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

Sponsor

Switchgear Committee
of the
IEEE Power Engineering Society

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IEEE 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

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Introduction

(This introduction is not a part of IEEE Std C37.20.4-1996, IEEE Trial-Use Standard for Indoor AC Switches (1 kV-38 kV) for Use in Metal-Enclosed Switchgear.)

This standard has been developed to define the basic design and performance requirements for indoor medium-voltage switches intended for use in metal-enclosed switchgear covered in IEEE Std C37.20.2-1993 and IEEE Std C37.20.3-1996. This standard was developed based upon design criteria stated in IEEE Std C37.30, IEEE Std C37.32, and IEEE Std C37.34. For other switches, see references IEEE Std C37.30-1992, IEEE Std C37.32-1990, and IEEE Std C37.34-1994 .[1]

This trial-use standard includes the requirements for only metal-enclosed interrupter switchgear. These requirements were previously a part of IEEE Std C37.20-1969 (Reaff 1981), IEEE Standard for Switchgear Assemblies Including Metal-Enclosed Bus (1974 consolidated edition).[2] Other types of equipment previously included in IEEE Std C37.20-1969 (Reaff 1981) are incorporated in separate publications.

The rated short-time current is an indication of the ability of the switch to survive a "through-fault," which may occur if the primary circuit protection fails to clear and the backup protection has to operate. In the past, the standards have set a single time duration for this fault condition. This time duration (2 s) has been based on the maximum tripping delay Y for medium-voltage circuit breakers. The 2 s requirement reduces the complexity of coordination and protection studies performed by the user and purchaser of the equipment; however, this requirement became restrictive especially concerning newer technologies and faster acting backup protection schemes. This standard allows a rating for "short-time current duration." It will require the user and/or purchaser to specify the short-time current and the short-time current duration for the equipment based upon needs and backup protection. It will also require the manufacturer to label the equipment for both ratings. ANSI C37.22 lists the preferred ratings for indoor AC switches used in metal-enclosed switchgear, which are not restrictive.

This standard uses IEEE 4-1978, IEEE Standard Techniques for High-Voltage Testing, instead of the current revision of the 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.

Publication of this trial-use standard for comment and criticism has been approved by the Institute of Electrical and Electronics Engineers. Trial-Use standards are effective for 24 months from the date of publication. Comments for revision will be accepted for 18 months after publication. Suggestions for revision should be directed to the Secretary, IEEE Standards Board, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, and should be received no later than 22 May 1998. It is expected that following the 24-month period, this trial-use standard, revised as necessary, shall be submitted to the IEEE Standards Board for approval as a full-use standard.

This standard was prepared by a working group of the Switchgear Assemblies Technical Committee, National Electrical Manufacturers Association (NEMA). NEMA is responsible for clause 5., Ratings, and clause 7., Construction.

The IEEE Switchgear Assemblies Subcommittee of the IEEE Switchgear Committee, which reviewed and approved this document is responsible for clause 3., Definitions; clause 4., Service conditions; clause 6., Tests; and clause 8., Application guide.

This publication is one of a series covering Switchgear Assemblies as follows (see figure A):

[1]These references are available from the IEEE. For more information on references, see clause 2.
[2]IEEE Std C37.20-1969 has been withdrawn. This standard was delineated into the various branches of the IEEE Std C37.20 series.

ANSI C37.22/D7	Preferred Ratings for Indoor Medium-Voltage Switches and Drawout Medium-Voltage Circuit Breakers Used in Enclosures
IEEE Std C37.20.1-1993	Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear (1000 V and Below)
IEEE Std C27.20.2-1993	Metal-Clad and Station-Type Cubicle Switchgear (Above 1000 V)
IEEE Std C37.20.3-1996	Metal-Enclosed Interrupter Switchgear (Above 1000 V)
IEEE Std C37.20.4-1996	Indoor AC Switches (1 kV-38 kV) for Use in Metal-Enclosed Switchgear
IEEE Std C37.21-1985	Control Switchboards
IEEE Std C37.23-1987	Metal-Enclosed Bus and Guide for Calculating Losses in Isolated Phase Bus

Through this joint effort over the many years, the switchgear assemblies standards have been of extreme value to the industry and further suggestions for improvement gained in the use of this standard will be welcomed.

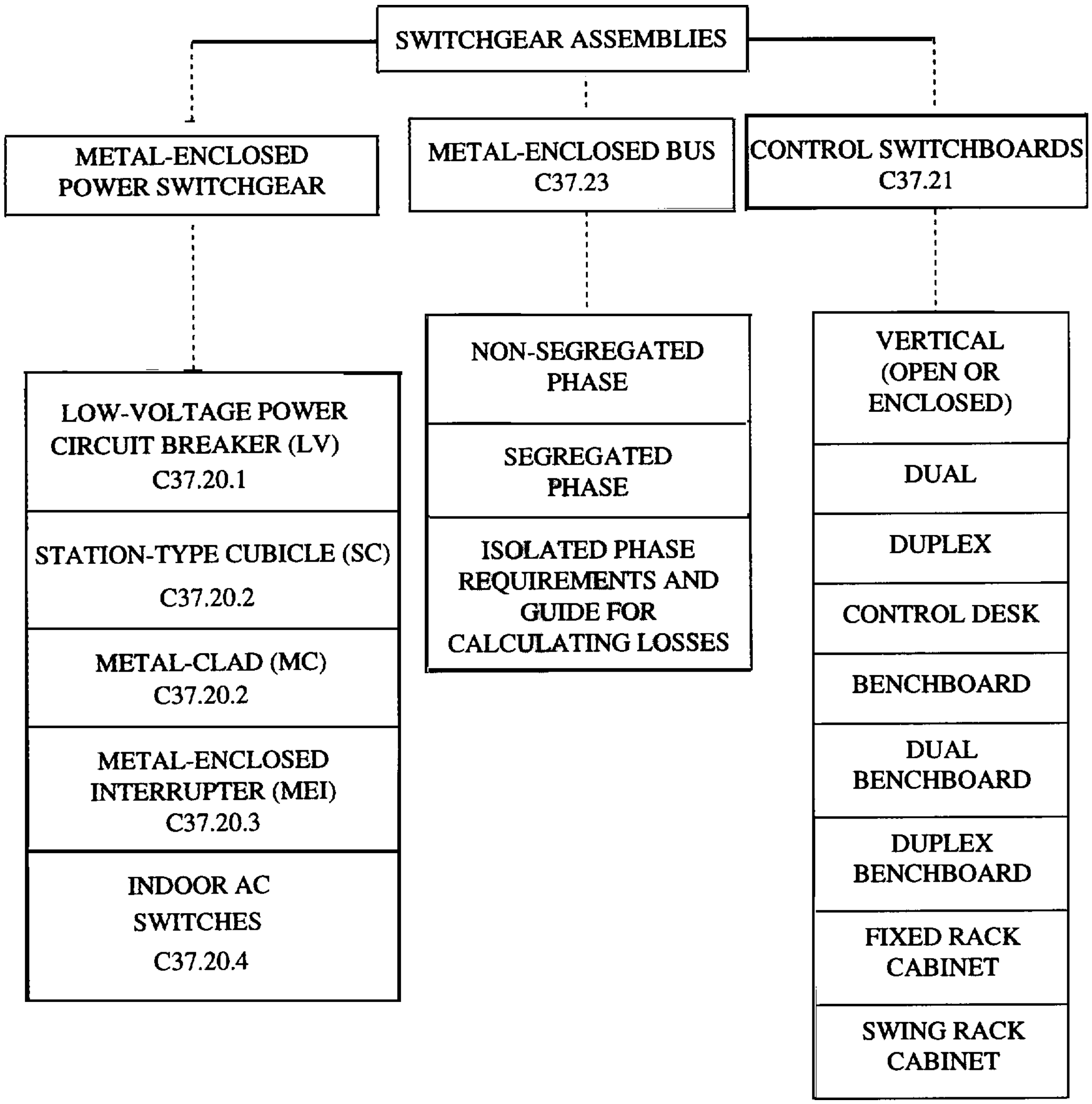

Figure A —Types of switchgear assemblies

The Standards Committee on Power Switchgear, C37, which reviewed and approved this standard, had the following personnel at the time of approval:

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When the IEEE Standards Board approved this standard on 21 March 1996, it had the following membership:

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

1. Scope

This standard covers indoor ac medium-voltage switches for use in enclosures for application in power circuits at voltages above 1 kV through 38 kV 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 Std C37.20.2-1993 [1] or IEEE Std C37.20.3-1996.

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 IEEE PC37.73, and to high-voltage air switches in IEEE Std C37.30-1992.

NOTES:

1 — Within this standard, the word “switch(es)” shall be considered to mean 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.

[1]Information on references can be found in clause 2.

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 IEEE Std 4-1978.

ANSI C37.22/D7, Preferred Ratings for Indoor Medium-Voltage Switches and Drawout Medium Voltage Circuit Breakers Used in Enclosures.[2]

ANSI C37.57-1990, American National Standard for Switchgear—Metal Enclosed Interrupter Switchgear Assemblies—Conformance Testing.[3]

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/NFPA 70B-1994, Electrical Equipment Maintenance.[4]

IEEE Std 1-1986 (R1992), IEEE Standard General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation (ANSI).[5]

IEEE Std 4-1978, IEEE Standard Techniques For High-Voltage Testing (ANSI).[6]

IEEE Std C37.09-1979 (R1988), IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (ANSI/DoD).

IEEE Std C37.20.2-1993, IEEE Standard for Metal-Clad and Station-Type Cubicle Switchgear (ANSI).

IEEE Std C37.20.3-1996, IEEE Standard for Metal-Enclosed Interrupter Switchgear (ANSI).

IEEE Std C37.30-1992, IEEE Standard Requirements for High-Voltage Air Switches (ANSI).

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 (ANSI).

IEEE Std C37.41-1994, IEEE Standard Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories (ANSI).

IEEE Std C37.48-1988 (R1992), IEEE Guide for Application, Operation, and Maintenance of High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories (ANSI).

IEEE Std C37.71-1984 (R1990), IEEE Standard for Three-Phase, Manually Operated Subsurface Load Interrupting Switches for AC Systems (ANSI).

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[2]As this standard goes to press, ANSI C37.22 is being developed. The draft standard is, however, available from ANSI. Anticipated publication date is December 1996. Contact the ANSI Sales Department at (212) 642-4900.

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

[4]NFPA publications are available from Publications Sales, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, USA.

[5]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

[6]The 1978 standard is used instead of the current test standard because of the need for several correction factors that were omitted in the revised document.

IEEE Std PC37.73 (Feb-95 D8), Standard Requirements for Padmounted Fused Switchgear.[7]

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

NEMA CC 1-1984 , Electrical Power Connections for Substations.[8]

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 the definition differs from that in IEEE Std C37.100-1992.

3.1 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. These tests may be used to demonstrate compliance with applicable industry standards. *Synonym:* type tests.†

NOTE — Design tests are made on representative apparatus or prototypes to verify the validity of 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 design 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.

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.

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

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

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

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

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.

3.7 unfused switch: A switch that has no fuses directly attached or in close proximity to the switch.*

[7]This IEEE standards project was not approved by the IEEE Standards Board at the time this publication went to press. For information about obtaining a draft, contact the IEEE.
[8]NEMA publications are available from the National Electrical Manufacturers Association, 1300 N. 17th St., Ste. 1847, Rosslyn, VA 22209, USA.

4. 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 C37.20.2-1993 or IEEE Std C37.20-3-1996 as follows:

a) The temperature of the ambient air surrounding the enclosure shall be within the limits of –30 °C to +40 °C.
b) The altitude of the installation does not exceed 3300 ft (1000 m).
c) Unusual service conditions such as outlined in 8.8 do not prevail.

5. Ratings

5.1 General

The designated ratings in this standard are preferred and are not considered restrictive. The ratings of switches are designations of operating limits under specified conditions of ambient temperature, temperature rise, etc.

5.2 Required ratings

The following types of switches listed in 5.2.1 through 5.2.3 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 impulse withstand voltage
c) Rated power frequency withstand voltage
d) Rated power frequency
e) Rated continuous current
f) Rated load current switching
g) Rated momentary current
h) Rated short-time current
i) Rated fault closing current
j) Rated short-circuit current for integral switch and fuse (if rated) (see the note below)

NOTE — An integral switch and fuse short-circuit current rating is different from the fault closing current rating of the switch alone. The integral switch and fuse short-circuit current rating is established by a fault closing test as specified by 6.2.4.1 a). This rating is dependent upon the type of fuse designated and its rated interrupting current.

5.2.2 Disconnect, transfer, or selector switches

a) Rated maximum voltage
b) Rated impulse withstand voltage
c) Rated power frequency withstand voltage
d) Rated power frequency
e) Rated continuous current
f) Rated momentary current
g) Rated short-time current

5.2.3 Grounding switches

a) Rated maximum voltage
b) Rated impulse withstand voltage
c) Rated power frequency withstand voltage
d) Rated power frequency
e) Rated momentary current
f) Rated short-time current

5.3 Voltage and insulation levels

5.3.1 Rated maximum voltage

The rated maximum voltage of switches is the highest rms voltage for which the equipment is designed, and is the upper limit for operation. The switches shall be rated at one of the rated maximum voltages listed in ANSI C37.22, table 1.

5.3.2 Rated insulation levels

The rated insulation levels of switches shall consist of the following two items:

a) Normal-frequency withstand voltage
b) Impulse withstand voltage

5.3.3 Rated voltage and insulation levels

The rated maximum voltages, and corresponding insulation levels for switches are listed in ANSI C37.22, table 1.

5.4 Rated power frequency

The rated power frequency of the device is the frequency of the circuit for which the switch is designed. (Ratings are based on a frequency of 60 Hz.)

5.5 Rated continuous current

The rated continuous current is the maximum current in root-mean squared (rms) amperes at rated power frequency, which the device will carry continuously without exceeding specified temperature rise limits under test conditions as specified by 6.2.2. Preferred continuous current ratings are listed in ANSI C37.22, table 2.

5.6 Rated load current switching

The load current switching rating is the ability of the switch to close into and interrupt load currents having a power factor between 0.80 to 0.99 lagging, requiring no maintenance for the number of operations stated in ANSI C37.22, table 3.

5.7 Rated momentary current

The current is the rms asymmetrical current that the switch shall be required to carry as specified in 6.2.3. 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 not less than 10 cycles. Preferred values are listed in ANSI C37.22, table 2.

5.8 Rated short-time current

The rated short-time current is the rms symmetrical current that the switch is required to carry for the rated short-time current duration.

5.9 Rated short-time duration

The rated short-time duration is the specified short-time interval that the switch carries the rated short-time current.

5.10 Rated fault closing current

The current is the rms asymmetrical current outlined in 6.2.4.4, which is the current available under fault closing conditions. The current shall be the rms value, including the direct-current 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 not less than 10 cycles. Preferred values are listed in ANSI C37.22, table 2. The value should be equal to the rated momentary current of the switch or switch and fuse.

Rated fault closing 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 closing ratings. The integral switch and fuse short-circuit current rating is the prospective rms asymmetrical current, which has been demonstrated by tests, that the combination switch and fuse can withstand during the fault closing test. During the fault closing test to demonstrate the integral switch and fuse short-circuit current rating, the current duration is limited by the clearing time of the fuse. The specific fuse types for which the integral Circuit current rating has been established shall be specified. Switches which have demonstrated unfused fault closing peak current rating equal to, or greater than, the maximum let-through peak current of the fuse, shall not require additional testing.

5.11 Rated control voltage

The rated control voltage of a switch is the designated voltage, within a specified range, which is to be applied at the terminals of the operating mechanism. Values are listed in ANSI C37.22, table 7.

5.12 Association of ratings

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

5.13 Rated cable-charging current switching (optional)

The cable-charging current switching rating is the maximum charging current flowing into an open-ended 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 frequency.

5.14 Temperature limitations

5.14.1 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 noncurrent-carrying structural parts

c) For air surrounding switches

5.14.2 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 IEEE Std 1-1986.		

5.14.3 Temperature limits for switch conducting parts

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

6. Tests

6.1 General

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

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)
a) Moving or hinge contacts:		
1) With silver or equivalent surfaces	65	105
2) With silver or equivalent to copper surfaces	50	90
3) With copper surfaces	30	70
b) Connecting joints:		
1) With silver, tin, or equivalent surfaces	65	105
2) With silver, tin, or equivalent to copper surfaces	50	90
3) With copper surfaces	30	70

NOTES:
1 — Ambient temperature is measured outside the enclosure.

2 — When fuses are used, temperature rise and total temperatures of the fuse assembly shall be in accordance with IEEE Std C.37.40-1993.

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

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.

6.2 Design tests

Design tests, as applicable per table 3, shall be made in accordance with 6.2.1 through 6.2.6. 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 spacings 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.

6.2.1 Dielectric tests

Normal-frequency withstand voltage tests (see 6.2.1.1) and impulse withstand voltage tests (see 6.2.1.2) shall be performed on switches to demonstrate the ability of the insulation system to withstand voltage levels in accordance with ANSI C37.22, table 1.

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 IEEE Std 4-1978. Humidity correction factors shall be based on curves for rod gaps as stated in IEEE Std 4-1978, figure 1.3. The equipment shall be clean and in good condition and tested in an enclosure as specified in 6.1.1.

Table 3— Design tests

Type test	Reference subclause	Switch type		
		LCIS	IDIS	GND
Normal-frequency withstand voltage	6.2.1.1	X	X	X
Impulse withstand voltage	6.2.1.2	X	X	X
Continuous current	6.2.2	X	X	
Momentary current	6.2.3	X	X	X
Short-time current	6.2.3	X	X	X
Fault closing current (switch only)	6.2.4	X		X
Mechanical endurance	6.2.5	X	X	
Load current switching	6.2.6	X		
Fault closing current (integral switch and fuse)	6.2.4.2.3	optional		

NOTES:
1 — The presence of an X indicates the types of test required for the switch type shown.
2 — Switch type:
LCIS—Load current interrupter switches
DIS—Disconnect, transfer, selector switches
GND—Grounding switches

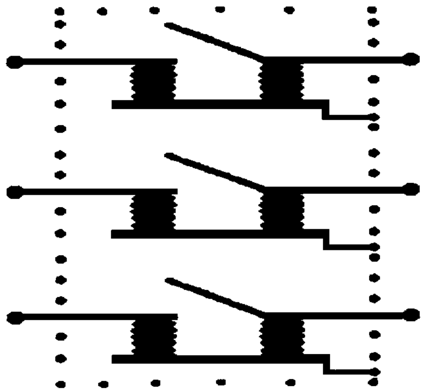
NOTE — If not applying correction factor(s) would result in a more severe test, the manufacturer may elect not to apply the factor(s).

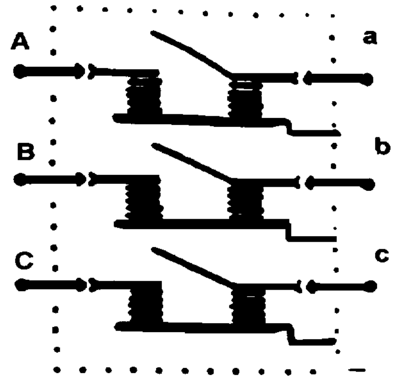
Test voltages shall be applied between the primary terminals and ground per figure 1.

Normal-frequency withstand voltage tests and impulse withstand voltage tests shall be made as follows in 6.2.1.1 and 6.2.1.2.

6.2.1.1 Normal-frequency withstand voltage test

A sinusoidal ac voltage having a crest value equal to 1.414 times the rms value specified in ANSI C37.22, table 1 shall be applied to the primary terminals per lines I through 9 of figure 1. The wave shape shall be essentially sinusoidal. The frequency shall be within ±20% of the rated frequency. The test potential is to be increased gradually from zero to reach the required test value within 30 s to 60 s and shall be held at the value for 1 min without flashover.





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
[a]12	V	G	V	G	V	G	G	T	C
[a]13	G	V	G	V	G	V	G	T	C
[a]14	V_1	G	V_1	G	V_1	G	F	T	O
[a]15	G	V_1	G	V_1	G	V_1	F	T	O

[a] Lines 12 to 15 are for drawout switches only.
V = test voltage (for values see ANSI C37.22, table 1)
V_1 = 1.1 × test voltage (for values see, ANSI C37.22, table 1)
G = ground

Figure 1— Dielectric tests

6.2.1.2 Impulse withstand voltage tests

The standard impulse is a full-wave impulse having a virtual front time of 1.2 μs to peak and a virtual time to half value of 50 μs of the value specified in ANSI C37.22, table 1. It is described as a 1.2 x 50 μs impulse test wave. In these tests, three consecutive positive and three consecutive negative impulse voltages shall be applied to the primary terminals per figure 1. If during the first group of three consecutive tests, flashover occurs in one test of the group, a second group of nine tests shall be made. If the equipment successfully withstands all nine of the second group of tests, the flashover in the first group shall be considered as a random flashover and the equipment shall be considered as having successfully passed the tests. The wave shape, used to define the limits, is described in IEEE Std 4-1978.

For the test across the open gap at 10% higher voltage (lines 10 and 11, 14 and 15), 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 that specified in ANSI C37.22, table 1. If this is not practicable, the test enclosure may be insulated from ground.

NOTES:

1 — 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 before the tests, is recommended.

2 — 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

To determine compliance with continuous current ratings, it is necessary to determine that temperatures of the various components of the switch are within the limits set forth in 5.14.

Temperature measurements shall be made in accordance with 6.2.2.1 through 6.2.2.5.

The continuous current rating of fused and unfused switches is based upon continuous current tests performed without fuses. In addition to tests performed without fuses, fused switches shall be tested with fuses in accordance with 6.2.2.9.

6.2.2.1 Test area conditions

Temperature tests shall be conducted indoors in a test area that is reasonably free from drafts.

6.2.2.2 Ambient air temperature limits

Tests may be made at any ambient air temperature between 10 °C and 40 °C.

6.2.2.3 Measurement of ambient air temperature

Indoor ambient air temperature shall be determined by taking the average of the readings of three temperature-measuring devices such as thermometers or thermocouples, placed as follows:

a) One level with the top of the test enclosure
b) One 12 in (305 mm) above the bottom of the test enclosure
c) One midway between the a) and b) positions.

All temperature-measuring devices shall be placed 12 in (305 mm) from the enclosure, not in front of ventilators, and in locations unaffected by drafts caused by the enclosure or appreciable radiation from the equipment. When the ambient air temperature is subject to variations that might result in errors in measuring the temperature rise, the temperature measuring devices should be immersed in a suitable liquid, such as oil, in a suitable container or reliably attached to a suitable mass of metal.

NOTE — A convenient form of such a container consists of a metal cylinder with a hole drilled partly through it. This is filled with liquid and the temperature-measuring device is placed therein. A glass bottle may also be used as a container. The size of the container shall be at least 1 in (25.4 mm) in diameter and 2 in (50.8 mm) high.

6.2.2.4 Method of measuring temperature

Thermocouples shall be used to measure the temperature at the required locations on the switch test arrangement. Thermocouples used for measuring the temperature of insulation, shall be located on the current-carrying member or other metal part. Thermocouples used for measuring the temperature of the drawout switch separable primary contacts shall be located approximately 0.5 in (13 mm) from the contacts on the current-carrying member. For cable terminations, the thermocouples shall be located at the junction of the conductor and its insulation.

Thermocouples shall be held in intimate contact with the conductor surface by such methods as welding, drilling, and peening or cementing.

The thermocouples shall be located in a manner so as to measure the hottest spot, even though it may involve drilling holes that destroy some parts. It is recognized that thermocouples cannot be located in the actual contact point of line or point contacts without destroying the effectiveness of such line or point contacts.

Measurements shall be made at junction points of insulation and conducting parts to ensure against exceeding temperature limits of the insulation.

6.2.2.5 Duration of tests

The continuous current test shall be made for such a period of time that the temperature rise of any monitored point in the assembly has stabilized. Stabilization is indicated by observing a temperature rise of no more than 1.0 °C (1.8 °F) as indicated by three successive readings at 30 min intervals. The equipment has passed the test if the temperature limits in tables 1 and 2 have not been exceeded.

6.2.2.6 Frequency of test current

The frequency of the test current shall not be less than the rated power frequency of the assembly tested. A sine-wave shape is recommended. The test shall be made with alternating current having a crest value equal to 1.414 times the rms test current.

6.2.2.7 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 4 ft (1.2 m).

6.2.2.8 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 are in opposite directions.

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	1/8 in × 1 in (3 mm × 25 mm)	One #2/0
600	1	1/4 in × 2 in (6 mm × 51 mm)	Two-350 kcmil
1200	1	1/4 in × 4 in (6 mm × 102 mm)	Four-500 kcmil
2000	2	3/8 in × 4 in (10 mm × 102 mm)	—
3000	3	3/8 in × 5 in (10 mm × 127 mm)	—

NOTE — When multiple bars are used, they are to be spaced 3/8 in (9.53 mm) apart. Vertical or horizontal configurations shall be at the option of the manufacturer.

6.2.2.9 Continuous current testing of fused switches

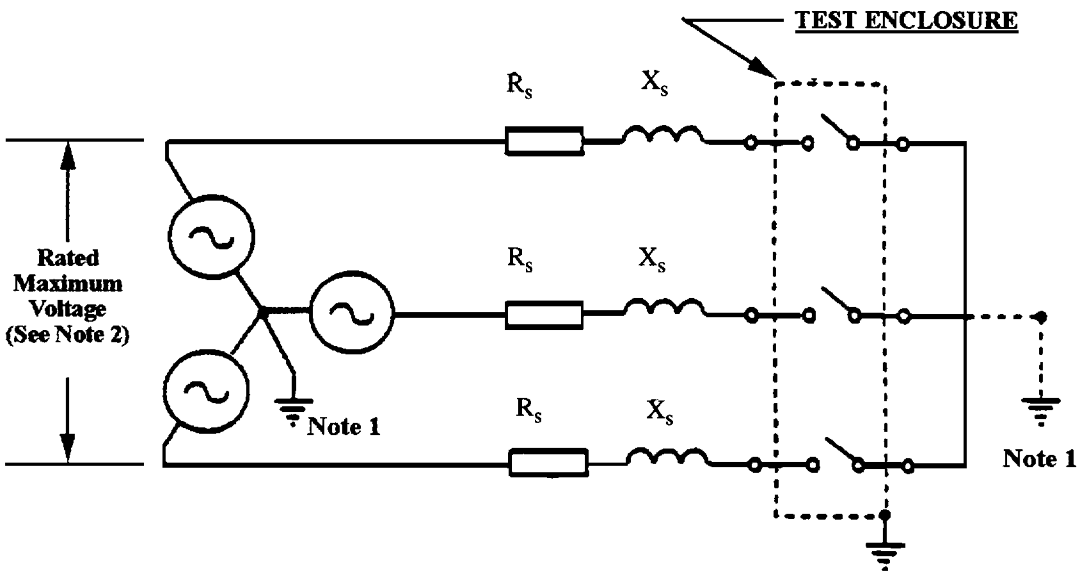
Fused switches shall be tested with fuses of the highest continuous current rating and having the highest thermal losses intended to be used with the fused switch selected. Tests shall be conducted with currents at the continuous current rating of the fuse or the continuous current rating of the switch and fuse combination.

6.2.3 Momentary and short-time current tests

Tests shall be performed to verify the momentary and the short-time current ratings of the switch.

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. See figure 2. Where the fused switch is the same as the unfused switch, only the unfused switch need be tested.



NOTES
1—Either the neutral of the load or the source is to be grounded but not both.
2—The voltage may be any convenient voltage for momentary and short-time tests.
3—The source may be delta- or wye-configured based upon the test laboratory's capabilities.

Figure 2— Momentary, short-time, and fault closing current test circuits for unfused switches

6.2.3.2 Momentary current test

For three-phase devices, three-phase tests shall be conducted. The rated rms asymmetrical momentary current is given in ANSI C37.22, table 2 and shall conform to the following:

a) The current shall be the rms value, including the dc component during the maximum cycle as determined from the envelope of the current wave during the test period as specified by 6.2.3.2.2.
b) The duration of current flow shall not be less than 10 cycles on a 60 Hz basis.
c) The test may be performed at any convenient voltage.
d) The timing of the application of asymmetrical test currents shall be such that the maximum asymmetrical current as defined by 6.2.3.2.1 shall occur in an outside pole.
e) The power factor of the test current shall be 15% lagging or less (x/r ratio of 6.6 or greater) with x and r in series connection.

After this test, the main switch path shall not be open and should be capable of conducting rated current, and the switch shall be capable of being operated, to the open position in its intended manner by the normal operating mechanism. The insulation system shall be capable of withstanding for one minute a normal frequency withstand voltage equal to the values specified in ANSI C37.22, table 1.

6.2.3.3 Short-time current test

Short-time 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.

After this test, the main switch path shall not be open and should be capable of conducting rated current, and the switch shall be capable of being operated, to the open position in its intended manner by the normal operating mechanism. The insulation system shall be capable of withstanding for 1 min a power frequency withstand voltage equal to the values specified in ANSI C37.22, table 1.

6.2.3.3.1 Determination of short-time current

The current shall be monitored throughout the duration of the test, and the demonstrated level of current shall be determined by integration of the current envelope over the rated short time current duration using the method described in IEEE Std C37.09-1979, "measurement of the rms value of a current during a short circuit of several cycles duration."

NOTES:

1 — If the test meets the requirements of 6.2.3.2, this test may be combined with the momentary 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.

6.2.4 Fault closing test

A fault closing test shall be made to demonstrate the ability of the switch to close, at the rated maximum voltage, into a faulted circuit. For three-phase devices, three-phase tests shall be conducted. The switch shall not flashover to ground and/or phase to phase. After the test, the switch main current path shall not be open and should be capable of conducting rated current. The switch shall be capable of being operated to the open position in its intended manner by the normal operating mechanism. The insulation system shall be capable of withstanding for l rain a normal-frequency withstand voltage equal to 75% of the values specified in ANSI C37.22, table 1.

6.2.4.1 Test arrangement

The switch shall be mounted in a test enclosure. The switch frame and enclosure shall be grounded with a minimum of 4/0 copper conductor. Test conductors shall be adequately braced to prevent undue forces on the switch and/or enclosure, but shall not add intentional bracing to the switch.

a) Switches of identical design for use as both fused and unfused switches, or switches for use as unfused switches only, shall be tested in accordance with 6.2.4.2.1 and 6.2.4.2.2.
   At the discretion of the manufacturer, additional tests per 6.2.4.2.3 may be performed to achieve higher fault closing rating when applied with fuses (current limiting and non-current limiting).
b) Switches for use as fused switches only shall be tested in accordance with 6.2.4.2.3 only.

6.2.4.2 Fault closing circuit configuration

The appropriate test configuration shall be used based upon the use of the switch as specified in 6.2.4.1.

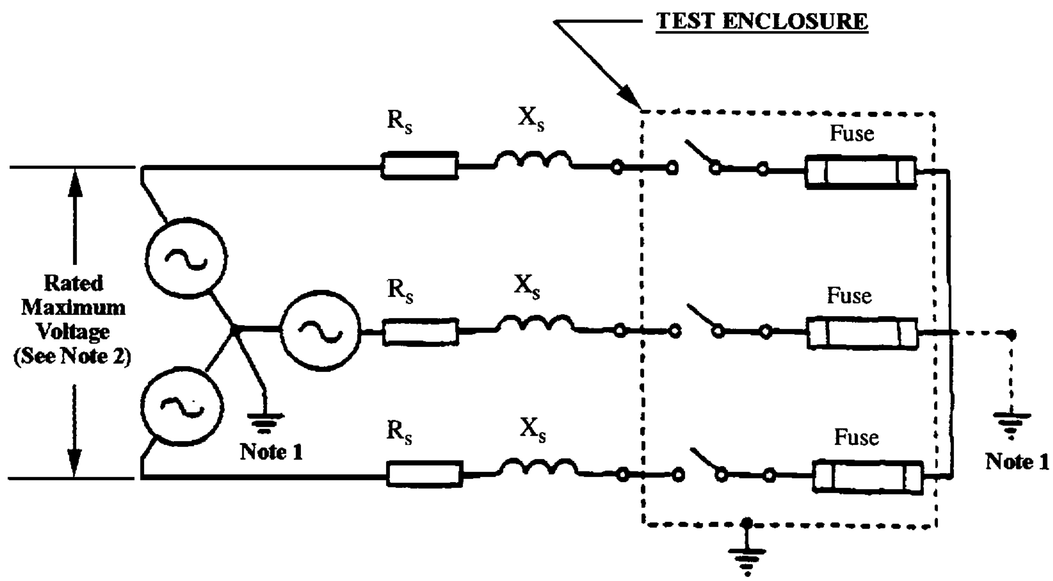
6.2.4.2.1 Unfused switches

Unfused switches used in accordance with 6.2.4.1a) shall be tested with all poles solidly faulted on the load side (see figure 1).

6.2.4.2.2 Fused switches

Fused switches used in accordance with 6.2.4.1a) shall be tested with the load side poles connected to fuses and the fuse load side terminals solidly faulted (see figure 3). The test per this subclause need not be repeated if the assigned fuse ratings are equal to or less than values in the test performed in 6.2.4.2.1.

NOTE — Tests in 6.2.4.2.1 and 6.2.4.2.2 shall be permitted to be performed on two separate switches or maintenance may be performed between tests on the same switch.



NOTES

1—Either the neutral of the load or the source is to be grounded but not both.

2—The source may be delta- or wye-configured based upon the test laboratory's capabilities.

Figure 3— Fault closing current test circuits for fused switches

6.2.4.2.3 Integral switch and fuse

Fused switches used in accordance with 6.2.4.1 a) or b), 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 closing 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 3).

6.2.4.3 Test voltage

The applied voltage is the open circuit rms voltage of the test circuit immediately before fault closing, and its value shall be equal to or greater than the rated maximum voltage of the switch. It shall be applied to all poles of the switch. Grounding shall be in accordance with 6.2.6.1.

6.2.4.4 Fault closing current and duration

The rated fault closing current may be determined by one of the two following methods:

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

— For integral switch and fuse configurations, the test current is the prospective asymmetrical current calibrated with the fuses short-circuited or omitted.

The current (as measured or prospective) shall be the rms value, including the dc component, during the maximum cycle as determined from the envelope of the current wave for the period of time as specified by a) or b) as applicable below.

a) For unfused switches tested in accordance with 6.2.4.2.1, the current shall flow for not less than ten (10) cycles (60 Hz base) after closing.
b) For fused switches tested in accordance with 6.2.4.2.2 and 6.2.4.2.3, the recovery voltage shall be impressed upon the switch for not less than ten (10) cycles (60 Hz base) after the fuse has cleared.

With electrically operated switches the closing mechanism shall be operated at the selected rated control voltage in accordance with ANSI C37.22, table 7.

6.2.4.5 Determination of test current values

Test currents and calibrations shall be measured in accordance with IEEE Std C37.09-1979.

6.2.4.6 Power factor

The power factor of the test current shall be 15% lagging or less (X/R ratio of 6.6 or greater) with X and R in series connection.

6.2.5 Mechanical endurance test

A mechanical endurance 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.

6.2.5.2 Power operation

A mechanical endurance test shall be performed on power operated switches and shall be conducted at the selected rated control voltage in accordance with ANSI C37.22, table 5.

6.2.5.3 Manual operation

A mechanical endurance test shall be performed on manually operated switches. Manually operated switches having stored energy mechanisms that differ from 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 endurance test requirements

The test shall consist of the required number of close-open operations in accordance with ANSI C37.22, table 4. The frequency of the 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 testing is completed, the electrical resistance of the primary circuit shall not exceed 200% of the dc resistance set by the manufacturer. If still in question, then a continuous current test shall be conducted and the switch temperature shall not exceed 150% of the values as listed in table 2.

6.2.6 Load current switching test

These tests shall demonstrate the ability of the switch to close and interrupt load currents for the number of operations specified in ANSI C37.22, table 3. Tests shall be conducted using an opening and a closing duty cycle as specified by the manufacturer. The switch shall be permitted to cool between the tests where required for proper performance. The switch shall not flashover to ground and/or phase to phase during these tests (see figures 4, 5, and 6).

6.2.6.1 Grounding

Test switches shall be connected to a circuit having the neutral point of the supply or the neutral point of the three-phase load circuit grounded, but not both. The switch frame shall be at the same potential as the test enclosure. The test enclosure shall be grounded with a minimum 4/0 copper conductor.

6.2.6.2 Test voltage and current

Three-phase switching tests shall be made with a normal frequency recovery voltage equal to or greater than the rated maximum voltage of the switch. Normal-frequency recovery voltage shall be determined from the envelope of each voltage wave at a point in time coincident with that peak which occurs more than 1/2 cycle and not more than 1-1/2 cycle after final arc extinction in the last phase to clear. The normal-frequency phase-to-phase recovery voltage for a three-phase test shall be taken as 1.73 times the average of the three values obtained in this manner for the three voltage waves. See figure 6. Values of current interrupted shall be those specified in ANSI C37.22 , table 3.

6.2.6.3 Load current switching test circuit

The load circuit shall be composed of resistance, reactance, and, if necessary, capacitors connected in parallel and of such a magnitude to produce a power factor of between 80% and 99% lagging.

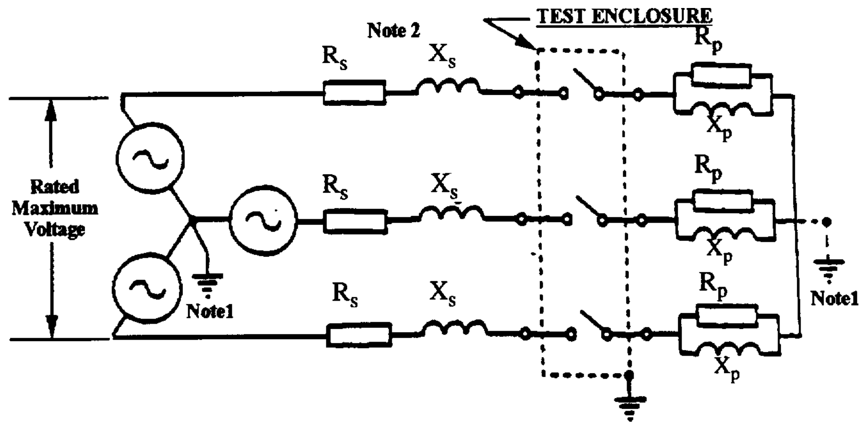
The test circuit shall be arranged as shown in figure 4. The R_s and X_s shall make up, between 10% to 20%, of the total circuit impedance.

6.2.6.4 Operation

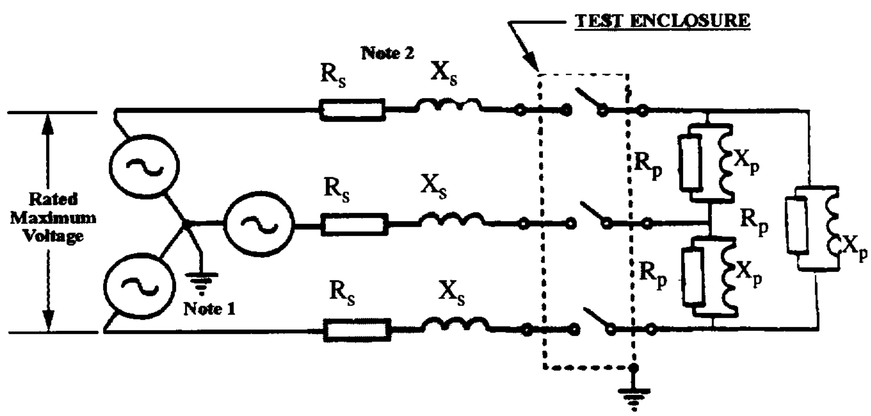
The switch shall be operated such that the timing of contact make and break with respect to the phase angle of the test current is random.

6.2.6.5 Transient recovery voltage

For load current switching tests, the transient recovery voltage (TRV) shall be equal to or greater than the values specified in figure 5, and the time-to-peak shall be equal to or less than the values specified in figure 2. The TRV should be measured on the first pole to clear. Capacitance and damping resistances may be added as required to adjust the TRV to the specified values.



a) Wye-connected



b) Delta-connected

NOTES

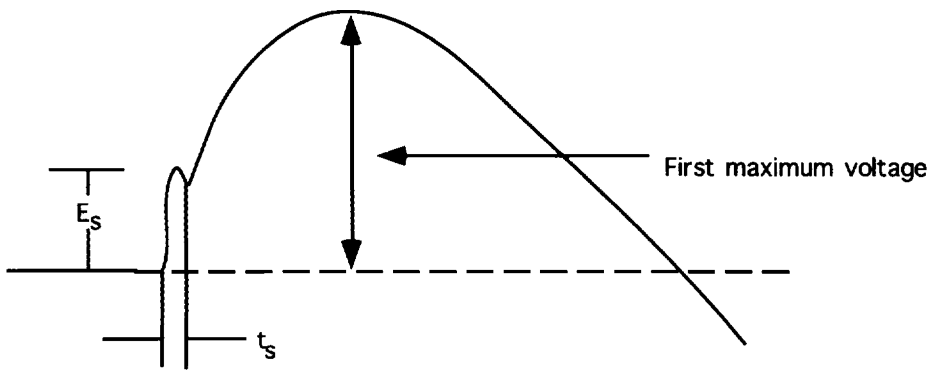
1—Either the neutral of the load or the source is to be grounded but not both.

2—R_S and X_S must be between 10% of total circuit impedance.

3—$ZS = \dfrac{(10\% \text{ to } 20\% \text{ of maximum rated voltage})}{\sqrt{3} \text{ times rated switching current}}$

4—Power factor = 80% to 90% lagging.

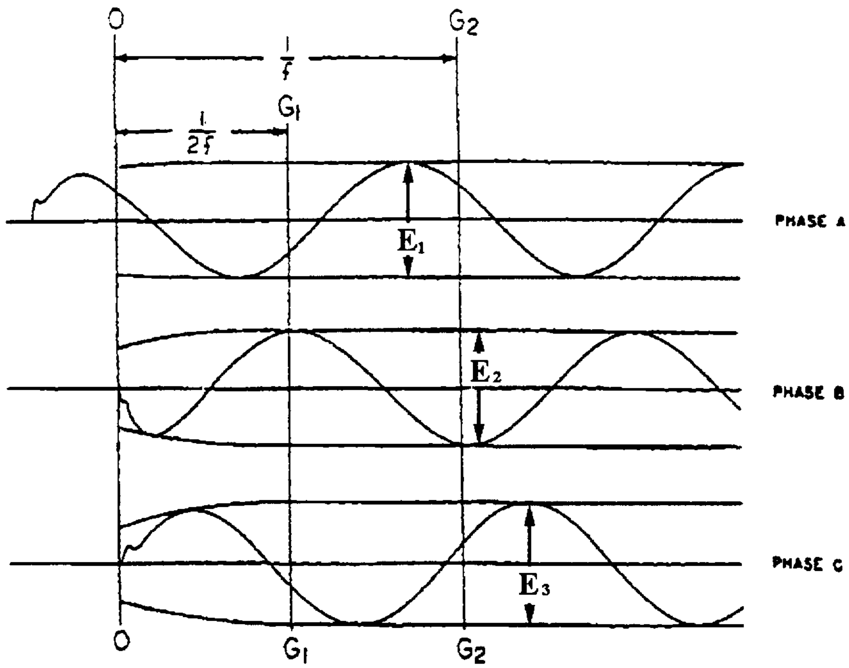
Figure 4— Load current switching test



Time-to-peak t_s (μs)

Rated maximum voltage (kV)	Peak E_s (kV)	Time-to-peak t_s (μs)
4.76	0.04	75
8.25	1.93	110
15.0	4.0	180
27.0	7.6	290
38.0	13.0	424

Figure 5— Inherent transient recovery voltage for load-current switching test



Phase A=first to open circuit

00 = instant of final arc extinction

G_1G_1 = instant after interval $\frac{l}{2f}$ from 00

G_2G_2 = instant after interval $\frac{l}{f}$ from 00

$\frac{E_1}{2.828}$ = normal frequency recovery voltage, phase A

$\frac{E_2}{2.828}$ = normal frequency recovery voltage, phase B

$\frac{E_2}{2.828}$ = normal frequency recovery voltage, phase C

Average normal-frequency pole recovery voltage

$$= \frac{\left(\frac{E_1}{2.828} + \frac{E_2}{2.828} + \frac{E_3}{2.828}\right)}{3}$$

Normal-frequency phase to phase recovery voltage

$$= \sqrt{3} \times \left(\frac{\text{Average normal-frequency}}{\text{Pole-unit recovery voltage}}\right)$$

NOTE—If as in Phase B, a voltage peak occurs exactly a G_1G_1, measurement is made at G_2G_2.

Figure 6— Normal-frequency recovery voltage measurement

6.2.7 Cable-charging current switching test (optional)

The switch shall be capable of closing and interrupting cable-charging currents up to its rated cable-charging switching current (see table 5 for preferred ratings).

Table 5— Cable-charging switching ratings (optional)

Rated maximum voltage—kV	Cable-charging current (A)	Miles of 1000 MCM cable
4.8	2	1
8.3	8	3
15.0	14	5
25.8	16	5
38	18	5
NOTE — The numbers in the above table are based on 1000 MCM cable.		

The use of laboratory test circuits for verification of the rated cable-charging switching current is an appropriate simulation of field performance if the switch is restrike-free. Currently available laboratory circuits may be used to demonstrate the interrupting performance for restriking devices, but they may not fully simulate field switching performance, especially in producing realistic field overvoltages when restriking occurs. For laboratory tests, the cables may he simulated by artificial circuits with lumped elements consisting of capacitors, reactors and resistors. See figure 7. Overvoltages caused by restriking in the laboratory may be substantially greater than those experienced in the field.

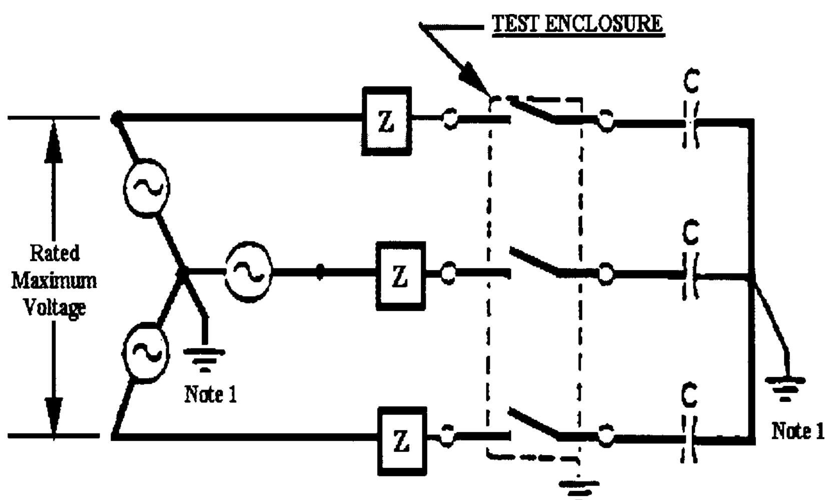


Figure 7— Cable charging current test circuit

6.2.7.1 Characteristics of source circuit

The source circuit shall have an impedance such that the prospective short-circuit current does not exceed the rated short-time current of the switch. The characteristics of the source circuit shall be such that the differential capacitance voltage is as small as possible and is in any case less than 5%.

Capacitance, inductance, and resistance may be added to the source circuit to control the transient recovery voltage frequency and amplitude factor or to properly simulate inrush currents during closing.

The neutral of the source shall be grounded.

6.2.7.2 Characteristics of the capacitive load

The characteristics of the switched capacitive load, with all necessary devices such as voltage dividers included, shall be such that the voltage decay on the switched capacitance does not exceed 0.1% at the end of an interval of 100 ms after final circuit interruption.

NOTE — Since the voltage decay may be significantly influenced by apparatus such as voltage transformers connected to the switched capacitive load, the measurement should be made with suitable voltage dividers.

When capacitors are used to simulate cables, a non-inductive resistance, not exceeding 10% of the capacitive impedance or 50 Ω, may be inserted in series with the capacitors; higher values may unduly influence the recovery voltage. If the peak inrush current is still unacceptably high, then an alternative impedance (e.g., inductance/capacitance), may be used instead of the resistor, provided that the current and voltage conditions at the instant of interrupting, and the recovery voltage, do not differ significantly from the specified values.

The neutral of the load circuit shall be grounded.

6.2.7.3 Test requirements

Three-phase tests shall be made at the rated maximum voltage. Single-phase tests may be conducted on a three-phase switch at 58% of rated maximum voltage.

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).

6.3 Production tests

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

6.3.1 Normal-frequency withstand voltage test

The normal-frequency test shall be performed per 6.2.1 and 6.2.1.1 (except the open gap (position) 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 (10) 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 60 Hz test voltage shall be applied after all circuit grounds have been disconnected. Either 1500 V for 1 min or 1800 V for 1 s may be utilized. All wires shall be tested either individually or in groups.

6.4 Conformance tests

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

6.5 Field dielectric tests

When normal-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, table 1.

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 first being restored to good condition.

7. Construction

7.1 General requirements

7.1.1 Primary connection

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 4.5 of NEMA CC1-1984.

7.1.2 Insulating material

Primary insulation materials shall be flame-resistant and track-resistant in accordance with IEEE Std C37.20.2-1993 and IEEE Std C37.20.3-1996.

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

Functional component	Operating mechanism type	
	Manual	Power
a) Power fuse—one per pole	X*	X*
b) Contact position indicator in accordance with 7.2.1	X	X
c) Operating handle	X	X
d) Independent manual operated mechanism	X†	—
e) Power operated closing and/or opening mechanism	—	X
f) Padlocking provisions in accordance with 7.2.3	X	X
g) Nameplate(s) with markings in accordance with 7.2.4	X	X
NOTE — The presence of an X indicates the types of test required for the switch type shown in table 3.		

*As required by the application.
†Required for all switches and fused switches that have a fault closing 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.

Provision 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 current, rms asymmetrical
g) Rated impulse withstand voltage
h) Rated short-time current, rms symmetrical
i) Rated short-time current duration

NOTE — The following ratings shall be provided in accordance with table 3.

j) Rated continuous current (as applicable)
k) Rated load current switching capacity (as applicable)
l) Rated control voltage (as applicable)
m) Rated fault closing current, rms asymmetrical for switch alone or for integral switch and fuse. (as applicable)
n) Rated short-circuit current (as applicable for integral switch and fuse)

7.2.4.1 Other ratings

When a switch is to have additional ratings other than those shown in 7.2.4, or special capabilities not defined in this document, 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 short-circuit 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, table 1. Control voltage variations should not exceed the rated ranges as specified in ANSI C37.22, table 7.

8.3 Frequency

The rated power frequency for switches is 60 Hz as stated in 5.4. For application at any other frequency or 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 current switching rating and/or fuses are applied, the continuous current is limited by the load switching rating or by the fuse rating.

8.5 Short-circuit current

Switches should have short-time, momentary, and fault closing ratings 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 which is not required when the connection between the switch and the load is bus, unshielded cable or less than 100 ft (30.5 m) of shielded cable.

8.7 Excitation (magnetizing) current capability

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

8.8 Unusual service conditions

The manufacturer should be consulted if a switch is subjected to service conditions that are other than the usual service conditions covered in clause 4. For unusual service conditions, see IEEE Std C37.20.2-1993 and IEEE Std C37.20.3-1996 since this switch is to be used in metal-enclosed switchgear.

8.9 Maintenance

Switches operating under usual service conditions should be maintained in accordance with the manufacturer's instructions, and supplemented with applicable portions of NFPA 70B-1994. Where unusual service conditions exist, the manufacturer should be consulted for guidance. Unusual service conditions in addition to those listed in 8.8 include, but are not limited to, special duty, frequency, or other operating requirements; difficulty of maintenance or unstable control voltages.