**IEEE Std C37.20.2-1993**
(Revision of IEEE Std C37.20.2-1987)

# IEEE Standard for Metal-Clad and Station-Type Cubicle Switchgear

Sponsor
**Switchgear Committee**
**of the**
**IEEE Power Engineering Society**

Approved September 15, 1993
**IEEE Standards Board**

**Abstract:** Metal-enclosed medium voltage switchgear (ME), which can contain either drawout electrically operated circuit breakers or stationary electrically operated circuit breakers in individual three-pole grounded metal compartments, is covered. Further, metal-clad switchgear (MC) is compartmentalized to isolate all components such as instrumentation, main bus, and both incoming and outgoing connections with grounded metal barriers. Rated maximum voltage levels for metal-clad switchgear (MC) range from 5 kV through 38 kV with main bus continuous current ratings of 1200 A, 2000 A, and 3000 A. Rated maximum voltage levels for station-type cubicle switchgear (SC) range from 15.5 kV through 72.5 kV with main bus continuous current ratings of 2000 A, 3000 A, 4000 A, and 5000 A. ME switchgear also contains associated control, instruments, metering, relaying, protective, and regulating devices as necessary. Service conditions, ratings, temperature limitations, and classification of insulating materials, insulation (dielectric) withstand voltage requirements, test procedures, and application are discussed.
**Keywords:** common or related terms, control, cumulative loading, cubicle switchgear, current transformers, drawout, indoor, instrumentation, load current-carrying, metal-clad switchgear (MC), metal-enclosed power switchgear (ME), metering, outdoor, protection, qualifying terms, stationary, station-type cubicle switchgear, switchgear assemblies, transformer accuracy, voltage transformers

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## Introduction

(This introduction is not a part of IEEE Std C37.20.2-1993, IEEE Standard for Metal-Clad and Station-Type Cubicle Switchgear.)

This standard has been revised to reflect needed technical changes that have been suggested since the original document was published in 1987.

This standard includes the requirements for only metal-clad and station-type cubicle 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). Other types of equipment previously included in IEEE Std C37.20-1969 (Reaff 1981) are incorporated in separate publications.

IEEE Std C37.20-1969[1] had for many years covered all switchgear assemblies, including metal-enclosed bus. Standards committees of the IEEE Switchgear Assemblies Subcommittee and the NEMA Power Switchgear Assemblies Technical Committee recommended that the document be further developed and, where appropriate, that the various sections be identified with their own standards. This approach also identifies with the Conformance Test Procedure Standards.

The IEEE Switchgear Assemblies Committee, in cooperation with the NEMA Power Switchgear Assemblies Technical Committee, was responsible for this revision.

NEMA is responsible for developing clauses 4. and 6.. The Switchgear Assemblies Committee of the IEEE Switchgear Committee is responsible for developing clauses 2, 3, 5, 7, and 8.

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

| | |
|---|---|
| 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 C37.20.3-1987 | Metal-Enclosed Interrupter Switchgear (Above 1000 V) |
| IEEE Std C37.21-1985 | Control Switchboards |
| IEEE Std C37.23-1987 | IEEE Standard for 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. Further suggestions for improvement gained in the use of this standard will be welcomed.

[1]IEEE Std C37.20-1969 has been withdrawn. This standard was delineated into the various branches of the IEEE Std C37.20 series.

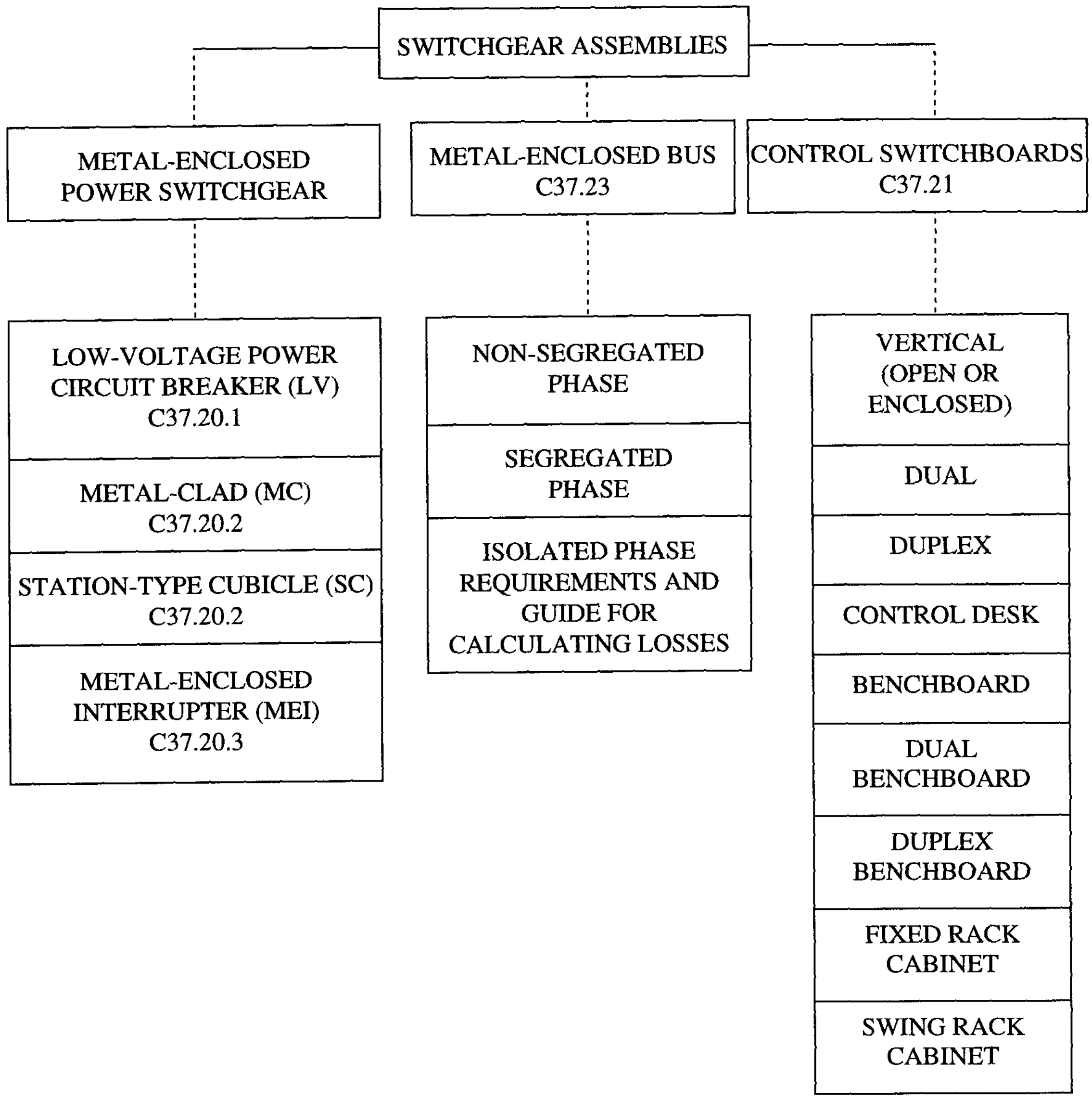


**Figure A —Types of switchgear assemblies**

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CLAUSE PAGE

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# IEEE Standard for Metal-Clad and Station-Type Cubicle Switchgear

## 1. Overview

### 1.1 Scope

This standard covers metal-clad and station-type cubicle switchgear containing, but not limited to, such devices as power circuit breakers; other interrupting devices; switches; control; instrumentation and metering; and protective and regulating equipment. It includes, but is not specifically limited to, equipment for the control and protection of apparatus used for power generation, conversion, and transmission and distribution.

This standard is concerned with enclosed, rather than open, indoor and outdoor switchgear assemblies rated above 1000 V. It applies to equipment that is part of primary and secondary unit substations. It does not include gas insulated substation equipments.

In this standard metal-clad switchgear shall be called MC switchgear, and station-type cubicle switchgear shall be called SC switchgear. Whenever the data covers both types of equipments, they shall be called ME switchgear.

### 1.2 References

This standard shall be used in conjunction with the following publications. When the standards referenced in this document are superseded by an approved revision, the revision shall apply.

Accredited Standards Committee C2-1993, National Electrical Safety Code.[1]

ANSI C37.06-1987, American National Standard for Switchgear—AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities.[2]

ANSI C37.11-1979, American National Standard Requirements for Electrical Control for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis and a Total Current Basis.

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[1]The NESC is available from the IEEE, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.
[2]ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

ANSI Z535.4-1991, American National Standard for Product Safety Signs and Labels.

ANSI/NFPA 70-1993, National Electrical Code.[3]

ANSI/UL 486A-1991, Wire Connectors and Soldering Lugs for Use With Copper Conductors.[4]

ASTM B117-90, Standard Test Method of Salt Spray (FOG) Testing.[5]

ASTM D229-91, Standard Method of Testing Rigid Sheet and Plate Materials Used for Electrical Insulation.

ASTM D714-87, Standard Method for Evaluating Degree of Blistering of Paints.

ASTM D1535-89, Standard Method for Specifying Color by The Munsell System.

ASTM D1654-79a (R 1984), Standard Method for Evaluation of Painted or Coated Specimens Subjected, to Corrosive Environments.

ASTM D2303-90, Standard Test Method for Liquid-Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials.

ASTM G21-90, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

IEEE Std 1-1986, IEEE Standard General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation (ANSI).[6]

IEEE Std 4-1978, IEEE Standard Techniques for High-Voltage Testing (ANSI).

IEEE Std 100-1992, The New IEEE Standard Dictionary of Electrical and Electronics Terms (ANSI).

IEEE Std 141-1993, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (IEEE Red Book).

IEEE Std 241-1990, IEEE Recommended Practice for Electric Power Systems in Commercial Buildings (IEEE Gray Book) (ANSI).

IEEE Std 242-1986 (Reaff 1991), IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (ANSI) (IEEE Buff Book).

IEEE Std 344-1987, IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations (ANSI).

IEEE Std 446-1987, IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications (IEEE Orange Book) (ANSI).

IEEE Std C37.04-1979 (Reaff 1988), IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (ANSI).

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[3]The National Electrical Code is published by the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269. Copies are also available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10018, USA.

[4]ANSI/UL publications are available from the Underwriters Laboratories Inc, Publication Stock, 333 Pfingsten Road, Northbrook, IL 60062. Copies are also available from the Sales Department, American National Standard Institute, 11 West 42nd Street, 13th Floor, New York, NY, 10036, USA.

[5]ASTM publications are available from the American Society for Testing and Materials, 1916 Race St, Philadelphia, PA 19103, USA.

[6]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08854-1331, USA.

IEEE Std C37.010-1979, IEEE Standard Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (ANSI).

IEEE Std C37.2-1991, IEEE Standard Electrical Power System Device Function Numbers (ANSI).

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

IEEE PC37.20.4, Standard for Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear. April 26, 1994/D20.[7]

IEEE Std C37.24-1986, IEEE Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Enclosed Switchgear (ANSI).

IEEE Std C37.55-1989, IEEE Conformance Test Procedures for Metal-Clad Switchgear Assemblies (ANSI).

IEEE Std C37.81-1989, IEEE Guide for Seismic Qualification of Class 1E Metal-Enclosed Power Switchgear Assemblies (ANSI).

IEEE Std C37.90.1-1989, IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems (ANSI).

IEEE Std C37.90.2-1987, IEEE Trial-Use Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interferences from Transceivers (ANSI).

IEEE Std C57.13-1993, IEEE Standard Requirements for Instrument Transformers.

NEMA CCI-1993, Electrical Power Connectors for Substations.[8]

NEMA LII-1989, Industrial Laminated Thermosetting Products.

NEMA WC5-1992/ICEA S-61-402, Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

NEMA WC7-1991/ICEA S-66-524, Cross-Linked Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

NEMA 260-1991, Safety Labels for Padmounted Switchgear and Transformers Sited in Public Areas.

## 2. 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 C37.100-1992[9] 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.

[7]This authorized standards project, PC37.20.4, was not approved by the IEEE Standards Board at the time this went to press. It is available from the IEEE Service Center.
[8]NEMA publications are available from the National Electrical Manufacturers Association, 2101 L Street, NW, Washington, DC 20037, USA.
[9]Information on references can be found in 1.2.

## 2.1 General

**2.1.1 ambient air temperature:** The temperature of the surrounding air that comes in contact with equipment.

NOTE — Ambient air temperature, as applied to enclosed switchgear assemblies, is the average temperature of the surrounding air that comes in contact with the enclosure (see 5.2.2.3 for method of measurement).

**2.1.2 auxiliary compartment:** That portion of the switchgear assembly that is assigned to the housing of auxiliary equipment, such as potential transformers, control power transformers, or other miscellaneous devices.*

**2.1.3 circuit breaker compartment:** That portion of the switchgear assembly that contains one circuit breaker or other removable primary interrupting device and the associated primary conductors.*

**2.1.4 conformance tests:** Conformance tests 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 (capabilities) beyond the standards is not required.

**2.1.5 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 may be used to demonstrate compliance with applicable standards of the industry.†

NOTES:

1 — Design tests are made on representative apparatuses or prototypes to verify the validity of design analyses and calculation methods and to substantiate the ratings assigned to all other apparatuses 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. Test 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.*

**2.1.6 field tests (for switchgear):** Tests made after the assembly has been installed at its place of utilization.

**2.1.7 ground and test device:** A term applied to a switchgear assembly accessory device which can be inserted in place of a drawout circuit breaker for the purposes of (1) grounding the main bus and/or external circuits connected to the switchgear assembly and/or (2) primary circuit testing.

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

**2.1.9 switchgear:** A general term covering switching and interrupting devices and their combination with associated control, instruments, metering, protective, and regulating devices; also assemblies of these devices with associated interconnections, accessories, and supporting structures used primarily in connection with the generation, transmission, distribution, and conversion of electric power.†

**2.1.9.1 switchgear assembly (see figure A in the introduction):** An assembled equipment (indoor or outdoor) including, but not limited to, one or more of the following: switching, interrupting, control, instrumentation, metering, protective, and regulating devices; together with their supporting structures, enclosures, conductors, electrical interconnections, and accessories.†

**2.1.9.2 metal-enclosed power switchgear (ME):** A switchgear assembly completely enclosed on all sides and top with sheet metal (except for ventilating openings and inspection windows) containing primary power circuit switching or interrupting devices, or both, with buses and connections. The assembly may include control and auxiliary devices. Access to the interior of the enclosure is provided by doors or removable covers, or both.†

**2.1.9.3 metal-clad switchgear (MC):** Switchgear that is characterized by the following necessary features:

a) The main switching and interrupting device is of the removable (drawout) type arranged with a mechanism for moving it physically between connected and disconnected positions and equipped with self-aligning and self-coupling primary disconnecting devices and disconnectable control wiring connections.
b) Major parts of the primary circuit, that is, the circuit switching or interrupting devices, buses, voltage transformers, and control power transformers, are completely enclosed by grounded metal barriers, that have no intentional openings between compartments. Specifically included is a metal barrier in front of, or a part of, the circuit interrupting device to ensure that, when in the connected position, no primary circuit components are exposed by the opening of a door.
c) All live parts are enclosed within grounded metal compartments.
d) Automatic shutters that cover primary circuit elements when the removable element is in the disconnected, test, or removed position.
e) Primary bus conductors and connections are covered with insulating material throughout.
f) Mechanical interlocks are provided for proper operating sequence under normal operating conditions.
g) Instruments, meters, relays, secondary control devices and their wiring are isolated by grounded metal barriers from all primary circuit elements with the exception of short lengths of wire such as at instrument transformer terminals.
h) The door through which the circuit-interrupting device is inserted into the housing may serve as an instrument or relay panel, and may also provide access to a secondary or control compartment within the housing.

NOTES:

1 — Auxiliary vertical sections may be required for mounting devices or for use as a bus transition.

2 — The term metal-clad (as applied to switchgear assemblies) is correctly used only in connection with switchgear conforming fully to the definition for metal-clad switchgear given in 2.1.9.3. Metal-clad switchgear is metal-enclosed, but not all metal-enclosed switchgear can be correctly designated as metal-clad.

**2.1.9.4 station-type cubicle switchgear (SC):** Metal-enclosed power switchgear characterized by the following required features:

a) The main switching and interrupting device is of the stationary mounted type, composed of a primary circuit compartment and a secondary or mechanism compartment. It is also arranged with gang-operated isolating switches that are mechanically interlocked with the main switching and interrupting device.
b) Each phase for the major parts of the primary circuit switching or interrupting devices, buses, and line-to-ground potential transformers is completely enclosed (or segregated) by grounded metal barriers that have no intentional openings between compartments. Specifically included are mechanically interlocked doors in front of, or a part of, the primary circuit compartment of the circuit switching and interrupting device so that when the group-operated isolating switches are closed, no primary parts can be exposed by the attempted opening of the interlocked doors.
c) All live parts are enclosed within grounded metal compartments.
d) Primary bus conductors and connections are bare.
e) Mechanical interlocks are provided for proper operating sequence under normal operating conditions.
f) Secondary control devices and their wiring are isolated by grounded metal barriers from all primary circuit elements with the exception of short lengths of wire such as at instrument transformer terminals.
g) The doors to the secondary or mechanism compartment of the primary switching or interrupting device are to provide access to the secondary or control equipment within the housing without danger to exposure to the primary circuit parts.

NOTE — Auxiliary vertical sections may be required for mounting devices or for use as a bus transition.

**2.1.10 vertical section:** That portion of the switchgear assembly between two successive vertical delineations and may contain one or more circuit breakers, auxiliary compartments, and associated primary conductors.†

## 2.2 Qualifying terms

The following qualifying terms are defined in IEEE Std 100-1992 and the user is referred to the definitions given therein:

#### 2.2.1 accessible

#### 2.2.2 alive (live)

#### 2.2.3 automatic (self-coupling)

#### 2.2.4 enclosed

#### 2.2.5 insulating

#### 2.2.6 isolated

#### 2.2.7 ventilated

The following qualifying terms are defined in IEEE Std C37.100-1992 and the user is referred to the definitions given therein:

#### 2.2.8 electrical

#### 2.2.9 enclosure

#### 2.2.10 flame-resistant (retardant)

#### 2.2.11 indoor

#### 2.2.12 metal-enclosed

#### 2.2.13 outdoor

#### 2.2.14 resistant (suffix)

#### 2.2.15 secondary

#### 2.2.16 ventilated enclosure

## 2.3 Common or related terms

The following common or related terms are defined in IEEE C37.100-1992 and the user is referred to the definitions given therein:

#### 2.3.1 asymmetrical

#### 2.3.2 auxiliary switch

#### 2.3.3 barrier

#### 2.3.4 bus

### 2.3.5 connected position

### 2.3.6 continuous current tests

### 2.3.7 current-limiting fuse

### 2.3.8 disconnected position

### 2.3.9 drawout-mounted device

### 2.3.10 ground bus

### 2.3.11 live parts

### 2.3.12 main (primary switchgear connections)

### 2.3.13 normal frequency

### 2.3.14 primary disconnecting devices

### 2.3.15 removable element

### 2.3.16 secondary and control wiring

### 2.3.17 secondary disconnecting contact

### 2.3.18 shutter

### 2.3.19 silver surfaced

### 2.3.20 stationary mounted device

### 2.3.21 symmetrical

### 2.3.22 terminal

### 2.3.23 terminal block

### 2.3.24 test position

## 3. Service conditions

Standards for the design and performance of ME switchgear are based on usual service conditions as described below. The selection of equipment for a particular application can be based on the construction and ratings as defined in this standard provided that the following usual service conditions exist:

a) The temperature of the cooling air (ambient air temperature) surrounding the enclosure of the ME switchgear is within the limits of -30 °C and +40 °C.
b) The altitude of the installation does not exceed 3300 ft (1000 m).
c) The effect of solar radiation is not significant. (The principles stated in IEEE Std C37.24-1986 may be used for guidance.)
d) Unusual service conditions, such as outlined in 7.1, do not prevail.

# 4. Ratings

## 4.1 General

The ratings of a switchgear assembly are designations of operating limits under specified conditions of ambient temperature, temperature rise, etc. Where the switchgear assembly comprises a combination of primary and secondary circuits, each may be given ratings.

ME switchgear shall have the following ratings:

a) Rated maximum voltage
b) Rated frequency
c) Rated insulation levels
d) Rated continuous current
e) Rated short-time current
f) Rated momentary current

The designated ratings in this standard are preferred but are not considered to be restrictive.

In addition to these ratings, a switchgear assembly may have interrupting or switching capabilities, which are determined by the rating of the particular interrupting and switching devices that are integral parts of the switchgear assembly. Refer to specific standards for the ratings of these devices.

## 4.2 Voltage and insulation levels

See table 1.

### 4.2.1 Rated maximum voltage

The rated maximum voltage of ME switchgear is the highest rms voltage for which the equipment is designed, and is the upper limit for operation.

### 4.2.2 Rated insulation levels

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

a) Normal frequency 1 min withstand voltage
b) Impulse withstand voltage

**Table 1— Voltage and insulation levels MC and SC switchgear**

| | Rated maximum voltage (kV rms) | Insulation levels (kV) | | |
|---|---|---|---|---|
| | | Normal frequency withstand (rms) | Impulse withstand | Reference * dc withstand |
| MC switchgear | 4.76 | 19 | 60 | 27 |
| | 8.25 | 36 | 95 | 50 |
| | 15.0 | 36 | 95 | 50 |
| | 27.0 | 60 | 125 | † |
| | 38.0 | 80 | 150 | |
| SC switchgear | 15.5 | 50 | 110 | |
| | 38.0 | 80 | 150 | |
| | 72.5 | 160 | 350 | |
| NOTE — For field test values see 5.5. | | | | |

*The column headed dc withstand is given as a reference only for those using dc tests to verify the integrity of connected cable installations without disconnecting the cables from the switchgear. It represents values believed to be appropriate and approximately equivalent to the corresponding normal frequency withstand test values specified for each voltage rating of switchgear. The presence of this column in no way implies any requirement for a dc withstand test on ac equipment or that a dc withstand test represents an acceptable alternative to the normal-frequency withstand tests specified in this standard, either for design tests, production tests, conformance tests, or field tests. When making dc tests, the voltage should be raised to the test value in discrete steps and held for a period of 1 min.

†Because of the variable voltage distribution encountered when making dc withstand tests, the manufacturer should be contacted for recommendations before applying dc withstand tests to the switchgear. Voltage transformers above 34.5 kV should be disconnected when testing with dc. See clause 8 of IEEE C57.13-1993, and in particular 8.8.2 (the last paragraph) which reads, “Periodic kenotron tests should not be applied to transformers of higher than 34.5 kV voltage rating.”

### 4.2.3 Voltages and insulation levels

The rated maximum voltages, and corresponding insulation levels for ME switchgear, are listed in table 1.

## 4.3 Rated frequency

The rated frequency of a device, or an assembly, is the frequency of the circuit for which it is designed (ratings are based on a frequency of 60 Hz).

## 4.4 Rated current

### 4.4.1 Rated continuous current

The rated continuous current of ME switchgear is the maximum current in rms amperes at rated frequency, which can be carried continuously by the primary circuit components, including buses and connections, without causing temperatures in excess of specified limits for

a) Any primary or secondary circuit component
b) Any insulating medium, or structural or enclosing member

The specified temperature limits applicable to switchgear assemblies are given in 4.5.1 through 4.5.6.

### 4.4.2 Continuous current ratings

The continuous current ratings of the main bus in ME switchgear are listed in table 2.

The continuous current rating of the individual circuit breaker compartment shall be equal to the ratings of the switching and interrupting devices used, except as may be modified by lower continuous current ratings for current transformers, power fuses etc.

**Table 2— MC and SC switchgear continuous current ratings of main bus**

| | Rated continuous current of buses (A) |
|---|---|
| MC switchgear | 1200/2000/3000 |
| SC switchgear | 2000/3000/4000/5000 |

### 4.4.3 Rated momentary current

The rated momentary current of ME switchgear is the maximum rms total current that it 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 during a test period of at least 10 cycles unless limited to a shorter time by the protective device.

### 4.4.4 Momentary current rating

The momentary current rating of the individual circuit breaker compartments of ME switchgear shall be equal to either of the following:

a) The circuit breaker close and latch, or
b) Switch fault close, or
c) Asymmetrical momentary current ratings of the switching devices used (See ANSI C37.06-1987 and IEEE PC37.20.4)

### 4.4.5 Rated short-time current

The rated short-time current of the ME switchgear is the average rms current that it shall carry for a period of 2 s unless limited to a shorter time by the protective device or current transformer ratings.

### 4.4.6 Short-time current rating

The short-time current ratings of the individual circuit-breaker compartments of the ME switchgear shall be equal to the short-time ratings of the switching and protective devices used or the short-time rating of the current transformers for a period not to exceed 2 s (see IEEE Std C57.13-1993, ANSI C37.06-1987, and IEEE PC37.20.4).

## 4.5 Temperature limitations

### 4.5.1 Limiting temperature

The limiting temperature for ME switchgear is the maximum temperature permitted

a) For any component, such as insulation, buses, instrument transformers, and switching and interrupting devices

b) For air in cable termination compartments
c) For any noncurrent-carrying structural parts
d) For air surrounding devices

### 4.5.2 Temperature limits for insulating materials

The total temperature to which insulating materials are subjected shall not exceed the values listed in table 3 for the various classes of insulating materials.

### 4.5.3 Temperature limits for buses and connections

The total temperature of buses and connections shall not exceed the values listed in table 4.

### 4.5.4 Temperature limitations for air surrounding devices within an enclosed assembly

The temperature of the air surrounding all devices within an enclosed assembly, considered in conjunction with their rating and loading as used, shall not cause these devices to operate outside their rated temperature range when the enclosure of the assembly is surrounded by air within an ambient temperature range of –30 °C through +40 °C.

### 4.5.5 Temperature limitations for air surrounding insulated power cables

The temperature of the air surrounding insulated cables within any compartment of an enclosed assembly shall not exceed 65 °C when the assembly is

a) Equipped with devices having maximum current rating for which the assembly is designed
b) Carrying rated continuous current at rated voltage and at rated frequency
c) In an ambient air temperature of 40 °C

NOTE — This temperature limitation is based on the use of 90 °C insulated power cables. Use of lower temperature rated cables requires special consideration.

### 4.5.6 Temperature limitations for external parts subject to contact by personnel

a) External parts handled by the operator in the normal course of his duties shall have no higher total temperature than 50 °C.
b) External surfaces accessible to an operator in the normal course of his duties shall have no higher total temperature than 70°C.
c) External surfaces not accessible to an operator in the normal course of his duties shall have no higher total temperature than 110°C.

**Table 3— Temperature limits for insulating materials as used in switchgear assemblies**

| 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 .

**Table 4— Temperature limits for buses and connections as used in switchgear assemblies**

| Type of bus or connection | Limit of hottest spot temperature rise (°C) | Limit of hottest spot total temperature (°C) |
|---|---|---|
| Buses and connections with unplated copper to copper connecting joints | 30 | 70 |
| Buses and connections silver surfaced, tin surfaced, or equivalent connecting joints | 65 | 105 |
| Connection to insulated cables unplated copper to copper | 30 | 70 |
| Connections to insulated cables silver surfaced, tin surfaced or equivalent | 45 | 85 |

NOTE — All aluminum buses shall have silver surfaced, tin surfaced, or equivalent connecting joints. Welded bus connections are not considered connecting joints.

## 4.6 Current transformer ratings

### 4.6.1 Current transformer mechanical rating

The mechanical ratings of current transformers shall be such that they will successfully withstand the momentary current for which the associated circuit interrupting devices are applied. When the primary circuit is protected by current-limiting fuses, the current transformers shall successfully withstand the maximum let-through current of the fuses. Unless specifically limited to a shorter time by the associated protective equipment, the duration of the short-circuit shall be considered as being 10 cycles.

### 4.6.2 Current transformer thermal ratings

The thermal ratings of current transformers shall be such that they will successfully withstand the short-circuit current for which the associated circuit interrupting devices are applied. When the primary circuit is protected by fuses, the current transformers shall successfully withstand the maximum $I^2t$ of the fuses. Unless specifically limited to a shorter time by the associated protective equipment, the duration of the short circuit shall be considered as 1 s.

### 4.6.3 Current transformer ambient temperature

Current transformers for use in switchgear assemblies shall be rated on the basis of at least 55 °C ambient temperature in accordance with 4.1.1.2 in IEEE Std C57.13 –1993.

## 4.7 Current transformer accuracies

Accuracies tabulated hereafter are the minimum that shall be supplied. The manufacturer should be consulted if higher accuracies are required by the purchaser. It should be recognized that current transformers with higher accuracies may not meet the requirements of 4.6.1 and 4.6.2.

### 4.7.1 Current transformer accuracies for MC switchgear

For installation in MC switchgear, the standard current transformer accuracies for metering and relaying are listed in table 5. When multiratio current transformers are supplied, the metering and relaying accuracies listed in table 5 apply only to the full winding in accordance with 6.3.2 in IEEE Std C57.13 –1993.

**Table 5— Standard accuracy class ratings* Current transformers in MC switchgear**

| Ratio | B0.1 | B0.2 | B0.5 | B1.0 | B2.0 | Relaying accuracy |
|---|---|---|---|---|---|---|
| 50:5† | 1.2 | 2.4‡ | — | — | — | C or T 10 |
| 75:5 | 1.2 | 2.4 | — | — | — | C or T 10 |
| 100:5 | 1.2 | 2.4 | — | — | — | C or T 10 |
| 150:5 | 0.6 | 1.2 | 2.4 | — | — | C or T 20 |
| 200:5 | 0.6 | 1.2 | 2.4 | — | — | C or T 20 |
| 300:5 | 0.6 | 1.2 | 2.4 | 2.4 | — | C or T 20 |
| 400:5 | 0.3 | 0.6 | 1.2 | 1.2 | 2.4 | C or T 50 |
| 600:5 | 0.3 | 0.3 | 0.3 | 1.2 | 2.4 | C or T 50 |
| 800:5 | 0.3 | 0.3 | 0.3 | 0.6 | 1.2 | C or T 50 |
| 1200:5 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | C 100 |
| 1500:5 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | C 100 |
| 2000:5 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | C 100 |
| 3000:5 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | C 100 |
| 4000:5 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | C 100 |

*See IEEE Std C57.13 –1993.
†These ratios and transformer accuracies do not apply for metal-clad switchgear assemblies having rated momentary current above 60 000 A rms. Where such assemblies have a rated momentary current above 60 000 A rms, the minimum current transformer ratio shall be 100:5.
‡This metering accuracy is not in IEEE Std C57.13 –1993.

### 4.7.2 Current transformer accuracies for SC switchgear

For installation in SC switchgear, the standard current transformer accuracies for metering and relaying are listed in table 6.

**Table 6— Standard accuracy class ratings* current transformers in SC switchgear**

| Ratio | B0.1 | B0.5 | B2.0 | Relaying accuracy |
|---|---|---|---|---|
| 300:5† | 0.6 | 1.2 | 2.4‡ | C or T 100 |
| 400:5 | 0.6 | 1.2 | 2.4 | C or T 100 |
| 600:5 | 0.3 | 0.6 | 2.4 | C or T 200 |
| 800:5 | 0.3 | 0.3 | 1.2 | C or T 200 |
| 1200:5 | 0.3 | 0.3 | 0.6 | C 200 |
| 1500:5 | 0.3 | 0.3 | 0.3 | C 400 |
| 2000:5 | 0.3 | 0.3 | 0.3 | C 400 |
| 3000:5 | 0.3 | 0.3 | 0.3 | C 400 |
| 4000:5 | 0.3 | 0.3 | 0.3 | C 400 |
| 5000:5 | 0.3 | 0.3 | 0.3 | C 400 |
| 6000:5 | 0.3 | 0.3 | 0.3 | C 400 |

*See IEEE Std C57.13 –1993.
†These ratios and transformer accuracies do not apply for station-type cubicle switchgear assemblies having rated momentary current above 115 kA. Where such assemblies have a rated momentary current above 115 kA, the minimum current transformer ratio shall be 800:5
‡Not in IEEE Std C57.13 –1993.

# 5. Tests

## 5.1 General

This subclause establishes physical and electrical conditions for tests and methods of determining temperatures and test values. All apparatus and devices in the power circuit shall be mounted in their normal locations during tests. No statement in this subclause is to be construed as modifying the test requirements for devices included in switchgear assemblies.

Tests are classified as design tests, production tests, conformance tests, and field tests. These are defined in clause 2.

NOTE — Except for the main switching or interrupting device, other devices, such as voltage transformers that are mounted in the switchgear assemblies, may be disconnected during the dielectric test. Such devices are individually tested in accordance with standards applying to them.

## 5.2 Design tests

Design tests as applicable shall be made in accordance with 5.2.1 through 5.2.9.

### 5.2.1 Dielectric tests

Normal-frequency withstand tests (see 5.2.1.1) and impulse withstand tests (see 5.2.1.2) shall be performed on switchgear assemblies to demonstrate the ability of the insulation system to withstand rated voltages in accordance with table 1. In addition, dielectric tests shall be made on the bus-bar insulation as specified in 5.2.1.3.

The tests on the insulation system shall be made under the temperature and humidity conditions normally obtained under conditions at the test site with appropriate correction factors for relative air density and humidity applied as outlined in IEEE Std 4-1978. Humidity correction factors shall be based on curves for rod gaps as stated in figure 1.3 of IEEE Std 4-1978. The equipment shall be clean and in good condition.

Test voltages shall be applied between the primary circuits and ground in the following manner:

a) For equipment with stationary mounted devices and for equipment with drawout devices with the removable elements in the connected position.
   1) With the switching device contacts closed; between each phase of the switchgear assembly individually with the frame and all other phases grounded
   2) With the switching device contacts open; between each terminal (incoming and outgoing) of the switchgear assembly with the frame and other terminals grounded
b) For equipment with drawout devices with the removable elements in the test position and the main switching devices in the closed position, apply the test voltage to primary circuits
   1) Simultaneously to all the incoming terminals of the switchgear assembly with the frame and outgoing terminals grounded. Repeat tests by applying test voltage to the outgoing terminals with the frame and incoming terminals grounded.
   2) Simultaneously between all incoming and outgoing terminals of the switchgear assembly. The test shall be made with a value of voltage 10% higher than that specified in table 1.

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 frame of the assembly so that the voltage between any live part and the frame will not exceed that specified in table 1. If this is not practical the frame may be insulated from ground.

2 — Successful completion of these tests does not necessarily provide assurance that with the circuit breaker in the test position, it will always flashover to ground instead of across the gap between line and load terminals. Switchgear insulation does not provide surge protection for the open gap. Where surge protection of the gap is required, suitable protective devices must be applied.

Normal-frequency withstand tests, impulse withstand tests, and where applicable, bus-bar insulation tests, and wet tests on entrance bushings shall be made as follows:

#### 5.2.1.1 Normal-frequency withstand tests

Alternating-current voltage shall have a crest value equal to 1.414 times the rms value specified in table 1. The wave shape shall be essentially sinusoidal. The frequency shall be within ±20% of the rated frequency. The test voltage is to be increased gradually from zero to reach the required test value within 30 s to 60 s and shall be held at that value for 1 min.

#### 5.2.1.2 Impulse withstand tests

The standard impulse is a full wave impulse having a virtual front time of 1.2 µs and a virtual time to half the value as specified in table 1 of 50 µs. It is described as a 1.2 · 50 µs impulse test wave. In these tests, three positive and three negative impulse voltages shall be applied to each point without causing damage or flashover. If flashover occurs on only one test during any group of three consecutive tests, nine more 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.

NOTE — 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 impulses of the reverse polarity at lower voltage before the tests, is recommended.

#### 5.2.1.3 Test for bus-bar insulation

The insulated bus-bar sample shall have a normal-frequency voltage applied from the conductor to an electrode effectively covering the outer surface of the insulation. The ac test voltage shall have a value not less than the appropriate rated maximum voltage as shown in table 1. The ac test voltage shall have a crest value equal to 1.414 times the rms value and the wave shape shall be essentially sinusoidal. The test voltage shall be applied for 1 min. The bus-bar sample shall have construction that is typical of bus bars, elbows, and joints.

NOTES:

1 — Suggested external electrodes are conductive paint or metallic foil or equivalent.

2 — This test is required on only one insulated bus-bar test sample for each rated voltage.

#### 5.2.1.4 Wet tests on entrance bushings

To be conducted in accordance with IEEE Std 4-1978.

### 5.2.2 Rated continuous current tests

To determine compliance with continuous current ratings, it is necessary to determine that temperatures of the various components of the switchgear assembly are within the limits set forth in 4.5. Temperature measurements shall be made in accordance with 5.2.2.1 through 5.2.2.7.

#### 5.2.2.1 Test area conditions

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

#### 5.2.2.2 Ambient-air-temperature limits

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

#### 5.2.2.3 Measurement of ambient air temperature

Indoor ambient air temperatures 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 structure
b) One 12 in (305 mm) above the bottom of the structure
c) One midway between the two above positions
d) All temperature-measuring devices shall be placed 12 in (305 mm) from the structure, not in front of ventilators, and in locations unaffected by drafts caused by the structure 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 for 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.

#### 5.2.2.4 Method of measuring temperature

Thermocouples shall be used to measure the temperature at the required locations on the switchgear assembly test arrangement. The thermocouples when 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 circuit breaker 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 on a design test 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.

#### 5.2.2.5 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 not increased by more than 1.0 °C during each of two successive 30 min intervals as indicated by three successive readings. If the temperature rise at the end of the second interval is equal to the established limits and if the temperature rise has increased since the previous reading, the test shall be continued until the temperature rise is constant.

#### 5.2.2.6 Frequency of test current

The frequency of the test current shall not be less than the rated 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.

#### 5.2.2.7 Copper conductors for use in continuous current tests

Bus bars as specified in table 7 shall be utilized for connection to the main bus. Cables or bus bars as specified in table 8 should be utilized for connection to the circuit-breaker outgoing terminals. If test arrangement internal bus sizes or configurations are different from tables 7 and 8, external bus sizes or configurations equal to internal bus bars may be substituted at the option of the manufacturer. The conductors shall have a minimum external length of 4 ft (1.2 m) and shall be insulated for proper voltage rating in accordance with the manufacturer’s practice.

**Table 7— Copper conductors for use in continuous current tests (main bus)**

| Main bus rating | Bus per terminal * | |
|---|---|---|
| | Quantity | Size, inches (mm) |
| 1200 | 1 | 1/4 × 4 (6.35 × 101.6) |
| 2000 | 2 | 3/8 × 4 (9.52 × 101.6) |
| 3000 | 3 | 3/8 × 5 (9.52 × 127.0) |

*Where multiple bus bars are used, they are to be spaced $^{3}/_{8}$ in (9.52 mm) apart. Vertical or horizontal configuration shall be at the option of the manufacturer.

**Table 8— Copper conductors for use in continuous current tests (outgoing terminals)**

| Circuit breaker rating | Size of copper conductor | | |
|---|---|---|---|
| | Circularmil size of copper conductors * | Bus per terminal † | |
| | | Quantity | Size, in (mm) |
| 1200 | 4–500 kc mil | | |
| 2000 | | 2 | 3/8 × 4 (9.52 × 101.6) |
| 3000 | | 3 | 3/8 × 5 (9.52 × 127.0) |

*Tests based on cross-sectional area, not cable insulation classification.
†Where multiple bus bars are used, they are to be spaced 3/8 in (9.52 mm) apart. Vertical or horizontal configuration shall be at the option of the manufacturer.

### 5.2.3 Short-time current withstand tests

Short-time current withstand tests shall be made to demonstrate the electrical adequacy of buses and connections in ME switchgear to withstand the rated short-time current for a 2 s period without physical damage.

This test may be a single-phase test at any convenient value of voltage. If the test current meets the requirements of 5.2.4, this test may be combined with the momentary current test.

### 5.2.4 Momentary current withstand tests

Three-phase momentary current withstand tests shall be made to demonstrate the mechanical adequacy of the structure, buses, and connections in ME switchgear to withstand the rated momentary current of the assembly with no breakage of insulation and

a) No permanent deformation of bus bar, or
b) If any deformation of the bus bar(s) has occurred, it should not prevent the dielectric test requirements from being met.

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 a test period of at least 10 cycles. This test may be made at any convenient voltage.

NOTE — The tests conducted in 5.2.3 and in 5.2.4 are to demonstrate the thermal and mechanical capability of the main bus and main bus connections. Connections on the outgoing terminals of protective devices may be limited to a short time and let-through current by the protective devices.

### 5.2.5 Mechanical endurance tests

Mechanical endurance tests shall be performed as follows. All primary power should be disconnected during the following mechanical tests:

a) For MC switchgear at least 100 mechanical endurance test cycles between test and connected positions shall be performed, using each frame size and type of switching and interrupting device, to demonstrate proper sequential operation and to establish satisfactory function of the following elements:
   1) Separable primary contacts
   2) Separable control contacts
   3) Circuit breaker removable element position interlocks (every tenth operation to the withdrawn position)
   4) Stored energy mechanism interlocks, as applicable (every tenth operation to the withdrawn position)
   5) Auxiliary switches mounted on stationary structure (every tenth operation)
   6) Housing mounted position switches

7) Shutters

b) For SC switchgear at least 100 mechanical close-open operation tests shall be performed, using each frame size and type of circuit switching and interrupting device to ensure proper sequential operation and to establish satisfactory function of the following elements:
   1) Isolating switch operation
   2) Switching and interrupting device interlocks as coordinated with isolating switch operation
   3) Stored energy mechanism interlocks, as applicable
   4) Housing mounted position switches

### 5.2.6 Sheet, molded, or cast-insulating materials for support of primary buses and connections

Sheet, molded, or cast-insulating materials used for the support of primary conductors shall be tested for flame resistance and tracking resistance as in the following subclauses.

NOTE — While these insulation flame-resistance and tracking-resistance tests are not design tests applied to assembled switchgear, they are included here because of the wide variety of insulating materials used in switchgear assemblies and because of the relative importance of these properties. The only intent here is that such insulation materials shall meet the requirements of the specified test procedures. When the insulation design utilized includes cut edges in the tracking path, these edges shall not degrade the tracking resistance below that is required by this standard.

#### 5.2.6.1 Flame-resistance tests

Sheet, molded, or cast primary insulating materials used in switchgear assemblies shall have a minimum average ignition time of 60 s and a maximum average burning time of 500 s when tested in accordance with method II in ASTM D229-91.

#### 5.2.6.2 Tracking-resistance tests

a) Switchgear assemblies of rated maximum voltage of 4.76 kV and less. The material shall be tested in accordance with ASTM D2303-90 and under condition A (see 6.4.1.1 in NEMA LI 1-1983) with specimens of 0.25 in (6.35 mm) in thickness shall have a minimum time to track to the 1 in (25.4 mm) mark of 20 min with 2500 V applied.
b) Switchgear assemblies of rated maximum voltage of 8.25 kV and greater.

The material shall be tested in accordance with ASTM D2303-90 and under condition A (see 6.4.1.1 in NEMA LI 1-1983) with specimens of 0.25 in (6.35 mm) in thickness shall have a minimum time to track to the 1.0 in (25.4 mm) mark of 300 min with 2500 V applied.

### 5.2.7 Flame-resistance tests for applied insulation

Applied insulation, such as fluidized bed systems, tape systems, and shrinkable-type tubing shall be tested as in the following subclauses:

#### 5.2.7.1 Test apparatus

The test apparatus shall consist of (see figure 1) the following:

a) Test chamber of sheet metal 12 in (305 mm) wide, 14 in (356 mm) deep, and 24 in (610 mm) high, that is open at the top and that is provided with means for clamping the test specimen at the upper end and supporting it in a vertical position
b) Means for adjusting the position of the test specimen
c) Tirrill burner with an attached pilot light and mounted on a 20 degree angle block. The burner shall have a nominal bore of 0.375 in (9.5 mm) and a length of approximately 4 in (102 mm) above the primary air inlets.
d) An adjustable steel angle (fixture) attached to the bottom of the chamber to ensure the correct location of the burner with relation to the test specimen

e) A supply of ordinary illuminating gas or equivalent at normal supply pressure
f) Timer
g) Flame indicators consisting of strips of gummed kraft paper having a nominal thickness of 0.005 in (0.127 mm) and a width of 0.5 in (12.7 mm)

NOTE — The paper used for the indicators is known to the trade as Grade B stock and is material such as covering tape, paper, and gummed Kraft paper.

### 5.2.7.2 Preparation of sample

Prepare a copper rod approximately 0.75 in (19.1 mm) in diameter, 22 in (550 mm) in length, with the necessary covering to be tested to a thickness of approximately 60 mils to 125 mils (1.5 mm to 3.2 mm).

### 5.2.7.3 Procedure

The test shall be made in a room that is reasonably free from drafts of air, although a ventilated hood may be used if air currents do not affect the flame. One end of the test specimen approximately 22 in (550 mm) in length shall be clamped in position at the upper end of the chamber. A paper indicator shall be applied to the specimen so that the lower edge is 10 in (254 mm) above the point at which the inner blue cone of the test flame is to be applied. The indicator shall be wrapped once around the specimen, with the gummed side toward the conductor.

The ends shall be pasted evenly together and shall project 0.75 in (19.1 mm) from the specimen on the opposite side of the specimen to that to which the flame is to be applied. The paper tab shall be moistened only to the extent necessary to permit proper adhesion. The height of the flame with the burner vertical shall be adjusted to 5 in (127 mm), with an inner blue cone 1.5 in (38.1 mm) high.

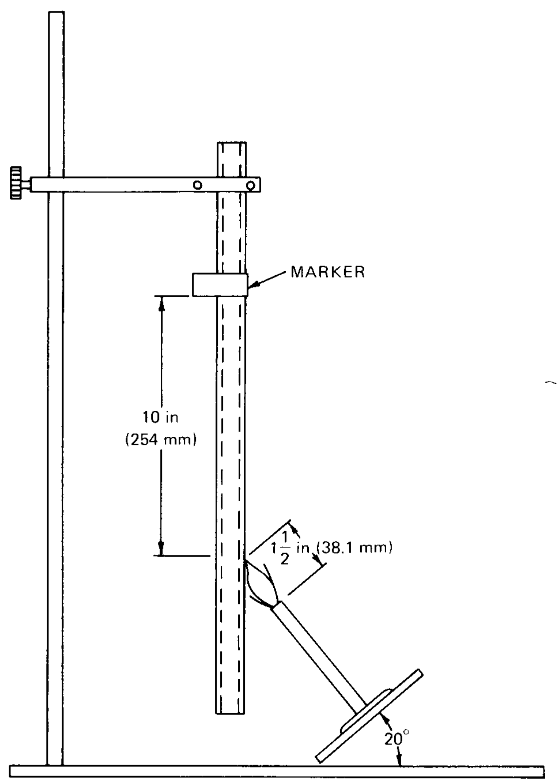



**Figure 1— Test apparatus**

The burner, with only the pilot lighted, shall be placed in front of the sample so that the vertical plane through the stem of the burner includes the axis of the specimen. The angle block shall rest against the fixture, which shall be adjusted so that there is a distance of 1.5 in (38.1 mm) along the axis of the burner stem between the tip of the stem and the surface of the specimen. The valve supplying the gas to the burner proper shall then be opened and the flame automatically applied to the sample. This valve shall be held open for 15 s and then closed for 15 s. This process shall be repeated four times. During each application of the flame, the specimen shall be adjusted if necessary, so that the top of the inner blue cone touches the surface of the specimen.

#### 5.2.7.4 Analysis

If more than 25% of the extended portion of the indicator is burned after the five applications of the flame, the specimen is considered to have conveyed flame. The duration of burning of the specimen after the fifth application of the flame shall be noted, and any specimen that continues to burn for more than 1 min shall be considered to have failed this test.

### 5.2.8 Paint qualification test

The paint qualification test applies to all enclosures incorporating external ferrous parts. Nonferrous enclosures with no external ferrous parts need not be tested.

The paint qualification test shall be performed to ensure the adequacy of finishes to inhibit the buildup of rust on ferrous metal materials used for enclosures.

The methods used are as follows:

#### 5.2.8.1 Test specimens

Representative test panels of a 3 in (76.2 mm) × 6 in (152.4 mm) minimum size that can be accommodated by the test chamber shall be provided. Each specimen shall be uniformly processed in the standard production paint-finishing system. At least four panels shall be selected for the test. All the test specimens shall be of standard gauge ferrous metal equivalent to that used for the enclosure. The specimen shall be allowed to age for a minimum of seven days before being tested.

#### 5.2.8.2 Test apparatus

The test apparatus shall consist of a fog chamber, salt solution reservoir, compressed-air supply, provisions for heating, and means of control. The conditions in the salt spray chamber, including the positioning of the specimens, content of the salt solution, and temperature and pressure to be maintained, shall be as defined in ASTM B117-90.

#### 5.2.8.3 Preparation of test specimens

Two of the test panels shall be suitably scribed for testing in accordance with ASTM D1654-79a.

#### 5.2.8.4 Exposure of test specimens

All test specimens shall be tested in the salt spray chamber for a period of 200 h continuously except for the short, daily interruptions necessary to inspect the test specimen or replenish the solution in the reservoir.

#### 5.2.8.5 Procedure

After completion of the exposure period, the scribed specimens shall be processed in accordance with either method A (tape) or method B (scraper) of ASTM D1654-79a.

#### 5.2.8.6 Evaluation

The scribed specimens shall then be evaluated for creepage from the scribe mark in accordance with rating schedule no. 1 in ASTM D1654-79a. The non-scribed specimen shall be evaluated for degree of blistering in accordance with ASTM D714-87.

#### 5.2.8.7 Performance

The scribed specimens shall be judged to have met the requirements of the test if their rating number is 5 or higher as determined by ASTM D1654-79a. The non-scribed specimens shall be judged to have met the requirements of the test if their blistering size is No. 6 or higher, and their frequency designation is F or M as determined by ASTM D714-87.

### 5.2.9 Rain test for outdoor ME switchgear

The enclosure to be tested shall be fully equipped and complete with all appurtenances such as roof bushings, and placed in the area to be supplied with artificial precipitation. For multiple-unit construction a minimum of two units shall be used to test the joints between units. A roof joint shall be included. The artificial precipitation shall be supplied by a sufficient number of nozzles to produce a uniform spray over the entire surface or surfaces under test. The various vertical surfaces of an enclosure may be tested separately or collectively, provided that a uniform spray is simultaneously applied to both a) and b) as follows:

a) The roof surface, from nozzles located at a suitable height
b) The floor outside the enclosure for a distance of approximately 3 ft (0.91 m) in front of the surface under test with the enclosure located at floor level

The nozzles used for this test shall deliver a square-shaped spray pattern with uniform spray distribution and shall have a capacity of at least 7.1 gal/min (450 $cm^3/s$) at a pressure of 60 $lbf/in^2$ (41.4 $N/cm^2$), and a spray angle of approximately 75 degrees. The centerline of the nozzles shall be inclined downward so that the top of the spray is horizontal as it is directed toward the vertical and roof surfaces being tested.

The pressure at the nozzles shall be a minimum of 60 $lbf/in^2$ (41.4 $N/cm^2$) under flow conditions. This is approximately equivalent to, rain driven by a 65 mi/h (29 m/s) wind. The quantity of water applied to each surface under test shall be at least 0.2 in (5.06 mm) per unit surface per minute, and each surface so tested shall receive this rate of artificial precipitation for a duration of 5 min. The spray nozzle shall not be more than 10 ft (3.05 m) from the nearest vertical surface under test.

After the test is completed, an inspection shall be made promptly to determine if the enclosure meets the requirements of outdoor construction. More specifically, the equipment shall have satisfactorily met the requirements of this test if the visible inspection indicates

a) No water on primary or secondary insulation
b) No water on any electrical components or mechanisms of the assembly
c) No significant accumulation of water retained by the structure or other noninsulating parts (to minimize corrosion)

## 5.3 Production tests

Production tests for ME switchgear shall be normal-frequency dielectric tests, mechanical tests, grounding of instrument transformer case tests, and electrical operation and control wiring test. For these tests, the removable elements need not be tested in the assembly if they are tested separately.

### 5.3.1 Dielectric tests

Normal-frequency withstand tests shall be made on ME switchgear in accordance with the general requirements of 5.2.1, with the exception that tests across the open gap are not required. Tests shall be made between each phase and ground with the other phases grounded.

### 5.3.2 Mechanical operation tests

Mechanical tests shall be performed to ensure the proper functioning of shutters, mechanical interlocks, etc. These tests shall ensure the interchangeability of removable elements designed to be interchangeable.

### 5.3.3 Grounding of instrument transformer case tests

The effectiveness of instrument transformer case or frame grounding shall be checked by a low potential source, such as 10 V or less, using bells, buzzers, or lights. This test is required only when instrument transformers are of metal case design.

### 5.3.4 Electrical operation and control wiring tests

#### 5.3.4.1 Control wiring continuity

The correctness of the control wiring of a switchgear assembly shall be verified by either or both of the following:

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

#### 5.3.4.2 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. At the option of the manufacturer, switchgear mounted devices that have been individually tested may be disconnected during the test.

#### 5.3.4.3 Polarity verification

Tests shall be made to ensure that connections between instrument transformers and meters or relays, etc., are correctly connected with proper polarities. Instruments shall be tested to ensure that pointers move in the proper direction. This does not require tests using primary voltage and current.

#### 5.3.4.4 Sequence tests

ME switchgear involving the sequential operation of devices shall be tested to ensure that the devices in the sequence function properly and in the order intended.

This sequence test need not include remote equipment controlled by the switchgear assembly. However, this equipment may be simulated, where necessary.

## 5.4 Conformance tests

Conformance test procedures for metal-clad switchgear are given in IEEE Std C37.55-1989.

### 5.5 Field dielectric tests

When normal-frequency withstand tests are to be made on ME switchgear after installation in the field, the switchgear shall not be tested at greater than 75% of the test values given in table 1.

NOTE — Field tests are recommended when new units are added to an existing installation or after major field modifications.The equipment should be 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 dirt, moisture, or other contaminants without first being restored to good condition.

## 6. Construction

### 6.1 General requirements

#### 6.1.1 Buses and primary connections

Buses and primary connections shall be of copper or aluminum, or both. For bus ratings, see table 2.

##### 6.1.1.1 Phase or polarity arrangements

a) The phase arrangement on three-phase assembled switchgear buses and primary connections shall be 1, 2, 3, from front to back, top to bottom, or left to right, as viewed from the main switching device operating mechanism side. Certain types of equipment may require other phasing arrangements and a neutral conductor. In these cases the phasing shall be suitably indicated.
b) Panel mounted devices shall be mounted in the same arrangement as in a) as viewed from the front of the panel.

##### 6.1.1.2 Phase sequence

The phase sequence on connection diagrams shall be such that, when considering voltages to neutral on a polyphase system with respect to the element of time, the voltage of phase 1 will reach a maximum ahead of the voltage of phase 2, phase 3, etc. This sequence shall be designated as phase sequence in consecutive numerical order starting with 1.

##### 6.1.1.3 Cable terminations

The ME switchgear shall provide space for the devices used for making electrical and mechanical connections to the incoming and outgoing cables. Each cable terminal connection point shall meet the bolt hole requirements of NEMA CC1-1984.

##### 6.1.1.4 Bushings, potheads, or other terminators

Space for mounting these devices shall be provided in the ME switchgear as required.

##### 6.1.1.5 Main bus splices

When bolts, nuts, and washers are provided for connecting through buses to other sections, the length of the bolts shall be such that the dielectric integrity is not impaired.

#### 6.1.2 Grounding

A ground bus shall be included that will electrically connect together the structures in a switchgear assembly in or on which primary equipment or devices are mounted.

At all points of connection between the ground bus and the assembly, any nonconductive coatings, such as paint, shall be removed or penetrated to ensure good electrical contact.

The ground bus for each group of vertical sections shall have facilities for connection to a station ground bus by suitable conductors.

Circuit connections to the ground bus shall be made so that it is not necessary to open circuit the ground bus to remove any connection made to the ground bus.

Ground connections shall be provided for all removable elements to ensure that the frame and mechanism are grounded until the primary circuit is disconnected and the removable element is moved a safe distance. (See IEEE Std C37.100-1992 for test or disconnected position definition.)

When mounted on metal switchgear structures, cases of instruments, instrument transformers, meters, relays, and similar devices shall be considered as being adequately grounded when secured to these structures by metal mounting hardware with adequate provision for penetrating the paint film.

The ground bus shall be capable of carrying the rated short-time current of the ME switchgear for 2 s.

### 6.1.3 Control and secondary circuits and devices

#### 6.1.3.1 General

All voltage circuits used for control, relaying, or metering shall be protected within the ME switchgear as follows:

a) All circuits supplied from external sources (ac or dc) shall have short-circuit protection. This may be provided by a single set of short-circuit protective devices within the control source incoming section.
b) All circuits supplied from internal sources (ac or dc) circuits shall have short-circuit protection within the same section as the supply source. If these circuits are supplied by a control power transformer, this protection may be in the primary circuit only.
   Overcurrent protection of voltage circuits may be provided in addition to the required short-circuit protection.

Other circuits supplying loads such as heaters, receptacles, or lights shall have overload and short-circuit protection.

Overcurrent protection of current transformer secondary circuits shall not be provided.

#### 6.1.3.2 Voltage transformer fusing

The following requirements shall be met:

a) Primary circuits of all voltage transformers shall include current-limiting fuses.
b) Secondary circuits of all voltage transformers shall include fuses or their equivalent.

EXCEPTION—Fuses may be omitted from secondary circuits of voltage transformers if the secondary burden includes voltage regulators, protective relays, or other devices considered sufficiently essential to the operation of the installation to make it preferable to incur hazards associated with the possible destruction of the voltage transformer by a sustained secondary short-circuit rather than to risk interruption of the voltage supply to such devices as the result of a momentary secondary short-circuit.

Primary and secondary protective devices may be omitted from voltage dividing devices such as capacitive and resistive voltage dividers.

#### 6.1.3.3 Control, secondary, and logic level wiring

Flame-resistant, 600 V insulated copper wire, with a cross-sectional area not less than AWG No. 14 stranded (4110 nominal cmil) shall be used on small wiring between component devices or parts of switchgear assemblies. Where wire is connected across a hinge, flexible wire (37 or more strands) shall be used.

For logic level wiring and for wiring from supervisory and annunciator devices to terminal blocks, smaller wire may be used provided it is adequately supported and meets the voltage and current requirements. Wire shall be Class C or D stranded and shall meet the surge requirements of IEEE Std C37.90.1-1989 and IEEE Std C37.90.2-1987. Smaller wire, when used, shall not run in the same wire packs with other control and secondary wiring.

Bushings, grommets, or other mechanical protection shall be provided for the wiring where logic level, control or secondary wiring is run through a metal sheet, barrier or raceway.

The internal wiring of component devices or parts shall be in accordance with the applicable industry standards.

The insulated wire shall be Type TBS or SIS as listed in ANSI/NFPA 70-1993 or an equivalent and shall meet the requirements of the following standards publication as applicable:

a) Type TBS NEMA WC5-1973 (ICEA S-61-402)
b) Type SIS NEMA WC7-1982 (ICEAS-66-524)

#### 6.1.3.4 Secondary-wiring terminals

Stranded control wire shall have solderless terminals of the type wherein the body of the terminal is crimped or indented onto the conductor or where the wire is formed into an eye and confined within a crimp and flat-washer assembly. Solderless terminals are not required for connection to devices that have integral pressure terminal connections. The wire may be soldered into terminals or, where desirable, directly to devices, such as secondary disconnecting contacts, or to soldered terminals on supervisory control and annunciator equipment.

NOTE — In the absence within this standard of definitive performance requirements, compliance with this subclause can be assessed by referencing ANSI/UL 486A-1991.

#### 6.1.3.5 Terminal blocks

Terminal blocks incorporating screw or stud-and-nut-type terminals shall accommodate wire lugs or similar devices affixed to stranded wire. Screw or stud-and-nut-type terminals intended for use with stranded wire shall be such that all strands of the conductor are confined. Terminal blocks incorporating pressure connectors shall not damage the wire and, when terminating stranded conductors, all strands shall be clamped within the connector.

Terminal blocks for external connections shall be suitable to accept AWG No. 10 (10380 nominal cmil) stranded wire. The use of solid wire is not recommended.

NOTES:

1 — Where long connections to the control battery are necessary the cable should be large enough to prevent excessive voltage drop.

2 — In the absence within this standard of definitive performance requirements, compliance with this subclause can be assessed by referencing ANSI/UL 486A-1991.

#### 6.1.3.6 Designation of auxiliary switches and contacts

The operation of auxiliary switches and contacts for circuit interrupting and switching devices shall be designated as follows:

*a* open when the device is in the de-energized or nonoperated position
*b* closed when the device is in the de-energized or nonoperated position
*aa* open when the operating mechanism of the main device is in the de-energized or nonoperated position
*bb* closed when the operating mechanism of the main device is in the de-energized or nonoperated position
*e, f, h, k* special contacts and auxiliary switches other than *a, b, aa,* or *bb*

Auxiliary switches mounted on the stationary housing used to indicate the connected position of the removable element shall have a suffix TOC (circuit breaker *truck*-operated cell switch). The position of the removable element in which the contacts are closed or open shall be designated. The following are examples:

$\frac{52TOC}{a}$ open when the circuit breaker is not in the connected position

$\frac{52TOC}{b}$ closed when the circuit breaker is not in the connected position

Auxiliary switches mounted on the stationary housing operated by the circuit breaker to indicate circuit-breaker open-closed position shall have a suffix MOC (circuit-breaker *mechanism*-operated cell switch). The open-closed position of the circuit breaker shall be designated for the contacts. The following are examples:

$\frac{52MOC}{a}$ open when circuit breaker is open

$\frac{52MOC}{b}$ closed when circuit breaker is open

If several auxiliary switches and contacts are present on the same device, they shall be designated numerically consecutive starting at 1, when necessary.

On diagrams of all types, contacts and switches shall be shown in the de-energized position of the device.

#### 6.1.3.7 Device function numbers

Device function numbers shall be in accordance with IEEE Std C37.2-1991.

#### 6.1.3.8 Voltage limits of instrument and control circuits

Voltage and current transformers shall be used for the instruments, meters, and relays connected to alternating-current circuits over 240 V so as to reduce the voltage on instrument wiring, which must necessarily be closely grouped.

DC instruments, meters, and relays may be used directly on circuits up to 250 V if their cases are grounded to the switchgear structures in accordance with 6.1.2.

#### 6.1.3.9 Polarity of dc connections to device coils

Where coils on devices used in ME switchgear are connected to a direct-current supply and when de-energized, are not disconnected from both the positive and negative supply leads, such coils shall be so connected that, when de-energized, they will be left connected to the negative supply lead to minimize the possibility of corrosion.

#### 6.1.3.10 Isolation

Instruments, meters, relays, secondary control devices and their wiring shall be isolated by grounded metal barriers from the primary circuit elements with the exception of short lengths of wire such as at instrument transformer terminals and secondary devices.

### 6.1.4 Miscellaneous

#### 6.1.4.1 Nameplate marking

The following minimum information shall be given on switchgear assemblies nameplates:

a) Manufacturer's name and address
b) Manufacturer's type designation (optional)
c) Manufacturer's identification reference
d) Rated maximum voltage (where applicable)
e) Rated frequency (where applicable)

#### 6.1.4.2 Wiring devices

Lighting fixtures provided in outdoor switchgear shall be of a type and shall be so located that lamps may be safely replaced without de-energizing the primary equipment. Convenience outlets shall be of the two-pole, three-wire grounding type and protected by a ground-fault interrupter.

#### 6.1.4.3 Inspection windows

Windows provided for the inspection of disconnecting switches or other devices shall be of a material suitable for this application.

#### 6.1.4.4 Covers

For ease in handling, cover plates that are intended to provide access for inspection and maintenance shall not exceed 12 $ft^2$ (1.12 $m^2$ in area or 60 lb (27 kg) unless they are equipped with lifting means or hinges.

#### 6.1.4.5 Ventilation openings and vent outlets

Openings for pressure relief or ventilation shall be so arranged that the gas or vapor escaping during normal operation will not endanger personnel operating the switchgear.

#### 6.1.4.6 Service disconnecting means

Switchgear assemblies designated as the service disconnecting means shall be designed so that they can be installed in accordance with the applicable provisions of Section 230 of ANSI/NFPA 70-1993.

### 6.1.5 Materials, finishes, and color

#### 6.1.5.1 Materials

The materials for ME switchgear shall be sheet metal suitably supported. Barriers between adjacent vertical sections and between major parts of each primary circuit, shall not be less than MSG No. 11 (nominal thickness of 0.1196 in [3 mm]). All other covers, barriers, panels, and doors shall be not less than MSG No.14 (nominal thickness of 0.0747 in [1.9 mm]).

The minimum thickness is based on the use of steel. Where other metals are used, the thickness shall be modified to provide equivalent strength and deflection. For example, if aluminum alloy sheet, having a yield strength of 20 000 $lbf/in^2$, is used in the place of sheet steel to provide equivalent strength and deflection, it is required that the thickness specified above be increased by 50%.

Doors or panels used to support devices shall be increased in thickness or otherwise strengthened, as necessary, to support the devices.

#### 6.1.5.2 Finishes and color

All steel surfaces to be painted shall receive a phosphatizing treatment or equivalent prior to application of paint.

External and internal surfaces shall be coated with at least one coat of corrosion-resistant paint. The finish paint system shall comply with the requirement of 5.2.8.

The under-surfaces of outdoor assemblies shall additionally receive either a corrosion-resistant undercoating or an additional thickness of corrosion-resistant paint.

The preferred color for the finish on switchgear assemblies shall be light gray No. 61 in accordance with ASTM D1535-89 (MUNSELL NOTATION 8.3 G6.10/0.54).

NOTES:

1 — Internal detail parts may have metallic plating or equivalent in lieu of paint finish.

2 — For conformance testing a recognized organic coating system that has been investigated and found suitable for use as protection against atmospheric corrosion of electrical equipment steel enclosures for outdoor use may be utilized.

3 — Two sheets of suitable thickness may be used to obtain the equivalent thickness.

### 6.1.6 Precautionary labels

Each ME switchgear should be provided with appropriate precautionary labels to call the user’s attention to potential hazards that are inherent to the equipment and which cannot be eliminated by design. See ANSI Z535.4-1991 and NEMA 260-1991 for recommendations.

## 6.2 MC switchgear

### 6.2.1 Barriers

MC switchgear shall be provided with metal barriers between primary sections of adjacent vertical sections and between major primary sections of each circuit. Primary sections comprise the bus compartment; the primary entrance compartment; the removable element compartment; the voltage transformer(s) compartment; and the control transformer(s) compartment. To minimize the possibility of communicating faults between primary sections, the barriers between primary sections shall have no intentional openings.

NOTES:

1 — Barriers are provided to segregate the voltage transformers for each polyphase circuit but not to segregate them individually.

2 — Where buses penetrate barriers, suitable bushings or other insulation shall be provided.

### 6.2.2 Shutters

On MC switchgear, automatic shutters shall be provided to prevent incidental contact with the live parts of the primary circuit when the removable element is in the test position, disconnected position, or has been removed.

### 6.2.3 Insulating materials for covering buses and connections

The insulation system for the primary or power-carrying conductors and connections shall be rated in accordance with table 1 and shall withstand the tests in 5.2.1. Each conductor shall have an insulating covering that by itself will withstand the maximum rated line-to-line voltage between the conductor and outside surface of the insulating covering for a period of 1 min.

This insulating covering is a requirement of metal-clad switchgear (see 2.1.2.1) and is provided to minimize the possibility of communicating faults and to prevent development of bus faults that would result if foreign objects momentarily contacted bare bus. This insulating covering is usually only a part of the primary insulation system and in such cases the outer surface of this insulating covering will not be at ground potential. It should not be assumed, therefore, that personnel can contact this insulating covering with complete safety.

Where possible, bus joints shall be completely covered by insulating materials at the factory. For interconnecting bus joints that must be made in the field, insulating material shall be supplied for application in accordance with the switchgear manufacturer's instructions. Insulating material for line and load terminations may not be furnished as standard.

Insulating materials shall be flame resistance in accordance with 5.2.7.

### 6.2.4 Interlocks

Mechanical interlocks shall be provided on metal-clad switchgear as follows:

a) To prevent moving the removable element to or from the connected position when the switching device is in the closed position
b) To prevent closing the switching device unless the primary disconnecting devices are in full contact or are separated by a safe distance. See test position in IEEE Std C37.100-1992 .
c) Means shall be provided for positively holding the removable element in place in the housing when it is in either the connected or test position. When a separate disconnected position is provided with the door closed, the removable element shall be positively held in this position.
d) To prevent the disconnection of and access to fuses on the primary side of control power transformers unless the secondary circuit is open
e) Circuit breakers equipped with stored energy mechanisms shall be designed to prevent the release of the stored energy unless the mechanism has been fully charged. Operators and service personnel shall be protected from the effects of accidental discharge of the stored energy by any of the following means:
    1) Interlocks provided in the housing to prevent the complete withdrawal of the circuit breaker from the housing when stored energy mechanism is charged
    2) A suitable device provided to prevent the complete withdrawal of the circuit breaker until the closing function is blocked
    3) A mechanism provided to automatically discharge the stored energy before or during the process of withdrawing the circuit breaker from the housing
f) Locking means shall be provided to prevent moving circuit breakers into the connected position.

### 6.2.5 Interchangeability of removable switching and interrupting devices

All removable elements of the same type and rating on a given assembly shall be physically and electrically interchangeable. Removable elements not of the same type and rating shall not be interchangeable.

### 6.2.6 Primary fuses and transformers

The primary fuses of transformers shall be mounted in such a way that they must be disconnected from the primary circuit before access can be obtained. Provisions shall be made for disconnecting or automatically grounding the secondary circuit of the voltage transformer when the primary circuit is disconnected. Provisions shall be made for momentarily grounding the primary winding and/or fuses during the disconnecting operation.

### 6.2.7 Secondary disconnect devices

Control wiring connections between stationary structure and the removable element shall be provided with automatic (self coupling) contacts or manual plug and receptacle for disconnection.

The manual control connector shall be either interlocked or inaccessible to prevent connection or disconnection of the control circuits when the removable element is in the connected position and the removable element shall be prevented from being installed in the connected position unless the manual control connector is connected.

With the manual arrangement, all connections shall be group-connectable simultaneously with the male contacts on the removable element and the female receptacles on the stationary structure.

NOTE — The intent of this requirement is to ensure that the circuit breaker control connections are always made and maintained when the circuit breaker is in the connected position.

One set of test jumpers or their equivalent shall be provided for each installation to complete all secondary connections for test in the withdrawn position.

### 6.2.8 Control wiring

Power circuit breaker control wiring shall be in accordance with figures 1, 2, 3, or 4 of ANSI C36.11-1979.

### 6.2.9 Handling device

If required, one of each size handling device needed to remove the removable elements from metal-clad switchgear shall be provided for each installation.

### 6.2.10 Test cabinet

When a test cabinet is furnished, it shall provide connection to the secondary contacts on an electrically operated removable element, permitting operation and testing of the removable element when removed from the housing.

### 6.2.11 Indoor MC switchgear, access, and ventilation

MC switchgear for indoor applications shall be enclosed in general-purpose, ventilated enclosures equipped with front-hinged panels with hand-operated fasteners and bolted rear covers. Ducts or grilles for venting exhaust gases shall be so constructed as to prevent foreign materials from entering the circuit breaker.

### 6.2.12 Outdoor MC switchgear, access, and ventilation

Enclosures (ventilated) for outdoor applications of MC switchgear shall be of either of the following types:

a) Outdoor enclosure without the operating and maintenance aisle that provides an enclosure for the switchgear and auxiliaries only. Doors shall be equipped with latches; stops shall be provided to hold the doors in the open position; and provision shall be made for padlocks. Heaters or other effective means shall be provided to minimize condensation.
b) Outdoor enclosure with the operating and maintenance aisle that provides an enclosure for the switchgear and auxiliaries and, in addition, provides an enclosed aisle for operating and maintenance. The aisle shall be of sufficient size to permit interchanging removable elements. The operating or maintenance aisle shall have access doors equipped with safety latches to permit opening from within under all conditions. Stops shall be provided to hold these doors in the open position, and provision shall be made for padlocks. Heaters shall be provided to minimize condensation in compartments containing primary circuit apparatuses and devices.

#### 6.2.13 Position indication

Indicating lights shall be provided to indicate the open and closed position of the circuit breaker. Unless otherwise specified, the closed position shall be indicated by a red light and the open position by a green light.

#### 6.2.14 Enclosure categories

See annex A for the description of enclosure categories and related requirements.

##### 6.2.14.1 Ground and test devices

When provided, these accessory devices can be inserted in place of a drawout circuit breaker for the purposes of either or both of the following:

a) Grounding the main bus and/or external circuits connected to the switchgear assembly
b) Primary circuit testing

These devices may be either electrically operated grounding devices or manual devices.

Due to the varied and complex procedures required by specific operating practices, the user should consult the manufacturer regarding the intended use of the device.

### 6.3 SC switchgear

#### 6.3.1 Barriers

Metal barriers shall be provided to segregate the circuit switching or interrupting device compartment, incoming and outgoing circuit and bus compartments, and the individual phases in each of these compartments. To minimize the possibility of communicating faults between primary sections, the barriers between the sections shall have no intentional openings.

#### 6.3.2 Buses and connections

The buses and connections shall have bare conductors mounted on porcelain, glass, or organic (class 105 or higher) insulation, suitable for the voltage rating (see table 3).

#### 6.3.3 Interlocks

Interlocks shall be provided between the circuit switching or interrupting device and isolating switches to prevent operating the switches if the circuit switching or interrupting device is closed.

Interlocks shall be provided between the isolating switches and the circuit switching or interrupting device to prevent opening the primary circuit compartment of the circuit switching or interrupting device unless the switches are in the open position.

#### 6.3.4 Control wiring

Power circuit switching or interrupting control wiring shall be in accordance with the requirements of figures 5, 6, or 7 of ANSI C36.11-1979.

### 6.3.5 Indoor station-type cubicles, access, and ventilation

Station-type cubicles for indoor applications shall be enclosed in general-purpose enclosures (ventilated) with front-hinged panels and bolted rear covers.

Adequate ducts or grilles shall be provided on units with air-blast circuit switching or interrupting devices to remove exhaust gases. Ducts or grilles for venting exhaust gases shall be so constructed as to inhibit foreign material from entering the circuit switching or interrupting device.

### 6.3.6 Outdoor station-type cubicles, access, and ventilation

Station-type cubicles for outdoor applications shall be enclosed in enclosures (ventilated) and shall be equipped with suitable access doors.

Doors shall be equipped with latches, stops shall be provided to hold doors in the open position, and provision shall be made for padlocks. Heaters shall be supplied to minimize condensation.

Adequate ducts or grilles shall be provided on units with air-blast circuit switching or interrupting devices to remove exhaust gases. Ducts or grilles for venting exhaust gases shall be so constructed as to prevent foreign materials from entering the circuit switching or interrupting devices.

### 6.3.7 Secondary and control devices

Relays, control switches, and similar items, other than circuit switching or interrupting device control relays, are not mounted integral with this type of switchgear.

# 7. Application guide for ME switchgear

## 7.1 Unusual service conditions

It is strongly recommended that the usual service conditions, as described in clause 3, be provided for ME switchgear applications, if practical (artificially, if necessary). However, if unusual conditions exist and cannot be eliminated, the considerations discussed in the following subclauses, apply:

NOTE — Any unusual service condition should be specified by the user.

### 7.1.1 Ambient air temperature above 40 °C

When ME switchgear is applied where the ambient air temperature is higher than 40 °C, its performance may be affected, and special consideration should be given to these applications. The total temperature limits for parts and materials as listed in 4.5 should not be exceeded. Therefore, for the higher ambients, the equipment should be derated to a continuous current value that maintains the total temperature limits. In general, the derating may be calculated in accordance with 7.4.1.

### 7.1.2 Ambient air temperature below –30 °C

Special consideration is also required when ME switchgear is applied where the ambient air temperature is less than –30 °C for significant periods of time. Space heating and thermal insulation to minimize the effects of exposure should be considered. If this is not possible, the effect of low temperatures on the functional performance of such materials as oils, plastic insulation on primary and secondary circuits, control wire insulation, and lubricants should be considered.

### 7.1.3 Application at unusual altitudes

Switchgear assemblies that depend on air for an insulating and cooling medium will have a higher temperature rise and a lower dielectric withstand capability when operated at altitudes above values specified in b) of clause 3. For applications at higher altitudes, the rated 1 min normal-frequency withstand voltage, the impulse withstand voltage, and continuous current rating of the assemblies should be multiplied by the correction factors in table 9 to obtain the modified ratings. For applications above 3300 ft (1000 m), use of surge arresters on each circuit selected to keep transient voltages below the reduced levels should be considered.

**Table 9— Altitude correction factors**

| Altitude (ft) | Voltage | Current |
|---|---|---|
| 3300 (1000 m) and below | 1.00 | 1.00 |
| 5000 (1500 m) | 0.95 | 0.99 |
| 10,000 (3000 m) | 0.80 | 0.96 |

NOTES:
1 — Intermediate values may be obtained by interpolation.
2 — For devices used in switchgear assemblies, standards covering the specific devices should be used to determine the specific altitude correction factors.

### 7.1.4 Modification of equipment for unusual environment

Successful performance of standard ME switchgear may be extended to unusual environments by special considerations when developing equipment specifications. Several construction modifications that will mitigate the effects of these environments may be made in accordance with 7.1.4.1 through 7.1.4.6, but the emphasis should be on eliminating such conditions, if at all possible. However, if these undesirable conditions cannot be eliminated, more frequent maintenance may be required.

#### 7.1.4.1 Exposure to damaging fumes, vapors, steam, salt air, and oil vapors

Indoor and outdoor equipment should be provided with the following modifications:

a) All structural parts should be covered with a minimum of two coats of paint, one of which should be a corrosion- or rust-resistant primer.
b) All steel parts that are not painted or plated should be covered with protective grease.
c) All current-carrying joints should be covered with a coating of nonoxidizing grease. Greasing of non-arcing contacts should only be done on the recommendations of the manufacturer.
d) All coils should be impregnated with insulating compound and covered with appropriate protective coating.
e) Heaters, in quantity and sufficient rating to minimize condensation in all compartments, should be furnished.

#### 7.1.4.2 Exposure to excessive dust, abrasive dust, magnetic or metallic dust

Indoor or outdoor equipment should be provided with the following modifications. Totally enclosed nonventilated equipment should be furnished with a current rating of 70% of the ventilated rating or as specified by the manufacturer. Condensation could be a problem and should be evaluated.

For outdoor assemblies ventilated enclosures may be furnished with the ventilating openings equipped with dust filters. The requirements for these filters vary over such a range that standard specifications for their application are not practicable. Filters are available in the washable type and the disposable type. Where used, they must be cleaned or replaced at intervals, depending upon the amount of dust in the air. Filters that are not cleaned or changed when required can cause excessive equipment temperature or condensation.

The type of filter used should be selected based on the size of dust particles encountered and the extent to which dust is to be excluded. Where very fine dust particles are to be excluded, disposable filters soaked in oil should be used. These must be changed at frequent intervals.

Forced ventilation may be required depending upon the volume of air required for ventilation and the severity of the environment. When a blower and filter are furnished based on conditions of the environment, they should be installed on the intake to minimize the possibility of drawing dust or other foreign matter into and throughout the switchgear assembly.

#### 7.1.4.3 Exposure to hot and humid climate

Indoor and outdoor equipment intended for exposure to hot and humid climates should be made fungus-resistant by the following modifications:

a) Heaters in quantity and rating sufficient to minimize condensation in all compartments should be furnished.
b) Secondary wiring that is not inherently fungus-resistant should have fungus-resistant coating applied. Secondary wiring that has fungus-resistant insulation should not require further treatment.
c) All impregnated coils should be given an external treatment with fungus-resistant coating. Encapsulated coils that are inherently fungus-resistant should not require further treatment.
d) Paints such as alkyd enamels having a fungus- and rust-resistant property should be used.

Insulation that is not inherently fungus-resistant should have fungus-resistant coating applied. Insulation in switchgear assemblies, that is inherently fungus-resistant, should not require further treatment. Fungus-resistant coatings should not be applied where they will interfere with proper operation of apparatus. In such cases, the part should be inherently fungus-resistant. These coatings should not reduce the flame-resistant properties.

The fungus-resistance of materials should be determined in accordance with ASTM G21-90. Materials to be classified as fungus-resistant should have a rating not greater than 1.

Materials that are made fungus-resistant by means of a coating should have the coating reapplied at periodic intervals.

#### 7.1.4.4 Exposure to explosive mixtures of dust or gases

Application of ME switchgear for explosion-proof requirements is not recommended.

#### 7.1.4.5 Exposure to abnormal vibration, shocks, or tilting

Indoor and outdoor equipment is designed for mounting on level structures free from vibration, shocks, or tilting.

Since these conditions vary so widely, it is recommended that the manufacturer be consulted for each specific application where vibration, shocks, or tilting are to be encountered.

It is important that the full nature of the abnormal motion be specified. The magnitude and frequency range of the dynamic motion is required so that resonances may be investigated. This is usually specified by means of an acceleration response spectrum curve for the mounting surface on which the ME switchgear is to be installed. The response spectrum is a plot of the maximum response of single-degree-of-freedom bodies, at a damping value expressed as a percent of critical damping of different natural frequencies. These bodies are plotted when they are rigidly mounted on the surface of interest (i.e., on the ground for the ground response spectrum or on the floor for the floor response spectrum) when that surface is subjected to a given abnormal motion as modified by any intervening structures. The response spectrum is useful in designing a test or in making an analysis of the performance of the ME switchgear equipment mounted on the same surface and subjected to the same motion.

In the case of tilting, it is also important that the maximum angles of tilt, both transverse and longitudinal, be specified. The exact performance requirements should also be defined. It should be recognized that equipment that is specifically designed for a usual installation on a substantially level surface free from excessive vibration, shock, or tilting may be damaged and may not be able to function properly when subjected to excessive motion and displacement. Hence, the application should be carefully analyzed and the essential performance requirements should be precisely defined.

#### 7.1.4.6 Exposure to seismic shock

Because of the importance of adequate performance of equipment when applied as Class 1E equipment in a nuclear power generating station, IEEE Std C37.81-1989 and IEEE Std 344-1987 were developed for this application.

### 7.2 System characteristics—Voltage and frequency

ME switchgear is designed for use on three-phase, 60 Hz, grounded or ungrounded ac systems. Application on other types of systems, such as the following, should be reviewed with the manufacturer:

a) Three-phase, four-wire with insulated neutral
b) Two-phase
c) Frequency other than 60 Hz or other than sinusoidal waveforms

ME switchgear is intended for application on systems where the maximum operating voltage of the system does not exceed the maximum voltage for which the equipment is designed. The voltages for various types of ME switchgear are listed in table 1.

NOTE — ME switchgear may utilize voltage sensitive components such as voltage transformers and surge arresters with a rated maximum voltage less than the rated maximum voltage of the ME switchgear. The upper limit for operation may be determined by the rating of these components.

### 7.3 Overvoltage considerations—insulation levels

The insulation levels to which ME switchgear is designed are also listed in table 1.

The information on the application of surge arresters and surge capacitors for protection against overvoltages is given in 7.7.2.

### 7.4 Continuous current rating and overload capability

ME switchgear assemblies are designed for normal application where the sustained load current does not exceed the rated continuous current, the altitude above sea level is 3300 ft (1000 m) or less, the ambient air temperature does not exceed 40 °C, and the effects of solar radiation can be neglected. For unusual altitudes, derating factors should be applied in accordance with 7.1.3. If solar radiation is significant, continuous current capability is limited. Refer to IEEE Std C37.24-1986.

The rated continuous current is based on not exceeding the limits of the hottest spot total temperature of the various parts of the switchgear assembly when this value of current is sustained in an ambient air temperature of 40 °C. When the ambient air temperature is greater than 40 °C, the current should be reduced to less than rated continuous current to keep total temperature of these parts within allowable limits. The application of switchgear assemblies should be based on avoiding operation at current higher than the rated continuous current of the assembly. However, since the criterion is total temperature, the following considerations are in order:

a) It is permissible to exceed rated current
   1) For short periods, such as in the starting of motors or synchronous condensers, or when energizing cold loads. Generally, the short duration of this type of current increase does not raise temperatures significantly.

2) When operating at an ambient air temperature below 40 °C (see 7.4.1).
3) For short periods following operation at a current less than that permitted by the existing ambient air temperature (see 7.4.1.1).

b) Since current transformer and outgoing cable current ratings are frequently less than the continuous current rating of the circuit breaker their capabilities to carry more than the rated continuous current must be verified.

### 7.4.1 Load current-carrying capabilities under various conditions of ambient temperature and load

When ambient air temperature is other than 40 °C, on which continuous ratings in table 2 are based, the allowable continuous current can be calculated by the following formula:

$$I_a = I_r\left(\frac{\theta_{max} - \theta_a}{\theta_r}\right)^{\frac{1}{2}}$$

where

$I_a$ is the allowable continuous load current, A, at the actual ambient temperature $\theta_a$ ($I_a$ is not to exceed two times $I_r$)
$I_r$ is the rated continuous current, A, on basis of 40 °C ambient
$\theta_{max}$ is the allowable hottest spot total temperature, °C
$\theta_a$ is the actual ambient temperature expected (between –30 °C and 60 °C), °C
$\theta_r$ is the allowable hottest spot temperature rise at rated current, °C

NOTE — The temperature rise of a current-carrying part is proportional to an exponential value of the current flowing through it. The exponent value of $^1/_2$ in the formula observed has been found to be generally valid for calculating overload capability of ME switchgear and is therefore used in this standard.

The construction features of ME switchgear dictate the appropriate values $\theta_r$ and $\theta_{max}$. The major components have several different temperature limits specified in standards or clauses of this standard as listed in table 10.

To assure that none of the temperature limitations specified in the standards or the clauses of this standard as listed in table 10 are exceeded, the permissible load current based on the actual ambient air temperature is determined by using the values for $\theta_r$ and $\theta_{max}$ selected as follows:

a) If the actual ambient air temperature is less than 40 °C, the component with the *highest* specified limit of total temperature should be selected.
b) If the actual ambient air temperature is greater than 40°C, the component with the *lowest* specified limit of total temperature should be selected. The use of this value in the calculation will result in an allowable continuous current that will not cause the temperature of any part of the assembly to exceed the specified limit.

NOTE — Information on the load current-carrying capability of power circuit breakers for applications other than in ME switchgear is given in 4.4.3 in IEEE Std C37.010-1979. When the power circuit breaker is used in MC switchgear all considerations of 4.4.3.2 in IEEE Std C37.010-1979 apply in this standard, except it should be noted that the exponent 1/2 is used in the formula for determining load current capability rather than 1/1.8.

Table 11 lists the calculated values of $I_a/I_r$, for each specified temperature limit for the various components of ME switchgear over a range of typical ambient air temperatures. The allowable current in any given situation can be estimated from table 11 or may be calculated directly from the stated formula.

**Table 10— Switchgear component-temperature limitations**

| Component | Reference |
|---|---|
| Circuit breakers | IEEE Std C37.04-1979 |
| Current transformers | IEEE Std C57.13-1993 |
| Insulating material in switchgear assemblies | Table 3 |
| Buses and connections | Table 4 |
| Air surrounding insulated power cables | Subclause 4.5.5 |
| Parts subject to contact by personnel | Subclause 4.5.6* |

*When applying switchgear at higher than the standard 40 °C maximum temperature, the limitations of this subclause may be exceeded.

### 7.4.1.1 Short-time load current capability

The considerations of ambient air temperatures in 7.4.1 are based on steady-state conditions. When the switchgear assembly has been operating at current levels below the allowable continuous current $I_a$, it is possible to increase the load current for a short period to a value greater than the allowable $I_a$ without exceeding the permissible temperature limits. The length of time that the short-time load current $I_s$ can be carried depends on the following factors:

a) The magnitude of $I_s$ to be carried
b) The magnitude of initial current $I_i$ carried prior to application of $I_s$
c) The thermal-time characteristics of the switchgear assembly.

The duration of the short-time current may be calculated directly or may be obtained by simply using figure 2. The time duration of the current $I_s$ determined in this manner will not cause the total temperature limits of any component of the switchgear assembly to be exceeded provided that the following requirements are fulfilled:

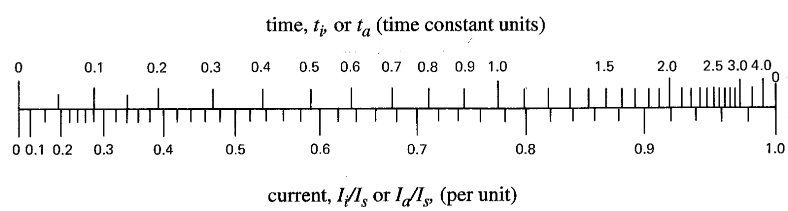
a) All main and feeder bus joints and power terminal connections are checked periodically in accordance with the manufacturer’s instructions. Bolted connections should be torqued to recommended foot-pound values.
b) The value used for the initial current $I_i$ is the maximum current carried by the main bus or circuit breaker, during the 4 hour period immediately preceding the application of short-time load $I_s$.
c) At the end of the time period, the current $I_s$ is reduced to a value that is no greater than the allowable continuous load current $I_a$.
d) The value of the current $I_s$ is limited to a maximum value of two times rated continuous current $I_r$Determination of allowable time for short-time load current.

**Table 11— Ratios of $(I_a/I_r)$ for various ambient temperatures**

| Maximum ambient °C | Limiting temperatures of different switchgear components | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\theta_{max}$ | **50** | **65** | **70** | **85** | **90** | **105** | **110** | **125** |
| | $\theta_r$ | **10** | **25** | **30** | **45** | **50** | **65** | **70** | **85** |
| 60* | — | — | 0.45 | 0.58 | 0.75 | 0.77 | 0.83 | 0.85 | 0.87 |
| 50 | — | — | 0.77 | 0.82 | 0.88 | 0.89 | 0.92 | 0.93 | 0.92 |
| **40** | **—** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** |
| 30† | — | 1.41 | 1.18 | 1.15 | 1.11 | 1.10 | 1.07 | 1.07 | 1.08 |
| 25 | — | 1.58 | 1.26 | 1.22 | 1.15 | 1.14 | 1.11 | 1.10 | 1.08 |
| 20 | — | 1.73 | 1.34 | 1.29 | 1.20 | 1.18 | 1.14 | 1.13 | 1.11 |
| 10 | — | 2.0‡ | 1.48 | 1.41 | 1.29 | 1.26 | 1.21 | 1.20 | 1.16 |
| 0 | — | 2.0 | 1.61 | 1.53 | 1.37 | 1.34 | 1.27 | 1.25 | 1.21 |
| –10 | — | 2.0 | 1.73 | 1.63 | 1.45 | 1.41 | 1.33 | 1.31 | 1.26 |
| 0 | — | 2.0 | 1.61 | 1.53 | 1.37 | 1.34 | 1.27 | 1.25 | 1.21 |
| –10 | — | 2.0 | 1.73 | 1.63 | 1.45 | 1.41 | 1.33 | 1.31 | 1.26 |
| –20 | — | 2.0 | 1.84 | 1.73 | 1.53 | 1.48 | 1.39 | 1.36 | 1.31 |
| –30 | — | 2.0 | 1.95 | 1.83 | 1.60 | 1.55 | 1.44 | 1.41 | 1.35 |

*For limiting current, use lowest $\theta_r$ and $\theta_{max}$
†For limiting current, use highest $\theta_r$ and $\theta_{max}$
‡Designated limit—not calculated

One method of determining the allowable duration of current $I_a$ is shown in figure 2. The values of time obtained from the figure are given in time-constant units. The actual time is determined by multiplying the time-constant units by the proper thermal time constant listed in table 12.




Required initial data
$I_i$ is the initial steady-state current
$I_a$ is the allowable continuous load current based on actual ambient temperature (from 7.4.1)
$I_s$ is the desired short-time load current

Calculation Procedure

a) Determine $I_i/I_s$, per unit initial current.
b) From the figure determine corresponding time, $t_i$.
c) Determine $I_a/I_s$, per unit allowable continuous current.
d) From the figure determine corresponding time $t_a$.
e) Calculate $t_a - t_i$ = time (in time constant units) that main bus, circuit breaker or interrupter switch, or both, can carry $I_s$, starting from initial continuous current of $I_i$, with ambient air temperature permitting continuous operation at $I_a$.

NOTES

This procedure and the design of this figure are based on the following assumptions:

1—At the constant current, the temperature approaches its steady-state value at an exponential rate. During any time interval equal to the thermal time constant of the main bus, circuit breaker, or interrupter switch, or both, the temperature rise will be equal to 63.2% of the remaining increment of possible increase existing at the start of the period. This is represented by the time scale at the top of the chart.

2—The temperature of the main bus, circuit breaker, or interrupter switch, or both, increases as the 2.0 power of the current increases. This is represented by the current scale at the bottom of the figure. Here, the current in per unit value is plotted to a scale representing the temperature produced by that current.

**Figure 2— Current-time relationship to determine short-time load current-carrying capability of metal-clad switchgear assemblies**

#### 7.4.1.2 Determination of allowable time for $I_s$ by direct calculation

The allowable duration of current $I_s$ may be calculated directly. While the chart method is quicker and simpler than hand calculation of these equations, the increasing availability of digital computers makes it desirable to provide the details of these calculations. These equations may be written in a computer language such as FORTRAN so that many sets of conditions may be analyzed quickly. The program also should then be immediately available for use. The following are the equations used to calculate the time duration $t_s$ for a short-time load current $I_s$:

$$t_s = -\tau \ln\left\{1 - \frac{\theta_{max} - Y - \theta_a}{YI_s/I_i^{1.8} - 1}\right\}$$

$$Y = (\theta_{max} - 40°C)(I_i/I_r)^{2.0}$$

where

- $\theta_{max}$ is the allowable hottest spot total temperature from tables 3 and 4, °C.
- $\theta_a$ is the actual ambient expected (between –30 °C and 60 °C), °C.
- $I_i$ is the initial current carried prior to application of $I_s$, A (the maximum current carried by the breaker during the 4 h period immediately preceding the application of current $I_s$).
- $I_s$ is the short-time load current, A.
- $I_r$ is the rated current, A.
- $\tau$ is the thermal time constant of the circuit breaker from table 12, h.
- $t_s$ is the permissible time for carrying current $I_s$, at ambient $\theta_a$ after initial current $I_i$. Time is in same units of hours as $\tau$.

NOTE — These equations are derived in the following manner:

Let

$\theta_s$ = total temperature, °C, that would be reached if current $I_s$ were applied continuously at ambient $\theta_a$

$\theta_i$ = total temperature, °C, due to continuous current $I_i$ at ambient $\theta_a$

$\theta_t$ = total temperature, °C, at some time t after current is raised from $I_i$ to $I_s$

Then,

$$\theta_t = (\theta_s - \theta_i)(1 - \epsilon^{-t_s/\tau}) + \theta_i$$

Let

$\theta_t = \theta_{max}$ and solve for $t_s$

Then

$$t_s = -\tau \ln\left[1 - \frac{(\theta_{max} - \theta_i)}{(\theta_s - \theta_i)}\right]$$

where

$\theta_i = (\theta_{max} - 40\ °C)(I_i/I_r)^2 + \theta_a$

$\theta_s = (\theta_{max} - 40\ °C)(I_s/I_r)^2 + \theta_a$

For the special case where the initial current is zero, the equations in this form are useful. By substitution the equations given above in terms of $Y$ are obtained; these are convenient to use in the more usual case where the initial current is not zero.

### 7.4.2 Load current-carrying capability of metal-clad switchgear

For metal clad switchgear, which may include one or more compartments in a single vertical section, the following guidelines are recommended for estimating the allowable cumulative loading.

**Table 12— Typical thermal time constants for MC switchgear**

| Circuit breakers and bus rating | Heating |
|---|---|
| 1200 A | 0.5 h |
| 2000 A | 0.5 h |
| 3000 A | 0.5 h |

#### 7.4.2.1 Determination of main bus load current-carrying capability

The ampacity for the main bus is usually a function of the main circuit breaker frame size or the current output of the supply transformer. The ampacity of the main bus is based on the temperature limitations as described in 4.5.

#### 7.4.2.2 Determination of vertical section load current-carrying capability

The load current-carrying capability of a vertical section consisting of one or two circuit breakers should be determined by the lesser of the following two considerations:

a) The main bus continuous current rating
b) The allowable cumulative circuit breaker loadings

#### 7.4.2.3 The cumulative circuit breaker loading

The actual cumulative load should be checked against table 13. These configurations provide optimum thermal distribution in a vertical section. If other configurations are required, it is recommended that the manufacturer be consulted.

The cumulative circuit breaker loading is the total current that all circuit breakers within a vertical section can carry simultaneously and with the main bus carrying a current equal to its continuous current rating without exceeding the temperature limits in 4.5. Allowable cumulative circuit breaker loading is given in table 13.

### 7.4.3 Special continuous current ratings

If an unusual situation requires consideration of a rating not included in the preferred rating structure, nor possible utilizing ambient compensation, consideration should be given to

a) Design modifications for increased current capacity of the primary circuit by means of larger conductor sizes or the use of higher conductivity materials.
b) Forced-air cooling utilizing automatic controls so that the forced cooling for increased rating is operational only when actually required. The air supply for forced cooling should be clean and dry.

### 7.4.4 Conductor temperature

Cables connected to ME switchgear should be capable of withstanding the 65 °C ambient temperature to which they may be subjected.

**Table 13— Allowable cumulative loads**

| Circuit breaker continuous current rating (amperes) | Number of circuit breakers carrying load | Allowable cumulative load (amperes) * |
|---|---|---|
| 1200 | 1 | 1200 |
| 1200 | 2 | 2000 |
| 2000 | 1 | 2000 |
| 2000 | 2 | 3200 |
| 1200 & 2000 | 2 | 2500 |
| 3000 | 1 | 3000 |

NOTES:
1 — If equal percentage reduction in each circuit breaker (as a percentage of rating) is not practical, the higher percentage load should be connected to the lower circuit breaker. The manufacturer should be consulted if other arrangements are required.
2 — In the absence of data from the manufacturer for a specific switchgear configuration it is recommended that the values for allowable cumulative loading given in table 13 not be exceeded for indoor ambient of +40 °C.

*Without forced ventilation.

### 7.4.5 Conductor terminations

Consideration should be given to the use of suitable connectors that are designed for use with the outgoing conductor and terminals in the switchgear units.

### 7.4.6 Control supply terminations

Where long connections to the control battery are necessary, the cable should be large enough to prevent excessive voltage drop.

NOTE — Larger terminal blocks than specified in 6.1.3.5 may be required for this termination.

## 7.5 Short-circuit considerations

ME switchgear should have short-circuit capability equal to or greater than the short-circuit capability of the system on which it is applied. The short-circuit capability (momentary or short-time, or both) of a unit of a switchgear assembly is equal to that of the included circuit breaker.

## 7.6 Nuclear power plant application

When ME switchgear is applied in nuclear power generating stations, and particularly when it is applied as Class 1E equipment, it should meet the requirements of pertinent standards that have been developed for such applications.

## 7.7 Associated devices often used in ME switchgear

### 7.7.1 Current transformers

The current transformers included in ME switchgear are in accordance with 4.6 and 4.7. The accuracies listed in 4.7 are the minimum supplied in the usual design of these equipments, and are adequate for most applications. If an application requires higher accuracies, it should be specified by the user. It should be recognized that current transformers with higher accuracies than listed in 4.7 may not meet the requirements of 4.6. The manufacturer should be consulted for possible solutions to the problem of obtaining required accuracy without compromising on other requirements.

### 7.7.2 Surge protective devices

#### 7.7.2.1 Rotating equipment

Capacitors or surge arresters, or both, used to protect the insulation of rotating machines, should be housed in a suitable enclosure adjacent to the machine and connected without fuses or disconnecting devices. Cable connections to these devices should be able to withstand possible short-circuit current, both thermally and mechanically.

#### 7.7.2.2 Exposed circuits

Protection against voltage surges should be considered for all switchgear assemblies having exposed circuits. Exposed circuits are those outside of buildings or those that do not have adequate surge protection connected to limit voltages to less than the withstand level of the switchgear.

#### 7.7.2.3 Surge arresters in switchgear assemblies

Surge arresters used in switchgear assemblies should have adequate discharge capability and be voltage limiting to keep voltage surges below the insulation level of the protected equipment. Special consideration should be given to the use of coordinated surge arresters for ME switchgear installed at high altitudes.

## 7.8 Protection and isolation of switchgear connected to other circuit protective equipment

When ME switchgear is electrically connected to other power switching and circuit protective equipment, the circuit protective equipment should be provided in the connection between the two so that a fault in one assembly will not result in the loss of the other assembly.

NOTE — Where both assemblies supply power to an entire integral unit process so that the shutdown of one pan necessitates the shutdown of the entire process, tie circuit protection equipment is not required. For additional information and further study of switching arrangements, see IEEE Std 141-1993, IEEE Std 241-1990, IEEE Std 242-1986, and IEEE Std 446-1987.

# 8. Guide for handling, storage, and installation

## 8.1 General

This subclause is a guide for the handling, storage, and installation of ME switchgear and emphasizes safety aspects and other considerations when working with this type of equipment. It supplements, but does not replace, the manufacturer's detailed instructions on these subjects. The objective is to furnish additional guidelines to promote and enhance a reliable installation.

The manufacturers of ME switchgear include instruction books and drawings with their equipment, containing detailed recommendations for storage, handling, installation, operation, and maintenance.

Personnel responsible for these functions should review these recommendations before handling the equipment. Particular attention should be given to recommendations for preparation of foundation and forms on which the switchgear is to be mounted. One set of manufacturer's instruction books should remain with the ME switchgear when in storage or at the installation site.

## 8.2 Handling

### 8.2.1 Receiving

ME switchgear should be carefully inspected and packed before leaving the factory. Immediately upon receipt, the equipment should be examined for damage that may have been sustained during transit. If damage is evident or indications of rough handling are visible, the carrier (transportation company) and the manufacturer should be notified promptly.

Only authorized personnel should be permitted to handle the equipment. Care should be exercised in handling each piece of equipment (even if crated) because parts may be damaged.

### 8.2.2 Rigging

Instructions for lifting and handling of the equipment are contained in the manufacturer's instruction books and drawings. The rigging should be adequate for the size and weight of the equipment.

### 8.2.3 Storage

Indoor switchgear that cannot be installed immediately should be stored in a dry, clean location and should remain in crates during the storage period. The longer the period of storage, the greater the care required for protection of the equipment. During storage, the ME switchgear should be placed on a level surface to prevent unnecessary strain and possible distortion. During the construction period, protection should be provided against dust, dirt, falling objects, dripping water, excessive water, excessive moisture, and other possible causes of damage to the equipment. Any temporary covering should not restrict ventilation and should not be removed until the equipment is ready for installation. It is preferable to store indoor equipment within a heated building. If this is not possible, special precaution should be taken to keep the equipment sufficiently warm with adequate ventilation to prevent condensation during the storage period. If necessary, temporary heating should be installed in the equipment.

If outdoor switchgear cannot be installed and energized, temporary power must be provided for the operation of the space heaters provided so as to minimize condensation of moisture within the housing.

**CAUTION —** Ensure that the normal supply source is open to prevent backfeed.

Ventilation openings in ME switchgear should be left open to permit proper circulation of air.

### 8.2.4 Installation

When installing ME switchgear

a) Protect workers adequately from live parts with barriers, screens, etc.
b) Accredited Standards Committee C2 (NESC), Part 1., Rule 124, for guarding live parts should be observed.

#### 8.2.5 Removal of shipping members

Before installation of ME switchgear, a careful check should be made to ensure that all members included for shipping purposes, have been removed.

#### 8.2.6 Connections

##### 8.2.6.1 Bus connections

When the ME switchgear consists of several shipping sections, the main bus is necessarily disconnected before shipping. The main bus should be reconnected with particular attention to the cleanliness of and pressure between the contact surfaces. It is essential that the connections be securely bolted because the conductivity of the joints is dependent on the applied pressure. Refer to the manufacturer's torque instructions and any other special instructions.

##### 8.2.6.2 Cable connections

Before making up the cable connections, the phasing of each cable should be determined in accordance with the connection diagram, and the cables tagged accordingly. The cable manufacturer's instructions should be followed when forming cable terminations and during the installation of the cable. It is essential that the connections be clean and securely bolted since the conductivity of the joints is proportional to the applied pressure. The terminating devices (where required) should be installed pursuant to the terminator manufacturer's instructions.

##### 8.2.6.3 Control connections

Control wires between shipping sections should be reconnected as marked by the manufacturer. Connections that are to be connected to terminals in apparatuses remote from the switchgear should be carefully checked against the connection diagram. When making connections to terminals, care should be exercised to ensure that the connections are properly made.

##### 8.2.6.4 Grounding

Sections of ground bus previously disconnected at shipping sections must be reconnected when the units are installed. It should be ensured that all secondary wiring is connected to the switchgear ground bus as indicated on the drawings. The ground bus should be connected to the system ground with as direct a connection as possible and should not be run in metal conduit unless the conduit is adequately bonded to the circuit. The grounding conductor should be capable of carrying the maximum line-to-ground short-circuit current for the duration of a fault. A reliable ground connection is necessary for every switchgear installation. It should be of sufficient capacity to handle any abnormal condition that might occur on the system and should be independent of the grounds used for other apparatuses. A permanent low-resistance ground is essential for adequate protection and safety.

### 8.3 Preoperation check

Care must be exercised to prevent the ME switchgear from being energized from the power system while preliminary tests are being conducted. If disconnecting means is not available, line leads should be disconnected. All internal connections should be examined to ensure that they have not been loosened or damaged during shipment or installation, and all bolted connections and joints should be tightened to ensure good contact. If spring washers are used under bolt heads and nuts, they should be tightened in accordance with manufacturer's instructions. All wiring connections should be checked for tightness, including those at the instrument transformers and all terminal blocks. Current transformer shorting devices on all active circuits should be removed.

All ties and blocking from the relay armatures or discs should be removed before the control energy is applied.

Protective relays, overcurrent trip devices, and breaker attachments included with the ME switchgear should be tested for correct connections and operation at the factory. However, the protective device settings for current, voltage, or other quantities must be made by the user in accordance with his operating practices. The manufacturer's instruction books should be studied carefully before setting the protective devices.

It is recommended that the integrity of control buses be checked with an ohmmeter to ensure against short circuits in the control wiring. Control wiring should be given a high-potential test or be insulation resistance tested and power circuits, such as buses and circuit breakers, should be given a normal-frequency withstand test as described in 5.1 and 5.5. After ME switchgear has been installed and all interconnections completed, any control schemes should be operationally tested and power connections given a final check for phase rotation/sequence before the switchgear is finally energized for service.

## 8.4 Removable elements

All circuit breakers should be inspected for damaged parts and any loose connections pursuant to the manufacturer's instructions. A check should be made of the manual operation with the manual closing lever or with the maintenance closing handle on the larger size circuit breaker elements. Each circuit breaker should be tripped by operating the manual trip device. Operation with maintenance handle and slow closing should be done outside the circuit breaker cubicle. The power-operated circuit breakers should be checked for proper operation while in the switchgear cubicle test position, for both closing and tripping at the normal control voltage.

## 8.5 Interlocks

Interlocks should be checked for proper operation before power is applied to the switchgear.

### 8.5.1 Metal-clad switchgear

Interlocks should be checked between removable element and housing to see that

a) The element cannot be moved to or from the connected position when the breaker is in the closed position.
b) The circuit breaker cannot be closed unless it is in the fully connected position or in the test position.

The shutters should be checked to make sure they are operable so that the primary disconnecting devices in the housing are automatically covered when the circuit breaker is withdrawn.

### 8.5.2 Station-type cubicle switchgear

The interlock should be checked between isolating switches and circuit switching or interrupting device to make sure that switches can be operated only when circuit switching or interrupting device is open. When grounding switches are used, the proper sequential operation with the interlocks should be checked. The interlock between isolating switches and the primary circuit compartment of the circuit switching or interrupting device should be checked to be sure that access is only allowed when the switches are open.

To maintain the integrity of key interlock systems, duplicate keys should be destroyed or retained in a place accessible only to authorized personnel.

## 8.6 Energizing

After the removable circuit breaker elements and interlocks have been tested satisfactorily, the circuit breakers may be moved to the connected position. Each compartment door should be closed and secured before energizing the circuit.

# Annex A Guide for enclosure categories and related requirements

# (Informative)

IEEE Std C37.20-1969 (Reaff 1981) (1974 consolidated edition) had included clause 7. entitled, “Tamperproof switchgear.” However, this terminology created questions of intent as related to public exposure and therefore, IEEE Std C37.20.2-1987 eliminated this construction feature from the basic standard.

During the development of other standards, an enclosure security section was developed to provide guidance for varying types of construction described as categories A, B, or C. These categories are included in IEEE Std C37.55-1989, but basic construction features are not normally included in a conformance test standard.

Construction details are normally included in the basic standards. However, since category A covers the prior concept of tamperproof, it was decided that it would be best contained in this annex with the other categories to be utilized as optional. Category C covers metal-clad switchgear with exposed bushings, bus, or terminals.

Category B, while it represents basic metal-clad switchgear construction, remains in this annex for continuity.

It is noted that IEEE Std C37.55-1989 requires conformance testing as applicable for categories A, B or C.

## A.1 Scope

This guide covers enclosure categories and related requirements.

## A.2 Enclosure categories

Switchgear assemblies are installed in a variety of locations that have a different degree of exposure to the general public. The enclosure of the switchgear assembly provides a degree of protection to the enclosed conductors or equipment and provides a degree of protection to personnel against incidentally contacting live parts.

Enclosures are categorized as category A, B, and C as listed in table A.1.

### A.2.1 Category A enclosures

Category A enclosures are intended to provide a degree of protection against contact with enclosed equipment in ground level installations subject to deliberate unauthorized acts by members of the unsupervised general public. The enclosure should meet the requirements of category A in table A.1.

### A.2.2 Category B enclosures

Category B enclosures are intended for use in installations not subject to deliberate unauthorized acts by members of the unsupervised general public primarily to provide a degree of protection to unauthorized and untrained personnel against incidental contact with enclosed equipment. The enclosures should meet the requirements of category B in table A.1.

### A.2.3 Category C enclosures

Category C enclosures are intended to provide a degree of protection against contact with enclosed equipment in secured installations intended to be accessible only to authorized persons. The enclosures should meet the requirements of category C in table A.1.

**Table A.1—Requirements for enclosure categories**

| Feature | Reference subclauses | Required for categories | | |
|---|---|---|---|---|
| **All enclosures**<br>**Basic requirements** | | **A** | **B** | **C** |
| Rigidity (sheet metal) | A.3.6 | Yes | Yes | Yes |
| Exposed live parts permissible | A.3.14 | No | No | Yes |
| Operating handle protection | A.3.9 | Yes | No | No |
| Vent openings (permissible) | A.3.8 | Yes | Yes | N/A |
| Doors (if supplied) | A.3.7 | Yes | Yes | Yes |
| Doors—handles lockable | A.3.7 | Yes | Yes | No |
| Doors—captive fasteners permitted | A.3.7 | N/A | Yes | Yes |
| Hinge pins—non-removable door | A.3.7 | Yes | No | No |
| Drain valves, gauges, etc.<br>Locked cover | A.3.12 | Yes | No | No |
| Caution and warning signs | A.3.15 | Yes | Yes | Yes |
| Viewing pane-lockable cover | A.3.11 | Yes | No | No |
| **Outdoor enclosures** | | | | |
| Material | A.3.13 | Yes | Yes | Yes |
| Hinges | A.3.13 | Yes | Yes | Yes |
| Gaskets | A.3.13 | Yes | Yes | Yes |
| Doorstop | A.3.13 | Yes | Yes | Yes |
| Drainage | A.3.13 | Yes | Yes | Yes |
| Design tests | A.3.13 | Yes | Yes | Yes |

N/A = Not applicable

## A.3 Enclosure requirements

The enclosure requirements should be as follows:

a) *Enclosure construction.* Enclosures should be of metal suitably supported, constructed, and assembled so that the enclosure will have the strength and rigidity necessary to meet the requirements of this standard.

b) *Enclosure finishes.* Unless the enclosure is of a material that will resist corrosion, both inside and outside surfaces should be finished in accordance with 6.1.5.2. The ME switchgear must withstand the applicable paint qualification test.

c) *Enclosure material.* The thickness of a sheet-metal enclosure should not be less than that indicated in table A.2. If metals other than steel are used, the thickness should be such that equivalent strength and deflection are provided.

d) *Supporting structures.* A supporting structure should be formed of angles, channels, folded rigid sections of sheet metal, or the equivalent, rigidly fastened together and having essentially the same outside dimensions as the enclosure surfaces.

e) *Supporting structures and frames.* With reference to item d) and table A.2, a construction is not considered to have a supporting frame if it is

1) A single sheet with single formed flanges (formed edges).
2) A single sheet that is die formed (corrugated or ribbed).
3) An enclosure surface loosely attached to a frame, i.e., with spring clips.

**Table A.2—Minimum thickness of sheet metal for carbon steel or stainless steel enclosures**

| Without supporting frame* | | | | With supporting frame or equivalent reinforcing* | | | | Minimum thickness (MSG) |
|---|---|---|---|---|---|---|---|---|
| Maximum width† | | Maximum length‡ | | Maximum width | | Maximum length | | Uncoated |
| in | mm | in | mm | in | mm | in | mm | |
| 33.0 | 838 | not limited | — | 51.0 | 1295 | not limited | — | 14 MSG |
| 38.0 | 965 | 47.0 | 1194 | 54.0 | 1372 | 66.0 | 1676 | 14 MSG |
| 42.0 | 1067 | not limited | — | 64.0 | 1626 | not limited | — | 13 MSG |
| 47.0 | 1194 | 59.0 | 1499 | 68.0 | 1727 | 84.0 | 2134 | 13 MSG |
| 52.0 | 1321 | not limited | — | 80.0 | 2032 | not limited | — | 12 MSG |
| 60.0 | 1524 | 74.0 | 1880 | 84.0 | 2134 | 103.0 | 2616 | 12 MSG |
| 63.0 | 1600 | not limited | — | 97.0 | 2464 | not limited | — | 11 MSG |
| 73.0 | 1854 | 90.0 | 2286 | 103.0 | 2616 | 127.0 | 3226 | 11 MSG |

*See A.3.5.
†The width is the smaller dimension of a rectangular sheet metal piece that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made from a single sheet.
‡For panels that are not supported along one side (e.g., side panels of boxes) the length of the unsupported side should be limited to the dimensions specified.

### A.3.1 Equivalent construction

#### A.3.1.1 Unsupported areas

The unsupported area of an enclosure may be greater than shown in table A.2 if the enclosure is reinforced so that it meets the requirements of A.3.1.2 and A.3.1.3.

#### A.3.1.2 Deflection test

The following test is to be applied to the front, end, side, and rear walls of each enclosure:

The inward deflection when a force of 100 lbf (444.8 N) is applied perpendicular to the surface of any point on the enclosure through a rod having a 0.5 in × 0.5 in (12.7 mm × 12.7 mm) face will not impair the dielectric criteria of subclause 4.2.2 or affect mechanical performance. For the test, the enclosure may be laid on its back on a smooth, solid, horizontal surface with the door closed and the front panel or cover secured as intended. The test force should be applied at various points on the enclosure likely to cause deflection. The same sample may be used for more than one test provided there is no permanent deflection due to a previous test.

#### A.3.1.3 Torsion test

With each enclosure in a vertical position, the base is to be secured to a rigid surface. The top corners are then to be twisted around the vertical axis of the enclosure by application of 200 lbf (889.6 N) to the corner that results in the greatest torsional deflection. With this torsional force applied, the dielectric capability should not be impaired, nor should mechanical performance be adversely affected.

### A.3.2 Access doors and covers

A part of the enclosure, such as a door, cover, or tank, should be provided with a means (such as latches, locks, interlocks, or captive fasteners) for firmly securing it in place. Such fasteners should be located or used in multiple so as to hold the door or cover closed over its entire length. A hinged cover more than 48 in (1.22 m) long on the hinged side should have at least a two-point latch, or have at least two captive fasteners.

The opening handles for doors on equipment for category A should be lockable. Captive fasteners are permitted on category B equipment. Exposed hinge pins should be nonremovable on doors of category A or, as an alternative, the door should be non-removable in the closed position.

### A.3.3 Enclosure and ventilation openings

#### A.3.3.1 Enclosure openings

When the enclosure is completely and properly installed, openings in the enclosure, other than ventilation openings, should prevent the entrance of a rod having a diameter of 0.125 in (3.2 mm), except that if the distance between the opening and the nearest not fully insulated live part is greater than indicated in table A.3, the opening may permit the entry of a rod having a diameter greater than 0.125 in (3.2 mm), but not greater than 0.500 in (12.7 mm).

A barrier or equivalent should be located so that it intercepts all live parts from line-of-sight through the opening protected.

#### A.3.3.2 Ventilation openings

Ventilation openings should prevent the entrance of a rod having a diameter of 0.500 in (12.7 mm), except that if the distance from the opening and the nearest not fully insulated live part is greater than indicated in table A.3, the opening may permit entry of a rod having a diameter greater than 0.500 in (12.7 mm) but not greater than 0.750 in (19.1 mm).

A barrier or equivalent should be located so that it intercepts all live parts from line-of-sight through the opening protected.

EXCEPTION—A larger opening above the upper edge of the enclosure, but under the overhang of the top, is acceptable, if by means of its size, baffling, etc., it will prevent a straight rod 0.500 in (12.7 mm) in diameter from approaching any uninsulated live parts inside the enclosure by a distance not less than indicated by table A.3.

**Table A.3—Clearance to ventilation openings**

| **Rated maximum voltage** | **Clearance** | |
|---|---|---|
| | **in** | **mm** |
| 4.76 | 5.5 | 140 |
| 8.25 | 6.5 | 165 |
| 15.0 | 8.0 | 203 |
| 38.0 | 15.0 | 361 |

The diameter of the wires of a screen should not be less than 0.051 in (1.30 mm) if the screen openings are 0.5 $in^2$ (323 $mm^2$) or less in area, and should not be less than 0.081 in (2.06 mm) for larger screen openings.

Perforated sheet steel and sheet steel employed for expanded metal mesh should not be less than 0.042 in (1.07 mm) thick for mesh openings or perforations 0.5 $in^2$ (323 $mm^2$) or less in area, and should not be less than 0.080 in (2.03 mm) thick for larger mesh openings or perforations.

A ventilating opening in the top of the enclosure should prevent the entry of falling dirt.

#### A.3.3.3 Rod entry tests

These tests should be made by attempting to insert the end portion of straight rods of diameters specified in A.3.3.1 and A.3.3.2 into the equivalent cavities of the enclosure.

#### A.3.3.4 Evaluation

The enclosure is considered to have met the requirement of these tests if the rod either has not entered the enclosure or is restricted by a barrier from intrusion into the enclosure interior.

### A.3.4 Operating handle protection

Device-operating handles on the external surface of metal-clad switchgear enclosures should be lockable or provided with lockable covers for category A equipment.

### A.3.5 Operating handles

If the mechanism of a switching device is such that the operation of a remote or automatic tripping device will result in sudden movement of an operating handle, the motion of the handle should be restricted or the handle should be guarded to prevent injury to persons in the vicinity of the handle.

### A.3.6 Viewing panes

A transparent material covering an observation opening and forming a part of the enclosure should be reliably secured in such a manner that it cannot be readily displaced in service, and should meet the following requirements:

a) Viewing panes should not shatter, crack, or become dislodged when both sides of the viewing panes in turn are subjected to the tests described below.
b) A force of 100 lbf (444.8 N) should be exerted perpendicular to the surface in which the viewing pane is mounted. This force should be evenly distributed over an area of 16 $in^2$ (0.010 $m^2$) (as nearly square as possible and as near the geometric center of the viewing pane as possible). If the viewing pane has an area less than 16 $in^2$ (0.010 $m^2$), the force should be evenly distributed over the entire viewing area. The 100 lbf (444.8 N) should be sustained for a period of 1 min.
c) The viewing pane should be subjected to an impact of 2.5 ft · lbf (3.4 J) using a steel ball weighing approximately 1.18 lb (0.535 kg) and measuring approximately 2 in (50 mm) in diameter.
d) Separate samples may be used for each of the tests described in a), b), and c).
e) If a viewing pane is intended to be exposed to insulating oil in a tank or compartment, it should be of a material that is resistant to the corrosive effects of the insulating oil.
f) Category A equipment should have lockable covers over viewing panes if viewing panes are furnished.

### A.3.7 Accessories

Drain valves, gauges, etc. should have a lockable cover on enclosures designated as category A.

### A.3.8 Outdoor enclosure requirements

#### A.3.8.1 General

These enclosures are intended for outdoor use primarily to provide a degree of protection against rain and sleet. They should meet rain test and paint qualification design tests.

Hinges and other attachments should be resistant to corrosion. Metals should not be used in combinations that result in galvanic action that adversely affects any part of the device.

If an outdoor enclosure has any opening for passage of a wire or bus bar to a switchboard section or to a wireway, auxiliary gutter or busway, a suitable gasket or other means should be provided that will prevent the entrance of water at such opening. If the opening is for attachment of a busway, the outdoor enclosure and the busway are to be investigated together to determine that water does not enter along the bus bars.

#### A.3.8.2 Test requirements

Outdoor enclosures should be tested and evaluated by

a) Rain test per 5.2.9.
b) Paint qualification test per 5.2.8.

#### A.3.8.3 Gasketing

An outdoor construction requiring a gasketed joint should meet the following requirements:

a) A gasket of rubber or neoprene, or a composition thereof, is to be exposed for 96 h to oxygen at a pressure of 300 lbf/in$^2$ (2068.0 kPa) and a temperature of 70 °C. The gasket is considered adequately resistant to aging if there is no visible evidence of deterioration such as softening, hardening, or cracking after flexing.
b) A gasket of thermoplastic material, or a composition thereof, may be accepted after consideration of the effects of heat aging, distortion under conditions of use, and the means of securing the gasket to the cover or enclosure.

### A.3.9 Exposed live parts

ME switchgear should have no exposed live conductors (such as entrance bushing studs, terminal connections, or bus bars) unless it is designated as a category C equipment.

### A.3.10 External marking

An assembly should be marked with its exposure category.