SWITCHBOARD

INSTALLATION AND MAINTENANCE MANUAL

ATTENTION
IMMEDIATELY CHECK FOR
ANY DAMAGE

Immediately upon receipt of the shipment, identify all component parts and check them against the shipping list. Make a thorough examination to detect any damage that may have been incurred during transit.

If any damage is discovered, file a claim immediately with the carrier and send notice of the extent of damage to the Z-Power and Distribution, giving complete identification, carrier's name, and railroad car number if the shipment was made by rail.

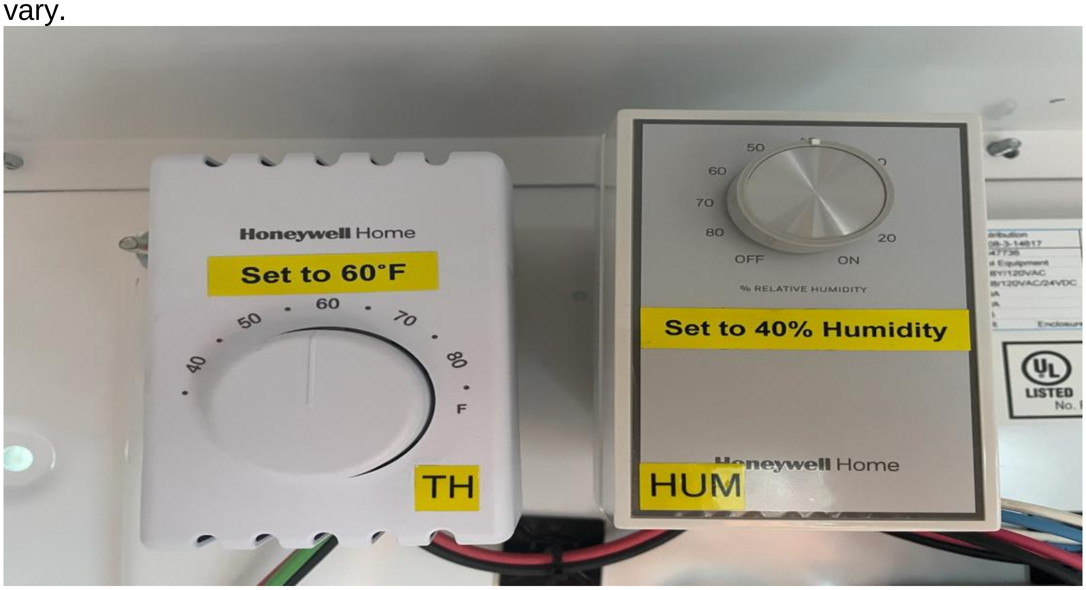
The information will enable the company to supply necessary data in support of claim.

THERMOSTAT AND HUMIDISTAT SETTINGS

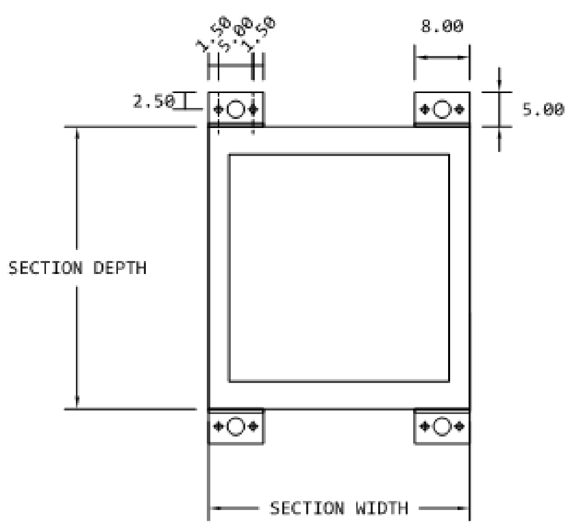
We ship all NEMA 3R enclosures with pre-set settings on installed Thermostat's/Humidistat's.
These settings are:

Thermostat @ 60°F
Humidistat @ 40% Humidity

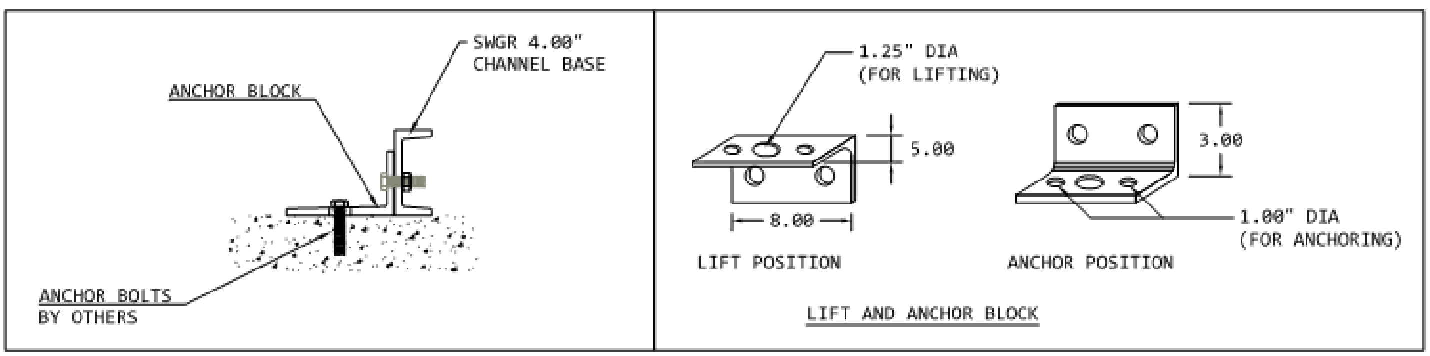
We strongly recommend maintaining these settings, but depending on the installation sites weather--they may vary.



STANDARD BASE PART HOLE LAYOUT



BASE ANCHOR LOCATIONS


SWGR 4.00"
CHANNEL BASE
ANCHOR BLOCK
ANCHOR BOLTS
BY OTHERS
1.25" DIA
(FOR LIFTING)
5.00
3.00
8.00
1.00" DIA
(FOR ANCHORING)
LIFT POSITION
ANCHOR POSITION
LIFT AND ANCHOR BLOCK

TIGHTENING BOLTED CONNECTIONS

All bus connections to be made with S.A.E. Grade # 5 hardware and torqued to recommended values. Grade # 5 nuts are identified with a “2H” marking on the face and have a Rockwell C-10 rating.

CONNECTING WIRE TORQUE SPECS					
Screw Driver			Internal Hex		
Wire	Torque LB-Inch		Hex Size	LB-Inch	
AWG	Min	Max		Min	Max
#14 - #10	32	35	1/8"	43	47
#8	36	40	5/32"	95	105
#4 - #6	41	45	3/16"	108	120
#3 - 2/0	45	50	1/4"	180	200
			5/16"	240	275
			3/8"	330	375
			1/2"	450	500
			9/16"	570	630

BUS BAR CONNECTIONS TORQUE SPECIFICATIONS	
BOLT SIZE	**FOOT POUNDS**
1/4"	7
5/16"	13
3/8"	20
1/2"	50

Note: Before putting this equipment into service, make sure that all bus and cable connections are torqued

PLEASE REFER TO NEMA INSTALLATION GUIDLINES AND NETA MAINTENANCE GUIDLINES OUTLINED BELOW

ANSI C37.55-2020

American National Standard for
Medium-Voltage Metal-Clad Switchgear Assemblies—
Conformance Test Procedures

Secretariat:

National Electrical Manufacturers Association

Approved: February 24, 2020

American National Standards Institute, Inc.

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CONTENTS

Foreword (This foreword is not part of American National Standard C37.55-2020.)

This Standard has been developed to describe selected tests and procedures to demonstrate conformance in accordance with Section 6, Tests, of IEEE Std. C37.20.2 Metal-Clad Switchgear. It is published separately from IEEE Std.C37.20.2 to facilitate its use and to permit timely revisions based on experience.

Major revisions have been made to this edition to coordinate with revisions made to IEEE Std. C37.04, IEEE Std. C37.09 and IEEE Std. C37.20.2. Previous editions of this Standard shall continue to apply for conformance tests made on equipment rated in accordance with the earlier editions of IEEE Std. C37.04, IEEE Std. C37.06 (withdrawn in 2018), IEEE Std. C37.09 and IEEE Std. C37.20.2.

This Standard is one of several in a series of test procedures for conformance testing of switchgear products. While this Standard is written for general guidance, performance criteria are established so that this Standard can be adopted as the basis for certification of metal-clad switchgear for use in non-utility installations subject to regulation by public authorities and similar agencies concerned with laws, ordinances, regulations, administrative orders, and similar instruments.

This Standard has been prepared by a Working Group sponsored by the Power Switchgear Assemblies Technical Committee of the Switchgear Section of the National Electrical Manufacturers Association (NEMA 8-SG-V). During the course of its preparation, coordination has been maintained with the High Voltage Power Circuit Breaker Technical Committee of the Switchgear Section of the National Electrical Manufacturers Association (NEMA 8-SG). Reports of progress were also made at regular intervals to the Switchgear Committee of the Power Engineering Society of the Institute of Electrical and Electronics Engineers.

Suggestions for improvement of this Standard will be welcome. They should be sent to the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Rosslyn, VA 22209.
This Standard was processed and approved for submittal to ANSI by Accredited Standards Committee on Power Switchgear C37. Committee approval of the Standard does not necessarily imply that all committee Members voted for its approval. At the time of its approval, the ASC C37 Committee had the following Members:

John Webb, Chair
Gerard Winstanley, Secretary

Organizations Represented:	*Name of Representative:*
Users	Roy Alexander
	Paul Barnhart
	Pete Dwyer
	George Nourse
	Mike Weitzel
General Interest	Doug Edwards
	John Leach
	Paul Sullivan
	Michael Wactor
Producers	Darryl Moser
	Carl Schneider
	John Webb
	Eddie Wilkie
	Terrance Woodyard

The following Members composed the NEMA Power Switchgear Assemblies Technical Committee at the time of publication of this Standard:

Carl Schneider, Chair
Gerard Winstanley, Secretary

Chris Ambrose
Eldridge Byron
Phil Fahey
Keith Flowers
Lou Grahor
Mark Gromlovits
Victor Hermosillo
Chad Kennedy
Darryl Moser
Tony Ricciuti
Karla Trost
John Webb
Eddie Wilkie
Terrance Woodyard
Charles Worthington

1 Scope

Conformance Testing Standard

This Standard is a conformance testing Standard optionally applicable to all medium-voltage metal-clad switchgear assemblies designed, tested, and manufactured in accordance with IEEE Std. C37.20.2, Metal-Clad Switchgear. This Standard covers selected tests to demonstrate the conformance of the basic switchgear section (which includes the structure, circuit breaker compartments, instrument compartments, buses, and internal connections) with the "Tests" clause of IEEE Std. C37.20.2.

In this Standard, the use of the term "MC switchgear" shall be considered to mean "metal-clad switchgear." The use of the term "circuit breaker" shall be considered to mean "indoor alternating current medium-voltage circuit breakers (rated above 1000 volts) applied as removable elements in metal-enclosed switchgear assemblies," unless qualified by other descriptive terms.

1.1 Purpose

This Standard specifies the tests that shall be performed to demonstrate that the MC switchgear being tested conforms with the ratings assigned to it and meets the mechanical and electrical performance requirements specified in IEEE Std. C37.20.2.

2 References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI C29.10, *Wet Process Porcelain Insulators — Indoor Apparatus Type*

ANSI C37.54, *Conformance Test Procedures for Alternating Current High-Voltage Circuit Breakers Applied in Metal-Enclosed Switchgear Assemblies*

ANSI C37.57, *Metal-Enclosed Interrupter Switchgear Assemblies — Conformance Testing*

ANSI C37.58, *Indoor Medium-Voltage Switches for Use in Metal-Enclosed Switchgear — Conformance Test Procedures*

IEEE Std. C37.04, *Ratings and 3 Requirements for AC High Voltage Circuit Breakers with Rated Maximum Voltage above 1000 V*

IEEE Std. C37.09, *Test Procedures for AC High-Voltage Circuit Breakers with Rated Maximum Voltage above 1000V*

IEEE Std. C37.20.2, *Metal-Clad Switchgear*

IEEE Std. C57.12.28, *Standard for Pad-Mounted Equipment—Enclosure Integrity*

3 Definitions

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

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause. An *IEEE Standards Dictionary Online* subscription is available at
http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html

A dagger (†) indicates that the definition differs from that in the *IEEE Standards Dictionary*.

3.1 Conformance Tests

Certain tests to demonstrate compliance with the applicable Standards. The test specimen is normally subjected to all planned production tests prior to the initiation of the conformance test program.†

Note: 1. Conformance tests may, or may not, be similar to certain design tests. Demonstration of margin (capabilities) beyond the Standards ratings is not required.

3.2 Design Tests (Type 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.†

Design tests are made on representative apparatus or prototypes to verify the validity of design analysis and calculation methods and to substantiate the ratings assigned to all other apparatus of basically the same design. These tests are not intended to be made on every design 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 assure 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.

3.3 Production Tests (Routine Tests)

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

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

3.4 Ceramic Insulation

Insulation made of a vitrified ceramic material, such as porcelain or glass.

3.5 Nonceramic Insulation

Insulation made of a material other than ceramic. This category includes all organic insulating materials.

3.6 Bus Insulation

Insulating material used to cover primary voltage conductors except where that conductor is a cable or wire. (Bus joint insulation is excluded from this category and is treated separately). The primary functions of bus insulation are to impede arc movement and to allow closer spacing of conductors than would be possible with bare conductors. Bus insulation may also serve a secondary function as an element of the bus support insulation system.

3.7 Bus Joint Insulation

Insulating material used to cover joints or connections in the primary voltage conductors. Otherwise, it is similar to bus insulation.

3.8 Bus Tap Insulation

Insulating material used to cover low current taps to the main primary voltage conductors. These taps include voltage and control power transformer primary leads, connections to surge arresters and surge capacitors, and other similar connections. Bus taps may be in the form of a wire, rod, or bar insulated similar to bus insulation for this service or in the form of an insulated wire or cable.

3.9 Bus Support Insulation

Insulation used primarily to physically support a conductor and prevent or limit its movement under specified operating conditions. Bus support insulation includes both conductor-to-conductor and conductor-to-structure supports.

3.10 Barrier Insulation

Insulation material used primarily to separate one item or area from another item or area within the equipment. Examples are as follows: (a) interphase barriers between poles of an interrupter switch; (b) bus barriers separating the bus compartment of one vertical section of switchgear from another; and (c) barriers used to shield grounded metal from electrical or thermal effects of circuit interruption within the equipment. Barrier insulation may be subdivided into two general types: Type 1 barriers that are not in contact with, and are not penetrated by energized parts; and Type 2 barriers that are in contact with or are penetrated by energized parts.

3.11 Circuit Breaker Primary Disconnects

These are penetration insulators that support bus stabs. Their primary function is to insulate the primary bus as it passes through the ground barrier and to support the bus so that it can properly engage the circuit breaker.

3.12 Entrance Bushings

Insulating structures including a through-conductor, or providing a passageway for such a conductor, with provision for mounting on a barrier (insulating or otherwise), for the purpose of insulating the conductor from the barrier so that current may be conducted from one side of the barrier to the other. Entrance bushings can be vertically mounted (e.g., roof bushings) or horizontally mounted (e.g., wall bushings).

3.13 Relative Thermal Index

An indication of a material’s ability to retain a particular property when exposed to elevated-use temperatures for an extended period of time. The relative thermal index is determined by the procedures outlined in ANSI/UL 746B. As used in this Standard, the electrical, thermal index includes such properties as dielectric strength, arc resistance, volume resistivity, and the like. The mechanical-without-impact relative thermal index includes such properties as tensile, flexural, shear strength, and the like. The mechanical-with-impact relative thermal index includes the properties of the mechanical-without-impact relative thermal index plus impact properties that are intended to stress the material under sudden-shock loading conditions.

4 Test Conditions

4.1 Ambient Conditions

Tests shall be conducted under conditions prevailing at the test site, which shall conform to “Usual Service Conditions” in accordance with the clause on “Normal (usual) service conditions from IEEE Std. C37.20.2, except that the temperature of the air surrounding the assembly (ambient) for the continuous current tests shall be within the ambient temperature range of 10°C (50°F) to 40°C (104°F).

5 Conformance Test Requirements

5.1 General

Tests are made on representative test arrangements of MC switchgear as described in 5.3 to demonstrate the capability of the MC switchgear design to meet its assigned ratings and to operate under normal service conditions as outlined in the clause on "Normal (usual) service conditions from IEEE Std. C37.20.2. The circuit breaker design utilized shall have been previously qualified in accordance with ANSI C37.54 or tested to the requirements of ANSI C37.54 simultaneously to tests in accordance with the requirements of this Standard.

The test specimen shall have been subjected to production tests in accordance with clause 7 prior to the initiation of conformance tests.

The requirements of this Standard have changed from those in the previous edition. If retesting becomes necessary in accordance with clause 8 (i.e., if the design has changed), the retests shall be performed in accordance with the requirements of ANSI C37.55-1989 if the product is to be rated in accordance with IEEE Std. C37.20.2-1993 (or earlier editions). If the product is to be rated in accordance with IEEE Std. C37.20.2-1999, conformance testing shall be performed in accordance with the requirements of ANSI C37.55-2002. Otherwise, conformance testing shall be performed in accordance with the requirements of this Standard.

5.2 Test Requirements

Representative test arrangements shall be subjected to the following tests as described in the sub-clauses indicated in parentheses:

a. Dielectric tests (5.4)
b. Continuous current tests (5.5)
c. Momentary withstand current test (5.6)
d. Short-time withstand current test (5.7)
e. Mechanical performance tests (5.8)

5.3 Test Arrangements

5.3.1 Arrangement To Be Used

For the tests specified in 5.4 through 5.7, each test arrangement construction shall contain a vertical circuit breaker section and an auxiliary section. There shall be a main bus in each section, and the test arrangement shall include the main bus splice. The main bus shall be typical, and of the same current rating as the circuit breaker.

The Mechanical Performance Tests specified in 5.8 shall be conducted in any representative housing intended to receive the circuit breaker size under test. This is permitted to be, but not required to be, one of the compartments in the above test arrangements.

5.3.2 Specifics of Test Arrangement

Each test arrangement shall include the maximum available number of current transformers per phase of Standard accuracy class or greater in accordance with clause "Design tests" of IEEE Std. C37.20.2, and shall be installed in Standard locations in the circuit breaker vertical section. Current transformer secondary windings shall be shorted and grounded for all tests and be rated in accordance with clause "Design tests" of IEEE Std. C37.20.2.

An auxiliary section of the test arrangement for each voltage class that is to receive the dielectric test shall contain within one of its compartments a voltage transformer assembly of manufacturer's Standard design having a disconnecting means and three voltage transformers connected wye-wye.

In the same test arrangement, a control power transformer disconnecting primary fuse assembly shall also be installed in one of the remaining compartments of the auxiliary section. Its primary stationary contacts shall also be connected to the main bus; however, connections from the load side contacts to a control power transformer are not required. Two fuses shall be installed for a standard line-line connection.

5.3.3 Representation

Due to similarities in the design and construction of functional elements used in several different types, styles, models, sizes, or ratings of MC switchgear, a test conducted on one test arrangement shall be properly extended to qualify other test arrangements using similarly designed elements within the intent of this Standard. In each case, consideration must be given to the nature of the specific test, its influence on the MC switchgear performance, and the elements of the MC switchgear that will be affected. The following criteria are intended for information and guidance in the selection of the representative test arrangement for each test and shall not limit its applicability.

a. **Dielectric test** - One test arrangement for each voltage class or combination of voltage classes that has the most highly electrically stressed insulation, e.g., minimum air clearance, shortest creepage path, and the like.

b. **Mechanical performance test** - The highest continuous current rating of the circuit breaker used with each type of interlocking arrangement.

c. **Continuous current test** - The most compact design for each continuous current rating and having the highest current density.

d. **Short-time withstand current test** - The highest short-circuit current densities.

e. **Momentary withstand current test** - For comparable bus bracing and spacings, the smallest conductor size, or for comparable bus design, the highest short-circuit current rating.

5.4 Dielectric Tests

Tests shall be performed in accordance with clause 6.2.1 of IEEE C37.20.2-2015.

5.5 Continuous Current Tests

Tests shall be performed in accordance with clause 6.2.2 of IEEE C37.20.2-2015.

5.6 Momentary Withstand Current Tests

Tests shall be performed in accordance with clauses 6.2.3 and 6.2.5 of IEEE C37.20.2-2015.

If provisions are made for accepting a ground and test device for use in the equipment, refer to IEEE Std C37.20.6™ for an additional test for the enclosure ground connection.

5.7 Short-Time Withstand Current Tests

Tests shall be performed in accordance with clause 6.2.4 of IEEE C37.20.2-2015.

If provisions are made for accepting a ground and test device for use in the equipment, refer to IEEE Std C37.20.6™ for an additional test for the enclosure ground connection.

5.8 Mechanical Performance Tests

Tests shall be performed in accordance with clause 6.2.6 of IEEE C37.20.2-2015.

The test requirements in clause 6.2.6 of IEEE C37.20.2-2015 for separable primary and control contacts and interlock checks shall be met for drawout Control Power Transformer Primary Fuses, drawout Control Power Transformers, and drawout Voltage Transformers in addition to circuit breakers.

5.9 Accessory Device Tests

5.9.1 General Accessory Devices

General accessory devices, as contrasted with functional components, are those devices that are not required for proper operation of a circuit breaker, but perform a secondary or minor function as an adjunct or refinement to the primary function of the circuit breaker. No additional conformance testing shall be required.

5.9.2 Housing-Mounted Accessory Devices

Housing-mounted accessory devices (e.g., mechanism-operated cell (MOC) or truck-operated cell (TOC) auxiliary switches) shall conform to the requirements of their applicable device Standards and shall not be tested electrically or mechanically other than to demonstrate performance as specified in this Standard.

5.9.3 Mechanical Accessory Devices

When accessory devices are mechanical only (e.g., key interlocks, and the like, which are operated rather infrequently), normal production tests shall be the criteria for demonstrating the operational performance of these devices.

5.10 Isolating Switch Tests

The isolating switches used in MC switchgear shall meet the conformance test requirements described in ANSI C37.58. If the isolating-switch compartment is physically equivalent to the isolation-switch test enclosure, no additional conformance testing in accordance with this Standard shall be required.

5.11 Drawout Interrupter Switch Tests

Draw out interrupter switches used in MC switchgear shall conform to the continuous current requirements in clause 6.2.2 of IEEE Std. C37.20.2. If the interrupter-switch compartment is physically equivalent to the interrupter-switch test enclosure (described in ANSI C37.58) and the interrupter-switch vertical section is identical to the circuit breaker vertical section, no additional conformance testing in accordance with this Standard shall be required. If the interrupter-switch vertical section is not identical to the circuit breaker vertical section, the conformance test requirements described in ANSI C37.58 shall apply.

5.12 Enclosure Conformance Tests

Enclosure conformance tests shall be conducted to complete the provisions of this Standard as applicable to the specified Category Type A, B, or C, as defined in clause B.2 of IEEE Std. C37.20.2-2015.

5.12.1 Category A Enclosure Conformance Tests

Tests shall be performed in accordance with clause 4.3.1of IEEE Std. C57.12.28-2014.

5.12.2 Category B Enclosure Conformance Tests

Tests (as applicable) shall be performed in accordance with the referenced clause of IEEE C37.20.2-2015 as follows:

Deflection test	B.3.1.2
Torsion test	B.3.1.3
Rod entry tests	B.3.3.2
Viewing panes tests	B.3.6
Outdoor enclosure tests	B.3.8.2
Gasketed joint test	B.3.8.3

5.12.3 Category C Enclosure Conformance Tests

No enclosure security tests are required for Category C equipment.

6 Treatment of Nonconforming Results

When nonconforming results occur during testing, the nonconformance shall be evaluated and corrected, and the equipment shall be retested. A design change made to the MC switchgear to correct a nonconformance shall be evaluated for its effect on preceding tests.

When analysis indicates that a particular corrective action would not have affected results obtained in previous tests, it shall be permitted to take the corrective action without repeating the previously completed tests.

When analysis indicates that a particular corrective action may have caused a nonconformance in tests previously completed, only those potentially affected tests shall be repeated on the MC switchgear to which the corrective action has been applied. In deciding whether or not to repeat a previous test, it is important that the decision is based on the corrective action taken and not on the nonconformance that occurred.

7 Production Tests (Routine tests)

7.1 General

Unless otherwise specified, all production tests shall be made by the manufacturer at the factory on the complete MC switchgear or its component parts for the purpose of checking the correctness of manufacturing operations and materials (See IEEE Std. C37.20.2). Drawout circuit breakers need not be tested in the assembly if they are tested separately.

Production tests shall include the following:

a. Dielectric withstand voltage tests (7.2)

b. Mechanical operation tests (7.3)

c. Grounding of instrument transformer cases tests (7.4) (if instrument transformers are of metal case design)

d. Electrical operation and wiring tests (7.5)

7.2 Dielectric Withstand Voltage Tests

Tests shall be performed in accordance with clause 6.3.1 of IEEE C37.20.2-2015.

7.3 Mechanical Operation Tests

Tests shall be performed in accordance with clause 6.3.2 of IEEE C37.20.2-2015.

7.4 Grounding of Instrument Transformer Cases Tests

Tests shall be performed in accordance with clause 6.3.3 of IEEE C37.20.2-2015.

7.5 Electrical Operation and Wiring Tests

Tests shall be performed in accordance with clause 6.3.4 of IEEE C37.20.2-2015.

8 Retesting

8.1 General

Retesting is not required if the design has not changed. A design change made to the MC switchgear shall be evaluated for its effect on rated performance. If it is determined that performance may be affected by the change, the relevant conformance tests shall be repeated.

8.2 Evaluation of Changes Made in Insulating Materials and Systems

The original design of the insulation system of the switchgear assembly shall be in conformance with the requirements of the clause "Insulating materials for covering buses and connections" of IEEE Std. C37.20.2.

This section of this Standard is to provide a method for evaluating substitute insulating materials and systems so that changes made in these materials and systems may be evaluated without performing a complete series of conformance tests on the switchgear equipment.

8.2.1 Requirements

This section defines the requirements that must be met by various types of insulating materials for materials substitution.

8.2.1.1 Nonceramic Insulation

8.2.1.1.1 Resistance to Long-Term Aging

Resistance to long-term aging shall be demonstrated by one or more of the methods listed in 8.2.1.1.1.1 and 8.2.1.1.1.2.

8.2.1.1.1.1 Relative Thermal Indexes of the Material

The relative thermal indexes of the material shall be determined in accordance with ANSI/UL 746B for each thickness of the material used. Under normal operating conditions, a material used for an insulation function shall not be exposed to temperatures in excess of its relative thermal indexes for the thickness used. Table 1 specifies which relative thermal indexes are to be considered for each insulating function.

8.2.1.1.1.2 Substitute Material

If it is desired to substitute a material for a previously qualified material, the substitute material will be considered to have satisfactory long-term aging characteristics if it has relative thermal indexes equal to or greater than the relative thermal indexes of the previously qualified material. The relative thermal indexes to be compared are those required for the insulation function under consideration, as listed in Table 1.

Table 1 Relative Thermal Indexes and Insulating Functions

Line No.	Insulation Function	Relative Thermal Index		
		Electrical	Mechanical without-impact	Mechanical with-impact
1	Bus	X	-	X
2	Bus joint	X	-	-
3	Bus tap	X	-	X
4	Bus support	X	-	X
5	Barriers, Type 1	X	X	-
6	Barriers, Type 2	X	-	X
7	Entrance bushings	X	-	X
8	Circuit breaker primary disconnects	X	-	X

8.2.1.1.2 Thermal Cycling Withstand

Substitute circuit breaker primary disconnects, entrance bushings, and bus and bus tap insulation applied to conductors by dipping, molding, fluidized bed coating, or other process that causes the insulation to adhere to the conductor shall meet the requirements for thermal cycling found in clause 6.2.7.3 of IEEE Std. C37.20.2-2015.

8.2.1.1.3 Dielectric Withstand

8.2.1.1.3.1 Substitute Bus Insulation, Bus Joint Insulation, and Bus Tap Insulation

Substitute bus insulation, bus joint insulation, and bus tap insulation shall pass the test for bus bar insulation in accordance with 6.2.1.3 (foil test) of IEEE Std. C37.20.2-2015.

8.2.1.1.3.2 Bus Support Insulation and Barrier Insulation

If it is desired to substitute another insulating material for the one used in the dielectric tests, the substitute material will be considered to have adequate dielectric strength if its perpendicular electric strength equals or exceeds the perpendicular electric strength of the original material. Measurement of perpendicular electric strength shall be in accordance with the short term-method in air described in ASTM D149. (The use of the short-term method under oil shall be permitted if the two insulating materials being compared are of the same generic type).

8.2.1.1.4 Flammability

8.2.1.1.4.1 Flame-Resistant Sheet or Cast Insulating Materials Used in Any Application

Substitute flame-resistant Rigid sheet, molded or cast insulating materials used in any application other than Type 1 barriers shall meet the requirements for rigid sheet, molded, or cast insulating materials found in clause 6.2.7.1.1 of IEEE Std. C37.20.2-2015.

8.2.1.1.4.2 Flame Resistant Sheet or Cast Insulating Materials Used as Type 1 Barrier

Substitute flame-resistant Rigid sheet, molded or cast insulating materials used in an application as a Type 1 barrier shall meet the requirements for rigid sheet, molded, or cast insulating materials found in clause 6.2.7.1.2 of IEEE Std. C37.20.2-2015.

8.2.1.1.4.3 Substitute Bus Joint Insulation

Substitute bus joint insulation shall meet the requirements for bus joint insulation found in clause 6.2.7.1.3 of IEEE Std. C37.20.2-2015.

8.2.1.1.4.4 Substitute Flame-Resistant Applied Insulation

Substitute flame-resistant applied insulation (such as fluidized bed systems, tape systems, shrinkable-type tubing, and the like) shall meet the requirements for applied insulation found in clause 6.2.7.1.4 of IEEE Std. C37.20.2-2015.

8.2.1.1.5 Tracking Resistance

Substitute bus-support insulation, Type 2 barrier insulation, entrance bushings, and circuit breaker primary disconnects shall meet the requirements for tracking resistance found in clause 6.2.7.2 of IEEE Std. C37.20.2-2015.

8.2.1.1.6 Volume Resistivity of Loss Index

For circuit breaker primary disconnects, the electrical losses of a substitute material will be judged acceptable provided either the volume resistivity (ASTM D257) is greater than [or the loss index (ASTM D150) is less than] or equal to that of the previously acceptable material.

8.2.1.1.7 Deflection Capability or Flexural Strength

8.2.1.1.7.1 Bus Insulation.

If it is desired to substitute another insulating material for the one used in the momentary withstand current test, the substitute material will be considered to have adequate deflection capability if it provides equivalent or greater performance, as shown by testing in accordance with the deflection test in 8.2.2.2.

8.2.1.1.7.2 Entrance Bushings

A substitute bushing for the one used in the momentary current test is considered to have adequate deflection capability if the substitute has equivalent strength, as shown by testing in accordance with the deflection test in 8.2.2.3.

8.2.1.1.7.3 Circuit Breaker Primary Disconnects

Substitute material for use in the same design will be considered to have adequate flexural strength if its flexural strength (ASTM D790) equals or exceeds the value of the original material.

8.2.1.1.8 Impact Strength

8.2.1.1.8.1 Bus Insulation

If it is desired to substitute another insulating material for the one used in the momentary withstand current test, the substitute material will be considered to have adequate impact strength if its impact strength as measured by the falling-dart impact test described in ASTM D5628 equals or exceeds the impact strength of the original material.

8.2.1.1.8.2 Bus Support Insulation, Type 2 Barriers, and Circuit Breaker Primary Disconnects

If it is desired to substitute another insulating material for the one used in the momentary current test, the substitute material will be considered to have adequate impact strength if its notched Izod impact strength as measured in accordance with ASTM D256 equals or exceeds the impact strength of the original material.

8.2.1.1.9 Creep Resistance

8.2.1.1.9.1 Bus and Bus Tap Insulation.

If this property is judged to represent a potential problem in a specific design, it shall be given special consideration when a substitute material is being evaluated.

8.2.1.1.9.2 Circuit Breaker Primary Disconnects

A substitute material will be judged to have acceptable creep resistance provided a bar with a span of 4 inches (102 mm) loaded to a maximum stress of 1,000 pounds per square inch (70.31 kilograms per square centimeter) and tested at 105°C for 24 hours has creep equal to or less than the original material. The specimen supports, deflection-measuring device, and the weight necessary to obtain a maximum fiber stress of 1,000 pounds per square inch (70.31 kilograms per square centimeter) are adequately described in ASTM D648.

8.2.1.1.10 Recognized Materials

Substitute materials recognized as NEMA Grade GPO-3, as described in paragraphs LI 1-15.07 through LI 1-15.15 of NEMA LI 1, and having thermal indexes in accordance with NEMA LI 6, shall be considered to be suitable for replacement of GPO-3 Type 1 or Type 2 barriers or bus support insulation without further testing. Materials recognized as NEMA Grade GPO-2 shall also be considered to be suitable for replacement of GPO-2 Type 1 or Type 2 or bus support insulation without further testing.

8.2.1.2 Ceramic-Insulation Deflection Capability, Impact Strength, and Compressive Strength

A substitute bushing or disconnect for the one used in the momentary withstand current test is considered to have adequate capabilities if the substitute has equivalent cantilever strength, as shown by testing in accordance with the deflection test of 8.2.2.3.

8.2.1.3 Indoor-Apparatus Insulators

A special class of bus support insulators, indoor apparatus insulators, is available both in ceramic and nonceramic varieties. These insulators are defined and described in ANSI/NEMA C29.10.

If an indoor-apparatus insulator of a particular voltage and strength class (e.g., 15 kilovolts, A20) has been qualified by testing, another insulator recognized as being of the same voltage and strength class may be substituted without further dielectric or mechanical testing. If the substitute insulator is not ceramic, it must meet the requirements stated in 8.2.1.1.4 for flammability, in 8.2.1.1.1 for resistance to long-term aging, and in 8.2.1.1.5 for tracking resistance.

Insulators having the same height, electrical properties and strength as indoor apparatus insulators described in ANSI/NEMA C29.10, but differing in such properties as the size, number, and location of bolt holes or the diameter of the insulating column may be substituted for each other in accordance with this subsection.

8.2.1.4 Composite Insulating Systems

It is recognized that a single insulating function may be performed by a composite insulating system consisting of several insulating materials. When it is desired to substitute a different material for one or more of the materials in a composite insulating system, it shall be determined which properties are required of each material in the composite system. Only those properties required of the material being replaced need be evaluated in accordance with this Standard.

8.2.2 Tests

Most of the tests required are detailed in other Standards, which are referenced under the requirements for each type and function of insulation in Section 8.2.1. Tests that are not described elsewhere are described in 8.2.2.1 through 8.2.2.3 and are referenced in the appropriate portions of Section 8.2.1.

8.2.2.1 Thermal Cycling Withstand

Substitute insulation applied to conductors by dipping, molding, fluidized bed coating, or other process that causes the insulation to adhere to the conductor, must not be damaged by variations in temperature as described in the following steps a to d. Test bars with insulation applied of both original and substitute material shall be subjected to a thermal cycling test consisting of ten cycles of alternate heat and cold. Each cycle shall consist of four steps, as follows:

a. Soak in a cold chamber at −30°C or lower for a minimum of eight hours.

NEMA Standards Publication SG 10-2019

Guide to OSHA and NFPA 70E Safety Requirements
When Servicing and Maintaining Medium-Voltage Switchgear, Circuit Breakers,
and Medium-Voltage Controllers Rated above 1000 V

Published by

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1300 North 17th Street, Suite 900
Rosslyn, Virginia 22209

www.nema.org

NOTICE AND DISCLAIMER

Foreword

This guide was written to emphasize basic principles and guidance for safety when performing inspection, operation, and maintenance of medium-voltage switchgear, circuit breakers, and medium-voltage controllers rated above 1000 V. It also draws the reader's attention to important OSHA and NFPA safety Standards. Proposed or recommended revisions should be submitted to:

NEMA Technical Operations Department
National Electrical Manufacturers Association
1300 North 17th Street, Suite 900
Rosslyn, VA 22209

This guide was developed by the Switchgear Section of the Power Equipment Division. Section approval of the guide does not necessarily imply that all section Members voted for its approval or participated in its development. At the time this guide was approved, the Section was composed of the following Members:

Organization Name	**City**	**State**
ABB Inc.	Cary	NC
Eaton	Cleveland	OH
Federal Pacific	Bristol	VA
G&W Electric Company	Bolingbrook	IL
GE Grid Solutions	Charleroi	PA
Hubbell Incorporated	Shelton	CT
Mersen USA Newburyport-MA, LLC	Newburyport	MA
Mitsubishi Electric Power Products, Inc.	Warrendale	PA
S&C Electric Company	Chicago	IL
Schneider Electric	Boston	MA
Siemens Industry, Inc.	Norcross	GA
Toshiba International Corporation USA	Houston	TX
Z Power & Distribution Inc.	Anaheim	CA

CONTENTS

Section 1
General

1.1 Scope

The main objective of this guide is to enhance electrical safety awareness and mitigate electrical hazards to Members of the workforce assigned to servicing and maintaining switchgear, owners, and users of the equipment, and the public. The goal of this guide is to ensure the adoption of OSHA and NFPA 70E safety-related practices for electrical work and requirements of electrical safety.

Provisions contained herein are applicable to all Members of the workforce who are engaged in testing, servicing, maintaining, and decommissioning switchgear, circuit breakers, and controllers rated above 1000 V.

This guide emphasizes OSHA and NFPA 70E safety requirements when servicing and maintaining equipment covered in, but not limited to, the following Standards:

a. Medium-voltage metal-clad switchgear assemblies (rated 1000 through 38,000 V) in accordance with ANSI/IEEE C37.20.2, *Standard for Metal-Clad Switchgear*
b. Medium-voltage metal-enclosed switchgear assemblies (rated 1000 through 38,000 V) in accordance with ANSI/IEEE C37.20.3, *Standard for Metal-Enclosed Interrupter Switchgear*
c. Circuit breakers rated above 1000 V in accordance with ANSI/IEEE C37.04, Standard Rating *Structure for AC High-Voltage Circuit Breakers*
d. Medium-voltage controllers in accordance with UL 347, *Medium-Voltage AC Contactors, Controllers, and Control Centers*
e. Medium-voltage pad-mounted switchgear (rated 1,000 through 38,000 V) in accordance with IEEE C37.74, *Standard Requirements for Subsurface, Vault, and Pad-Mounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems Up to 38 kV*.
f. C37.60, IEEE/IEC International Standard—High-voltage switchgear and controlgear—Part 111: Automatic circuit reclosers and fault interrupters for alternating current systems up to 38kV

For convenience, this equipment will be called switchgear assemblies. Switchgear assemblies and controller assemblies may contain but are not limited to devices such as power circuit breakers, contactors, interrupter switches, selector switches, power fuses, controls, instrumentation, metering, and other protective equipment. These assemblies may be part of unit substations.

1.2 Purpose

The provisions of the *National Electric Code®* (NEC), *Standard for Electrical Safety in the Workplace,* NFPA 70E, *National Electric Safety Code* (NESC), and OSHA Standards contained in this guide should be complied with at all user-controlled premises. These guidelines have specific requirements that apply to installations, servicing, and maintaining switchgear regardless of when they were designed or installed and are considered essential for ensuring workplace safety.

1.3 General Considerations

Working on or around electrical equipment is potentially dangerous, and accidents in the course of maintaining and servicing electrical equipment can lead to death or serious injury. These accidents do not have to happen. Almost all accidents can be avoided if OSHA and NFPA Standards, as well as the operation and maintenance instructions for the equipment, are carefully followed. Read and understand them fully before work is started! A few examples by which maintenance and service personnel might avoid serious injury or death when working around electrical equipment:

a. If you are tired or stressed, take a break from work and avoid the risk of a serious accident that might be caused by worker fatigue or stress.
b. Do not assume that a conductor is de-energized. A false assumption can lead to serious injury or death. Confirm that a conductor is de-energized and grounded before working on electrical equipment.
c. Do not assume that electrical equipment is de-energized. Again, a false assumption can lead to serious injury or death. Review the entire operation sequence for disconnecting and grounding with a second knowledgeable person before doing the work, and make sure the entire sequence for disconnecting and grounding is followed. Failure to follow the entire operation sequence could lead to serious injury or death.
d. Do not rely on interlocks and other indicators to prevent an accident. Relying on interlocks and indicators is not a substitute for following the entire operation sequence for disconnecting and grounding electrical equipment to de-energize and avoid the risk of death or serious injury. Interlocks are only a backup.
e. Follow the Standards and recommended practices developed by OSHA and NFPA 70E.

The purpose of this guide is to alert operating and maintenance personnel who service and maintain switchgear assemblies to federally required safety procedures in OSHA 29 CFR Parts 1910 and 1926, and NFPA 70E. This guide is based on the versions of OSHA and NFPA 70E Standards in effect when this guide was prepared (2019).

This guide DOES NOT include all of the requirements in the OSHA and NFPA 70E Standards. Users of this guide are responsible for understanding all of the applicable requirements in these Standards and in any other codes and Standards in effect for their installations. This guide also does not address the tasks required during maintenance (e.g., removal of arc chutes, cleaning of insulation, lubrication, which are discussed in the instruction manuals for the specific equipment).

1.4 Safety

Always assume that hazardous voltage is present in switchgear assemblies unless proven to be in an electrically safe work condition as defined in NFPA 70E. This voltage can cause serious injuries, such as a shock or burn, or even death. Only qualified persons should be allowed to operate, inspect, or maintain switchgear assemblies.

Additional hazards that might be present include arc flash, acoustic shock, and toxic byproducts caused by an internal arcing fault and other sources of energy, such as mechanical energy.

OSHA and NFPA Standards contain requirements for a continuing safety program, training personnel, and performing work safely. The manufacturer neither condones nor assumes any responsibility for practices that deviate from those requirements.

Appropriate warning signs should be displayed on the switchgear. These signs should follow ANSI and OSHA requirements for warning signs and typically provide the following information:

a. Alert personnel to the level of the hazard.
b. State the hazard clearly.
c. Describe the consequences.
d. Give instructions on how to avoid the hazard.

Inspection or maintenance on switchgear assemblies should be performed in accordance with safety procedures listed in OSHA 29 CFR 1910.333, NFPA 70E Chapter 2, NFPA 70B Chapter 6, and the manufacturer's service instructions. The basic requirements include, but are not limited to, the following:

a. All sources of power to the equipment have been turned off, including possible back feed sources. See the note under Section 4.2.

b. All power sources have been locked out and tagged out.
c. Adequate visible grounding connections have been applied.

1.5 References

The following normative documents contain provisions, which through reference in this text, constitute provisions of this Standards Publication. By reference herein, these publications are adopted, in whole or in part as indicated, in this Standards Publication. Use the latest version, including amendments.

American National Standards Institute (ANSI)
11 West 42nd Street
New York, NY 10036

ANSI C2	*National Electrical Safety Code*

National Fire Protection Association (NFPA)
1 Batterymarch Park
Quincy, MA 02169-7471

ANSI/NFPA 70	*National Electrical Code®*
ANSI/NFPA 70B	*Recommended Practice for Electrical Equipment Maintenance*
ANSI/NFPA-70E	*Standard for Electrical Safety in the Workplace*

IEEE
3 Park Avenue
New York, NY 10016-5997

ANSI/IEEE C37.04	*Standard Rating Structure for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V*
ANSI/IEEE C37.20.2	IEEE *Standard for Metal-Clad Switchgear*
ANSI/IEEE C37.20.3	IEEE *Standard for Metal-Enclosed Interrupter Switchgear*
ANSI/IEEE C37.20.6	IEEE *Standard for Medium-Voltage Ground and Test Devices Used in Enclosures*
ANSI/IEEE C37.74	IEEE *Standard Requirements for Subsurface, Vault, and Pad-Mounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems Up to 38 kV*
IEEE Standard 902	*IEEE Guide for Maintenance, Operation, and Safety of Industrial and Commercial Power Systems (IEEE Yellow Book)*
IEEE Standard 510	IEEE *Recommended Practices for Safety in High-Voltage and High Power Testing*
IEEE 1584	*IEEE Guide for Performing Arc-Flash Hazard Calculations*
IEEE/IEC C37.60	*High-voltage Switchgear and Controlgear - Part 111: Automatic circuit reclosers and fault interrupters for alternating current systems up to 38 kV*

American Society for Testing and Materials (ASTM)
100 Barr Harbor Drive
PO Box C700
West Conshohocken, PA 19428-2959

ASTM F855	*Specifications for Temporary Protective Grounds to be Used on De-energized Electric Power Lines and Equipment*

Occupational Safety and Health Administration (OSHA)
200 Constitution Avenue, NW
Washington, DC 20210

OSHA 29 CFR Part 1910	*Occupational Safety and Health Standards*
OSHA 29 CFR Part 1926	*Safety and Health Regulations for Construction*

Underwriters Laboratories
Comm-2000
1414 Brook Drive
Downers Grove, IL 60515

UL 347	*Medium Voltage AC Contactors, Controllers, and Control Centers*

U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585

10 CFR 851	*Worker Safety and Health Program*
DOE O 440.1A	*Worker Protection Program for DOE (including the National Nuclear Security Administration), Federal Employees Guide for Use with DOE O 440.1B*
DOE O 430.1B	*Real Property Asset Management*

In addition to the above documents, safety procedures and programs established by the owner of the facility, prime contractors, and equipment supplier's recommendations should be coordinated in developing a safety program to which to adhere.

Section 2
Definitions

2.1 Qualified Persons

OSHA 29 CFR 1910.399 defines a qualified person as "one who has received training in and has demonstrated skills and knowledge in the construction and operation of electric equipment and installations and the hazards involved." NFPA 70E Article 100 defines a qualified person as "one who has demonstrated skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to identify and reduce the associated risks."

NFPA 70E Article 110 also states, "a qualified person shall be trained and knowledgeable of the construction and operation of equipment or a specific work method and be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method. Such persons shall also be familiar with the proper use of special precautionary techniques, PPE*, insulating and shielding materials, and insulated tools and test equipment. A person can be considered qualified with respect to certain equipment and methods but still be unqualified for others."

Note: PPE—personal protective equipment, including arc-flash suit, insulating gloves, etc.

2.2 Approach Boundaries

Refer to NFPA 70E Article 130.4 for specific requirements regarding distances from exposed energized electrical conductors and circuit parts that define approach boundaries.

Section 3
Training

In accordance with 29 CFR 1910.332 and NFPA 70E Chapter 1, all personnel associated with maintenance or service of switchgear assemblies should be qualified. They should be trained in:

a. Safety-related work practices and procedural requirements necessary to provide protection from electrical hazards
b. The ability to identify and understand the relationship between electrical hazards and possible injury
c. The skills and techniques that are necessary to distinguish exposed energized parts from other parts of electrical equipment
d. The skills and techniques that are necessary to determine the nominal voltage of exposed energized parts
e. Approach distances specified in 29 CFR 1910.333 and the shock protection boundaries and approach boundaries specified in NFPA 70E Chapter 1
f. Decision-making process necessary to determine the extent of the hazard and the personal protective equipment and job planning required to perform the task safely

Qualified persons should also be trained in and familiar with:

a. Lockout/tagout procedures specified in 29 CFR 1910.147 and NFPA 70E
b. Proper use of and maintenance of personal and other protective equipment as specified in NFPA 70E
c. Proper use of test equipment
d. Proper procedures to apply temporary protective grounds
e. Electrical equipment in general, as well as the particular model of equipment involved

Section 4
Job Plan

4.1 Job Plan Creation

Before servicing, maintaining, or performing diagnostic routines on switchgear assemblies, a job plan in accordance with NFPA 70E Chapter 1 is required. See Appendix A for an example. Established Standards and regulations related to maintenance, operation, installation, and safety, including OSHA requirements, *National Electric Safety Code* (ANSI C2), *National Electric Code*® (NEC, NFPA 70), *Recommended Practices for Electrical Equipment Maintenance* (NFPA 70B), and *Standard for Electrical Safety in the Workplace* (NFPA 70E) should be available, closely studied, and followed.

4.2 Job Briefing

The person in charge of servicing, maintaining, or diagnostic routines on switchgear assemblies should be qualified and responsible in accordance with NFPA 70E. That person should conduct a job briefing with all employees involved at the beginning of each day and each shift, and audit practices to assure conformance. The job briefing should include, but is not limited to:

a. Tasks and objectives
b. Electrical system parameters
c. Voltages (line-to-line)
d. Short-circuit current available at equipment
e. Power sources and protective device(s) fault clearing time
f. System single-line or three-line electrical diagrams
g. Approach boundaries per NFPA 70E Chapter 1
h. All sources of power, including back feed sources (see note below)
i. Hazards
j. Work procedures
k. Energy source controls
l. Personal protective equipment
m. Testing and service equipment
n. Safety grounding equipment
o. Lockout and tagout procedures and materials
p. Switchgear assembly information, including modifications after installation
q. Manufacturer's instruction books, recommended practices, and checklists
r. Manufacturer's outline, schematic, and detail wiring drawings, including modifications after installation
s. Nameplate data and information
t. Review local safety procedures with responsible persons
u. Review and understand the consequences of actions (and failure to act) on other operations at a facility

Note: "Back feed" refers to any possible source of conductors' energization from other than the normal source. This can include sources such as test equipment, generators, alternate sources, emergency sources, temporary connections, and many other sources of voltage (intentional or unintentional). Take special precautions to isolate control and instrument transformers from their primary circuits prior to injecting any secondary test voltage.

Section 5
Emergency Plan

Emergency plans include the following items as a minimum:

a. Communications
b. First aid per 29 CFR 1910.151
c. CPR per 29 CFR 1910.269(b)(1)
d Medical services availability and evacuation plan per 29 CFR 1910-38(c)(2) and 29 CFR 1926 Subpart C

Section 6
Area Security

Barricades (tapes, cones, fences, or metal structures) should be erected in the work area to provide warning and to limit access to a hazardous area. Refer to 29 CFR 1910.335 and NFPA 70E Chapter 1.

Section 7
Removing Equipment from Service

The ’individual’s correct sequence of actions while performing service or maintenance is essential to prevent accidents. Each ’person’s knowledge, mental awareness, and planned and executed actions often determine whether an accident will occur.

Incorrect procedures, unplanned energization from potential sources of back feed, and/or equipment malfunctions, among other reasons, are causes of accidents around electrical equipment. Only a qualified person should be allowed to de-energize equipment and remove it from service. The following summarizes typical safety practices, including those required by OSHA and NFPA:

a. Assume all conductors are energized unless properly grounded.
b. Wear proper personal protective equipment.
c. Disconnect all primary sources of electrical power.
d. Disconnect all control power sources.
e. Isolate voltage transformers and control power transformers at the primary and secondary connections.
f. Lockout/tagout all sources of energy, including control power.
g. Test for absence of voltage using a testing device intended for the voltage. See Section 7.1.
h. Interlocks, position indicators, and visual inspection alone do not guarantee personal safety.
i. Apply temporary protective grounds in accordance with Section 7.2.
j. Have another qualified person conduct a safety check to ensure circuits are de-energized, tagged out/locked out, and properly grounded.

7.1 Voltage Detection

Voltage detection should be performed only by a qualified person who is properly trained in accordance with 29 CFR 1910.333(b) (2) (iv) (B) and NFPA 70E Chapter 1. The procedure below summarizes typical safety practices used when de-energizing circuits or equipment, including those required by OSHA and NFPA.

a. Test voltage detector operation against known voltage source (at the same voltage as the operating voltage of the circuit to be tested).
b. Test circuit to be serviced or grounded for the absence of voltage.
c. Retest voltage detector operation against known voltage source (at the same voltage as the operating voltage of the circuit tested) to verify that the voltage detector has not failed.

Some equipment might have a built-in voltage detection system, which can be used provided the system can be tested to prove that it is in working condition. Follow items 1-3 above.

7.2 Grounding

Temporary protective grounding equipment should be applied. Refer to 29 CFR 1910.269.

The grounding conductors and connections should be in good condition and adequate to carry full fault current from all possible sources for the maximum duration required for the protective equipment to clear the circuit. Refer to NFPA 70E Chapter 1.

Some equipment might have built-in grounding switches. These can be used with, or in place of, temporary protective grounds.

7.3 Lockout/Tagout Procedures

Tags, by themselves, are not adequate to ensure that a circuit will remain de-energized. Lockout/tagout requirements are found in 29 CFR 1910.147 and 1910.333, and NFPA 70E Article 120.

Section 8
Returning Equipment to Service

Only a qualified person should be allowed to re-energize equipment and return it to service. The following points summarize typical safety practices, including those required by OSHA and NFPA:

a. Inspect equipment for tools, loose wires, test jumpers, temporary protective grounds, etc.
b. Test as required (e.g., power frequency withstand voltage test, megger).
c. Inform facility personnel of pending equipment energization.
d. Follow the manufacturer's instructions.
e. Clear area of personnel.
f. Wear proper personal protective equipment.
g. Remove temporary protective grounds or open grounding switches.
h. Remove lockout tags and locks.
i. Energize control circuits.
j. Secure all doors, covers, latches, and other points of access.
k. Restore equipment to operating configuration.

Section 9
Recordkeeping and Responsibilities of Individuals

9.1 Recordkeeping

All field testing records, including replacement of parts, repairs, equipment maintenance, inspection records, and personnel training records, must be maintained.

9.2 Responsibilities of Individuals

It is the responsibility of all levels in the organization, from management to Members of the workforce, to ensure a safe workplace where the level of risk from electrical hazards that might cause injury, illness, or death is as low as reasonably achievable. Managers shall expect all personnel to comply with these regulations.

Members of the workforce are expected to report immediately to management any unsafe conditions and stop work until the condition is corrected.

While the work is performed, field supervision should be assigned to a qualified person who is given the responsibility to observe the workers and operations being performed, prevent careless acts, quickly de-energize the equipment in emergencies, and alert emergency personnel, and who has completed CPR training.

Appendix A
Job Plan Example
for Servicing and Maintaining Switchgear Assemblies

1. Voltage Level Involved

Main circuit voltage (phase to phase) ______________
Control voltage (max) _____________

2. Flash Protection required per NFPA 70E guidelines?

YES_____NO ______

3. Personal Protection (per OSHA, NEC & NFPA 70E)

3.1 Approved type test equipment to be used:

a. Voltage sensing, Contact_____________ Non-contact _____________________________
b. Voltage measurement_______________Current Measurement________________________
c. Thermographic______________________Phasing___________________________________
d. Other____

3.2 Type of hand shock protection (insulated gloves), voltage rated with protectors:

___500 V (“Class 00”) ____1,000 V (“Class 0”) ____7.5 kV (“Class 1”)
___17 kV (“Class 2”) ____26.5 kV (“Class 3”) ____36 kV (“Class 4”)
Other ____

3.3 Flash protection required; body part protection level:

a. Total Body Protection ____
b. Eye Protection____
c. Hand ____
d. Head Protection (face, neck, and chin) ____
e. Foot and Leg Protection____
f. Ear Protection ____
g. Other ____

3.4 Other protective equipment and considerations

a. Guarded/Insulated Tools ____
b. Insulate Worker from Ground ____
c. Hard Hat/Safety Glasses ____
d. Safety Grounds or Grounding Switches ____________________________________
e. Discharge Grounds ____
f. Fall Protection ____
g. Non-Conductive Ladders ____
h. Other ____

3.5 Securing work area

a. Barricades ____
b. Signs ____
c. Person(s) ____
d. Other ____

4. Equipment on which work is to be performed

a. Location____
b. Manufacturer ____
c. Model ____
d. Type: Metal-Clad Switchgear__________Metal-Enclosed Interrupter Switchgear __________
Circuit Breaker ______________
e. Voltage Class ____
f. Year of Manufacture _____________________
g. Serial Number ____
h. Number of Cubicles, Sections or Circuit Breakers___________________________________
i. Indoor____________Outdoor _____________
j. Condition ____
k. Visual Inspection Findings: Is there adequate:
l. Working space Yes_____No ______
m. Lighting Yes_____No ______
n. Access/Egress Yes_____No ______

5. Verification of Information: References Used to Prepare the Plan

a. Single Line Diagram No.____
b. Schematic Diagram No.____
c. Manufacturer Manuals____
d. Other documentation ____
e. Are there any back feeds? Yes______No ______
f. Are there any external power sources? Yes______No ______

6. Step-by-Step Written Work Plan

7. Emergency Response Information

a. Nearest Telephone Location____
b. Emergency Response Telephone Number____
c. Fire Extinguisher Location____
d. CPR Trained Person____
e. Other Communication Needs____

8. Review and Authorization

Name/Title______________________________Signature__________________________________

9. Job Plan Review with Person(s) Performing Work

Worker(s) signatures____

§

b. Remove from the cold chamber and allow it to stand at room temperature for two hours.
c. Place in the oven at 105°C or above for four hours.
d. Remove from the oven and allow to stand at room temperature for two hours.

After the tenth cycle is completed, the substitute insulation shall be as free of cracking or other physical damage as the original material.

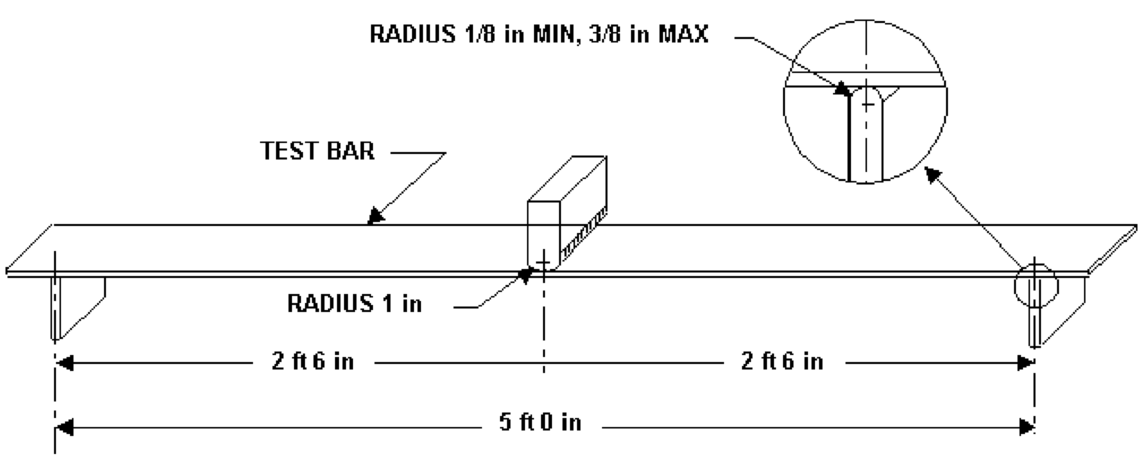
8.2.2.2 Deflection Capability – Bus Insulation

Samples of copper bars 1/4 inch (6.2mm) x 4 inches (102 mm) x a minimum length of 5 feet 6 inches (1.68 m), or aluminum bars 3/8 inch (9.5 mm) x 4 inches (102 mm) x a minimum length 5 feet 6 inches (1.68 m), shall be covered with the insulating material to be investigated and the original material. The tests shall be made on the conductor material being used in the equipment. If both conductor materials are used, both must be tested. The test bars shall be supported on two cylindrical supports having a minimum radius of 1/8 inch (3.1 mm) and a maximum radius of 3/8 inch (9.5 mm) and spaced 5 feet 0 inches (1.52 m) apart. A cylindrical loading nose having a radius of 1 inch (25.4 mm) shall be applied at the center of the span (See Figure A1) with sufficient force to deflect the test specimen 2 inches (50.8 mm) at the rate of 2 (50.8 mm) to 4 inches (101.6 mm) per minute. (If 2 inches (50.8 mm) is too great a deflection for the original qualified material to withstand, the maximum deflection shall be reduced accordingly to provide a comparative test.) The force shall then be removed at the same rate and the test specimen allowed to return to its normal position. The test specimen shall then be turned over and similarly deflected in the opposite direction. It shall be thus deflected five times in each direction, following which 1 inch (25.4 mm) in the center of the specimen shall pass a test for bus bar insulation in accordance with the (foil test) of ANSI/IEEE C37.20.2. The substitute material shall provide equivalent or greater performance.

8.2.2.3 Deflection Capability – Bushings

The bushing shall be rigidly mounted with the load applied normal to the longitudinal axis of the bushing and at the midpoint of the thread or threaded terminals, and at the terminal plate on bushings so equipped. Tests shall be applied to the inner and outer terminals of the bushing, but not simultaneously.

The specified load shall be applied for a period of one minute. After the load has been removed for one minute, the permanent deformation, measured at the inner end, shall not be greater than the deformation of the bushing used in the momentary test.



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AMERICAN NATIONAL STANDARD

APPENDIX B
FREQUENCY OF MAINTENANCE TESTS

an excerpt from the
ANSI/NETA *Standard for Maintenance Testing Specifications* *for Electrical Power Equipment and Systems*

Secretariat
NETA (InterNational Electrical Testing Association)

Approved by
American National Standards Institute

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FOREWORD

(This Foreword is not part of American National Standard ANSI/NETA MTS-2019)

The InterNational Electrical Testing Association (NETA) was formed in 1972 to establish uniform testing procedures for electrical equipment and apparatus. NETA has been an Accredited Standards Developer for the American National Standards Institute since 1996. NETA's scope of standards activity is different from that of IEEE, NECA, NEMA, and UL. In matters of testing electrical equipment and systems NETA continues to reference other standards developers' documents where applicable. NETA's review and updating of presently published standards takes into account both national and international standards. NETA's standards may be used internationally as well as in the United States. NETA firmly endorses a global standardization. IEC standards as well as American consensus standards are taken into consideration by NETA's ballot pools and reviewing committees.

The first NETA *Maintenance Testing Specifications for Electrical Power Equipment and Systems* was published in 1975. Since 1989, revised editions of the *Maintenance Testing Specifications* have been published in 1993, 1997, and 2001.

In 2005, this document was approved for the first time as an American National Standard. It was published as a revised American National Standard in 2011 and in 2015. The 2019 *Standard for Maintenance Testing Specifications for Electrical Power Equipment and Systems* is the most current revision of this document, and was approved as a revised American National Standard on February 4, 2019.

The ANSI/NETA *Standard for Maintenance Testing Specifications for Electrical Power Equipment and Systems* was developed for use by those responsible for the continued operation of existing electrical systems and equipment to guide them in specifying and performing the necessary tests to ensure that these systems and apparatus perform satisfactorily, minimizing downtime, and maximizing life expectancy. This document aids in ensuring safe, reliable operation of existing electrical power systems and equipment. Maintenance testing and understanding the condition of maintenance can identify potential problem areas before they become safety concerns or major problems requiring expensive and time-consuming solutions.

APPENDIX B

Frequency of Maintenance Tests

NETA recognizes that the ideal maintenance program is reliability-based, unique to each plant and to each piece of equipment. NETA's Standards Review Council presents the following time-based maintenance schedule and matrix.

One should contact a NETA Accredited Company for a reliability-based evaluation.

The following matrix is to be used in conjunction with Appendix B, Inspections and Tests. Application of the matrix is recognized as a guide only.

Specific condition, criticality, and desired reliability must be determined to correctly apply the matrix. Application of the matrix, along with the culmination of historical testing data and trending, should provide a quality electrical preventive maintenance program**.**

MAINTENANCE FREQUENCY MATRIX				
		Equipment Condition		
		Poor	**Average**	**Good**
Equipment Reliability Requirement	**Low**	1.0	2.0	2.5
	Medium	0.50	1.0	1.5
	High	0.25	0.50	0.75

APPENDIX B
Frequency of Maintenance Tests

Inspections and Tests
Frequency in Months
(Multiply These Values by the Factor in the Maintenance Frequency Matrix)

Section	Description	Visual	Visual & Mechanical	Visual & Mechanical & Electrical
7.1	Switchgear & Switchboard Assemblies	12	12	24
7.2	Transformers			
7.2.1.1	Small Dry-Type Transformers	2	12	36
7.2.1.2	Large Dry-Type Transformers	1	12	24
7.2.2	Liquid-Filled Transformers	1	12	24
	Sampling	–	–	12
7.3	Cables			
7.3.1	Low-Voltage, Low-Energy	–	–	–
7.3.2	Low-Voltage, 600-Volt Maximum	2	12	36
7.3.3	Medium- and High-Voltage	2	12	36
7.4	Metal-Enclosed Busways	2	12	24
	Infrared Only	–	–	12
7.5	Switches			
7.5.1.1	Air, Low-Voltage	2	12	36
7.5.1.2	Air, Medium-Voltage, Metal-Enclosed	–	12	24
7.5.1.3	Air, Medium- and High-Voltage Open	1	12	24
7.5.2	Oil, Medium-Voltage	1	12	24
7.5.3	Vacuum, Medium-Voltage	1	12	24
7.5.4	Medium-Voltage, SF_6	1	12	24
7.5.5	Cutouts	12	24	24
7.6	Circuit Breakers			
7.6.1.1	Air, Insulated-Case/Molded-Case	1	12	36
7.6.1.2	Air, Low-Voltage Power	1	12	36
7.6.1.3	Air, Medium-Voltage	1	12	36
7.6.2	Oil, Medium-Voltage	1	12	36
	Sampling	–	–	12
7.6.2	Oil, High-Voltage	1	12	12
	Sampling	–	–	12
7.6.3	Vacuum, Medium-Voltage	1	12	24
7.6.4	SF_6	1	12	12
7.7	Circuit Switchers	1	12	12
7.8	Network Protectors	12	12	24

APPENDIX B
Frequency of Maintenance Tests (*continued*)

Inspections and Tests
Frequency in Months
(Multiply These Values by the Factor in the Maintenance Frequency Matrix)

Section	Description	Visual	Visual & Mechanical	Visual & Mechanical & Electrical
7.9	Protective Relays			
7.9.1	Electromechanical and Solid State	1	12	12
7.9.2	Microprocessor-Based	1	12	12
7.10	Instrument Transformers			
7.10.1	Current Transformers	12	12	36
7.10.2	Voltage Transformers	12	12	36
7.10.3	Coupling-Capacitor Transformers	12	12	36
7.11	Metering Devices			
7.11.1	Electromechanical and Solid-State	12	12	36
7.11.2	Microprocessor-Based	12	12	36
7.12	Regulating Apparatus			
7.12.1.1	Step-Voltage Regulators	1	12	24
	Sample Liquid	–	–	12
7.12.1.2	Induction Regulators	12	12	24
7.12.2	Current Regulators	1	12	24
7.12.3	Load Tap-changers	1	12	24
	Sample Liquid	–	–	12
7.13	Grounding Systems	2	12	24
7.14	Ground-Fault Protection Systems	2	12	12
7.15	Rotating Machinery			
7.15.1	AC Induction Motors and Generators	1	12	24
7.15.2	Synchronous Motors and Generators	1	12	24
7.15.3	DC Motors and Generators	1	12	24
7.16	Motor Control			
7.16.1.1	Motor Starters, Low-Voltage	2	12	24
7.16.1.2	Motor Starters, Medium-Voltage	2	12	24
7.16.2.1	Motor Control Centers, Low-Voltage	2	12	24
7.16.2.2	Motor Control Centers, Medium-Voltage	2	12	24
7.17	Adjustable-Speed Drive Systems	1	12	24
7.18	Direct-Current Systems			
7.18.1	Batteries			
7.18.1.1	Flooded Lead-Acid	1	12	12
7.18.1.2	Vented Nickel-Cadmium	1	12	12
7.18.1.3	Valve-Regulated Lead-Acid	1	12	12
7.18.2	Battery Chargers	1	12	12

APPENDIX B
Frequency of Maintenance Tests (*continued*)

Inspections and Tests Frequency in Months (Multiply These Values by the Factor in the Maintenance Frequency Matrix)				
Section	**Description**	**Visual**	**Visual & Mechanical**	**Visual & Mechanical & Electrical**
7.18.3	Rectifiers	1	12	24
7.19	Surge Arresters			
7.19.1	Low-Voltage Surge Protection Devices	2	12	24
7.19.2	Medium- and High-Voltage Surge Protection Devices	2	12	24
7.20	Capacitors and Reactors			
7.20.1	Capacitors	1	12	12
7.20.2	Capacitor Control Devices	1	12	12
7.20.3.1	Reactors, (Shunt and Current-Limiting) Dry-Type	2	12	24
7.20.3.2	Reactors, (Shunt and Current-Limiting) Liquid-Filled	1	12	24
	Sampling	–	–	12
7.21	Outdoor Bus Structures	1	12	36
7.22	Emergency Systems			
7.22.1	Engine Generator	1	2	12
	Functional Testing	–	–	2
7.22.2	Uninterruptible Power Systems	1	12	12
	Functional Testing	–	–	2
7.22.3	Automatic Transfer Switches	1	12	12
	Functional Testing	–	–	2
7.23	Communications - Reserved			
7.24	Automatic Circuit Reclosers and Line Sectionalizers			
7.24.1	Automatic Circuit Reclosers, Oil/Vacuum	1	12	24
	Sample	–	–	12
7.24.2	Automatic Line Sectionalizers, Oil	1	12	24
	Sample	–	–	12
9.	Thermographic Survey	–	12	–
10.	Electromagnetic Field Survey – As Needed	–	–	–
11.	Online Partial Discharge Survey for Switchgear	–	–	12