be performed on two separate switches or maintenance may be performed between tests on the same switch.

6.2.4.2.1 Multi-use switches

Switches of identical design for use as both fused and unfused switches shall be tested in accordance with 6.2.4.3.1 and 6.2.4.3.2.

At the discretion of the manufacturer, additional tests per 6.2.4.3.2 may be performed to achieve higher fault making rating when applied with fuses (current limiting and/or non-current limiting).

6.2.4.2.2 Fused switches

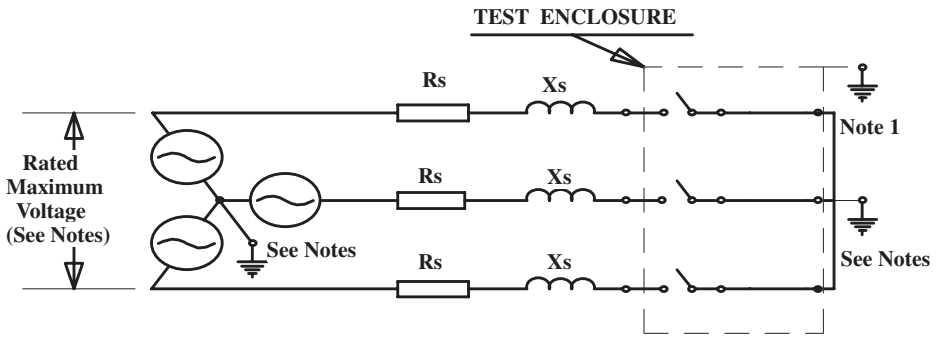
Switches for use as fused switches shall be tested only in accordance with 6.2.4.3.2.

6.2.4.2.3 Unfused switches

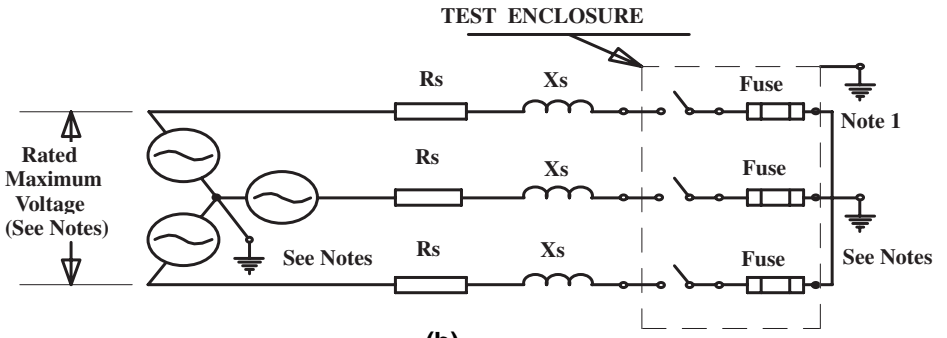
Switches for use as unfused devices shall be tested in accordance with 6.2.4.3.1.

6.2.4.3 Fault making circuit configuration

The appropriate test configuration shall be used, based upon the use of the switch as specified in 6.2.4.1 and 6.2.4.2; also see Figure 2a and Figure 2b.



(a)



(b)

NOTES

1—Enclosure shall be ground per 6.2.3.1 (Momentary withstand test) or connected to ground per 6.2.4.2 (fault making test).

Momentary withstand test

2—Either the neutral of the load or the source is to be grounded but not both.
3—The source may be delta or wye configured, based upon the laboratory's capabilities.

Fault making test

4—Ground is removed for the fault making test and connected per 6.2.4.2 and/or described in Note 5 and Note 6.
5—The source shall be grounded wye for the fault making test.
6—The testing laboratory may add a high resistance ground to the test system neutral and the shorting point for generator protection.

Figure 2—Momentary and fault making current test circuits

6.2.4.3.1 Unfused switch test

Unfused switches used in accordance with 6.2.4.2.1 or 6.2.4.2.3 shall be tested in accordance with IEEE Std 1247-1998 except that all tests shall be conducted as three-phase tests (single-phase tests are not allowed).

6.2.4.3.2 Fused switch test

Fused switches used in accordance with 6.2.4.2.1 or 6.2.4.2.2 shall be tested with the designated type of fuse in place and the fuse load terminals solidly faulted. Fuses of each designated type (current limiting and non-current limiting) shall be tested. The maximum current rating designated for each type of fuse shall be tested. The rated interrupting current of the fuse may be used if it is different from the fault making current rating of the switch provided the switch can demonstrate this capability. By doing so, an integrated switch and fuse short-circuit current rating is demonstrated (see Figure 2b). Switches which have demonstrated unfused fault making current rating equal to, or greater than, the maximum let-through peak current of the fuse, shall not require additional testing. Therefore a test to 6.2.4.3.2 need not be performed if the assigned fuse ratings are equal to or less than values in the tests performed per 6.2.4.3.1.

6.2.4.4 Fault making current and duration

The value of the current shall be the same as the rated momentary current of the switch. The rated fault making current may be determined by one of the two following methods:

a) The current for the test is the current as calibrated through the unfused switch when the switch is in the closed position.

   For unfused switches tested in accordance with 6.2.4.3.1, the current shall flow for not less than ten cycles after closing.

b) For integral switch and fuse configurations, the test current is the current as calibrated with the fuses short-circuited or omitted when the switch is in the closed position.

   For fused switches tested in accordance with 6.2.4.3.2, the recovery voltage shall be impressed upon the switch for not less than ten cycles after the fuse has cleared.

6.2.5 Mechanical operation test

A mechanical operation test shall be made to demonstrate the no-load mechanical capability of the switch.

6.2.5.1 Test arrangement

The switch shall be mounted in a test enclosure. The power frequency withstand voltage test (110% tests are not required) and the electrical resistance test should be run before the start of testing on the sample.

6.2.5.2 Power operation

A mechanical endurance test shall be performed on power-operated switches and shall be conducted in accordance with IEEE Std 1247-1998 Clause 8.8 and with the preferred values for the number of mechanical operations and at the control voltage listed in ANSI C37.22-1997.

6.2.5.3 Manual operation

A mechanical operation test shall be performed on manually operated switches and shall be conducted in accordance with IEEE Std 1247-1998 Clause 8.8. Manually operated switches having stored energy mechanisms that differ from the power-operated mechanism only in the means of supplying energy to the stored energy mechanism need not be subjected to endurance tests if the test in 6.2.5.2 has been performed.

6.2.5.4 Mechanical operation test requirements

The test shall consist of the rated number of close and open operations. Preferred values are listed in ANSI C37.22-1997. The frequency of operation shall be as specified by the manufacturer. During the test, no component shall be repaired or replaced, and no maintenance shall be performed. After the mechanical endurance tests are completed, the electrical resistance of the primary circuit shall not exceed 200% of the dc resistance measured before the test. If still in question, then a continuous current test shall be conducted and the switch temperature rise values shall not exceed 150% of the temperature rise limits as listed in Table 2. After the test, the switch must successfully pass a withstand voltage test at 75% of its rated power frequency withstand voltage (110% tests are not required).

6.2.6 Load switching current test

These tests shall demonstrate the ability of the switch to make and interrupt load currents for the number of operations specified in ANSI C37.22-1997. The switch shall be tested in accordance with IEEE Std 1247-1998 Clause 8.3.2.1. Values of current interrupted shall be the rated current. Preferred values are listed in ANSI C37.22-1997.

6.2.7 Cable-charging current switching test (optional)

The switch shall be capable of making and interrupting cable-charging currents up to its rated cable-charging switching current (see Table 5 for preferred ratings). The switch shall be tested in accordance with IEEE Std 1247-1998 Clause 8.3.2.3. The switch shall close and interrupt not less than the rated cable-charging current for 20 randomly timed close and open operations (60 operations, 20 on each pole, if tests are single-pole on a three-pole switch).

Table 5—Cable-charging switching ratings (optional)

Rated maximum voltage (kV)	Cable-charging current (A)	1000 kcmil cable length, km (miles)
4.76	2	1.6 (1)
8.25	8	4.8 (3)
15.0	14	8 (5)
25.8	16	8 (5)
38	18	8 (5)

NOTE—Cable-charging current values are based on 1000 kcmil cable.

6.2.8 Unloaded transformer switching test (optional)

This test shall demonstrate the ability of the switch to make and interrupt unloaded transformer currents for 20 operations. The switch shall be tested in accordance with IEEE Std 1247-1998 Clause 8.3.2.5.

6.2.9 Direct acting fuse tripping current test (optional)

This test shall demonstrate the ability of the switch to coordinate interruption of the overload current between the switch and fuse. The switch shall be tested in accordance with IEC 60420-1990 Test Duties 4 and 5.

6.3 Production tests

Unless otherwise specified, all production tests shall be made by the manufacturer on the completed switch assembly.

6.3.1 Power frequency withstand voltage test

Test per 6.2.1.1 (except that the open gap test at 10% above rating is not required).

6.3.2 Mechanical operation test

Mechanical operation tests shall be performed to assure the proper functioning of the switch. Ten close–open operations of the switch shall be performed.

6.3.3 Terminal-to-terminal resistance test

Switches shall be checked for resistance with a minimum of 100 A dc flowing, and shall not exceed the maximum resistance established by the manufacturer.

6.3.4 Power operation and control wiring test (for power-operated switches only)

6.3.4.1 Control wiring continuity

The correctness of the control wiring shall be verified by either or both:

a) Actual electrical operation of the component control devices, or
b) Individual circuit continuity checks by electrical circuit testers.

6.3.4.2 Control wiring insulation test

A power frequency test voltage (rated power frequency ± 20%) shall be applied after all circuit grounds have been disconnected. Either 1500 V for one minute or 1800 V for one second may be utilized. All wires shall be tested either individually or in groups. Mechanism motors are permitted to be tested at 900 V ac and rated frequency ± 20% for one minute.

6.4 Conformance tests

Conformance testing (when required) shall be in accordance with ANSI C37.58-1990.

6.5 Field dielectric tests

When power frequency withstand voltage tests are to be made on switches after installation in the field, the switches shall not be tested at greater than 75% of the test values given in ANSI C37.22-1997.

NOTE—Field tests are recommended on initial installation, when new units are added to an existing installation, or after major field modifications. The equipment should be put in good condition prior to the field test. It is not expected that equipment shall

be subjected to these tests after it has been stored for long periods of time or has accumulated a large amount of dust, dirt, moisture, or other contaminants without it first being restored to good condition.

7. Construction

7.1 General requirements

7.1.1 Primary connections

The switch shall provide space for the devices used for making electrical and mechanical connections to the incoming and outgoing conductors. Each terminal connection point shall meet the bolt hole requirements of NEMA CC1-1993.

7.1.2 Insulating materials

Primary insulation materials shall be flame resistant and track resistant in accordance with IEEE Std C37.20.2-1999 and IEEE Std C37.20.3-2001.

7.2 Functional components

The functional components required for manual and power operated switches are listed in Table 6. Additional accessory devices may be available. The manufacturer should be consulted for specific information.

Table 6—Functional components required for manual and power-operated switches

Functional component	Operating mechanism type	
	Manual	Power
Power fuse—one per pole	X[a]	X[a]
Contact position indicator in accordance with 7.2.1	X	X
Operating handle	X	X
Independent manually operated mechanism	X[b]	–
Power-operated closing and/or opening mechanism	–	X
Provisions for locking in accordance with 7.2.3	X	X

[a]As required by the application.
[b]Required for all switches and fused switches that have a fault making current rating.

7.2.1 Contact position indicator

The following colors shall be used:

a) Red background with the word CLOSED in contrasting letters to indicate closed contacts
b) Green background with the word OPEN in contrasting letters to indicate open contacts

7.2.2 Stored energy indicator (if supplied)

The following colors shall be used:

a) Yellow background with black lettering to indicate that the closing mechanism is charged
b) White background with black lettering to indicate that the closing mechanism is discharged

7.2.3 Locking

Provisions for locking the manually operated switch in the open and closed positions shall be provided.

Provisions for locking the power-operated switch in the open position shall be available as an optional feature.

7.2.4 Nameplate markings

The following minimum information shall be given on the switch nameplates:

a) Manufacturer's name and address
b) Manufacturer's type and identification
c) Month and year of manufacture
d) Rated maximum voltage
e) Rated power frequency
f) Rated momentary withstand current
g) Rated lightning impulse withstand voltage
h) Rated short-time withstand current
i) Rated short-time withstand current duration
   NOTE—The following ratings shall be provided in accordance with Table 3.
j) Rated continuous current (as applicable)
k) Rated load switching current (as applicable)
l) Rated unloaded transformer switching current (as applicable)
m) Rated control voltage (as applicable).
n) Rated fault making current, peak current for switch alone or for integral switch and fuse (as applicable)
o) Rated short-circuit current (as applicable for integral switch and fuse)
p) Rated cable-charging switching current (as applicable)

Other ratings—When a switch is to have additional ratings other than those shown above, or special capabilities not defined in this standard, it shall be added to the above nameplate or on a separate nameplate.

NOTE—The type, ratings, and manufacturer of the fuse for which the integral switch and fuse short-circuit current rating was established shall be designated by the manufacturer in an appropriate manner. (Required if integral switch and fuse fault-making current rating is established.)

8. Application guide

8.1 General

Switches should be applied within their assigned ratings as defined in this standard with proper consideration given to the usual service conditions stated in Clause 4.

8.2 Voltage

The voltage of the system to which the switches are applied, including any possible variations, should not exceed the rated maximum voltages listed in ANSI C37.22-1997. Control voltage variations should not exceed the rated ranges as specified in ANSI C37.22-1997.

8.3 Frequency

The preferred rated power frequency for switches is 60 Hz as stated in 5.6. For application at any other frequency or with other than sinusoidal wave forms, the manufacturer should be consulted.

8.4 Continuous current

Switches should be applied to a circuit having a maximum continuous load current no greater than the continuous current rating of the switch. When the switch has a load switching current rating and/or fuses are applied, the continuous current is limited by the load switching current rating or by the fuse rating.

8.5 Short-circuit current

Switches should have short-time current withstand, short-time current withstand duration, momentary withstand current, and fault making current ratings (if the switch has fault making current capability) equal to or greater than the short-circuit current available at the location where they are applied.

8.6 Cable-charging current

Switches that are connected to the load with shielded cable may be required to switch cable-charging current. For applications, consult the manufacturer. This is an optional rating that is not required when the connection between the switch and the load is bus, unshielded cable, or less than 30 m (100 ft) of shielded cable.

8.7 Unloaded transformer switching current capability

Switches with load switching current capability also have the inherent capability to interrupt unloaded transformer (magnetizing or excitation) currents.

8.8 Direct acting fuse trip capabilities

The direct acting fuse trip capabilities measure the ability of a switch and fuse combination to coordinate interruption of overload currents. This capability may be needed in cases where switches have mechanisms that are directly tripped or otherwise activated by a blown fuse mechanism. The manufacturer should be consulted for proper application and sizing of fuses. Testing of the switch and fuse combination test should be done per IEC 420-1990 Test Duties 4 and 5.

8.9 Unusual service conditions

The manufacturer should be consulted if a switch is subjected to service conditions that are other than usual service conditions covered in Clause 4. For unusual service conditions see IEEE Std C37.20.2-1999 and IEEE Std C37.20.3-2001 since this switch is to be used in metal-enclosed switchgear.

8.10 Maintenance

Switches operating under usual service conditions should be maintained in accordance with the manufacturer's instructions, supplemented by the applicable portions of ANSI/NFPA 70B-1998. Where unusual service conditions exist, the manufacturer should be consulted for guidance. Unusual service conditions in addition to those listed in IEEE Std C37.20.2-1999 and IEEE Std C37.20.3-2001 include, but are not limited to, special duty, frequency, or other operating requirements, difficulty of maintenance, or unstable control voltages.