ANSI C37.57-2003

American National Standard for Switchgear—

Metal-Enclosed Interrupter Switchgear Assemblies—

Conformance Testing

ANSI C37.57-2003

American National Standard
For Switchgear—

Metal-Enclosed Interrupter Switchgear Assemblies—Conformance Testing

Secretariat:

National Electrical Manufacturers Association

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Foreword (This Foreword is not part of American National Standard C37.57-2003.)

This standard has been developed to describe selected tests and procedures to demonstrate conformance in accordance with Section 6 of Tests, of American National Standard for Metal-Enclosed Interrupter Switchgear, ANSI/IEEE C37.20.3-2001. To facilitate its use and to permit timely revisions based on experience, a separate document has been provided.

This standard is one of several in a series of test procedures for conformance testing of switchgear products. Although this standard is written for general guidance, performance criteria are established so that this standard can be adopted as the basis for certification of indoor ac medium-voltage switches for use in metal-enclosed switchgear for nonutility installations subject to regulation by public authorities and similar agencies concerned with laws, ordinances, regulations, administrative orders and similar instruments.

This standard was prepared by a Working Group sponsored by the Power Switchgear Assemblies Technical Committee of the Switchgear Section of the National Electrical Manufacturers Association (NEMA 8SG-V). During the course of its preparation, coordination has been maintained with the Power Switching Equipment Technical Committee of the Switchgear Section of the National Electrical Manufacturers Association (NEMA 8SG-VI) and the Switchgear Committee of the Power Engineering Society of the Institute of Electrical and Electronics Engineers.

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

Suggestions for improvement of this standard will be welcome. They should be sent to the National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1847, 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 C37 Committee had the following members:

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AMERICAN NATIONAL STANDARD ANSI C37.57-2003

For Metal-Enclosed Interrupter Switchgear Assemblies— Conformance Testing

1 Scope

This standard is a conformance testing standard optionally applicable to all metal-enclosed interrupter switchgear assemblies designed, tested, and manufactured in accordance with ANSI/IEEE C37.20.3. The requirement of ANSI/IEEE C37.20.3 is sufficient for application of metal-enclosed interrupter switchgear assemblies, and conformance testing is not necessary to satisfy the basic requirements of that standard. Conformance testing is performed to show compliance with the basic requirements when required to satisfy special agreements or regulatory agency requirements. Conformance testing may be performed associated with the basic design testing if agreeable to those concerned; however, conformance testing is more likely to be performed some time after original development to satisfy a special need. Conformance testing need not be performed if not required.

Metal-enclosed interrupter (MEI) switchgear may include control and instrumentation components unique for the application, which are not individually evaluated under this standard.

NOTE—In this standard, the use of the term "MEI switchgear" shall be considered to mean "metal-enclosed interrupter switchgear."

This standard does not cover equipment intended for use in installations under the exclusive control of electric utilities for the purpose of communication or metering, or for the generation, control, transformation, transmission, and distribution of electric energy located in buildings used exclusively by utilities for such purposes or located outdoors on property owned or leased by the utility or on public highways, streets, or roads, or outdoors by established rights on private property.

NOTE—An electric utility is an entity that is overseen by a public utility commission, a public service commission, or other regulatory agency having jurisdiction for such installations.

1.1 General

This standard specifies the tests that shall be required to demonstrate that the MEI switchgear being tested conforms with the ratings assigned to it and meets the electrical and mechanical performance requirements specified in ANSI/IEEE C37.20.3.

1.2 Definitions

1.2.1 Design tests

Design tests are 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. Design tests may be used to demonstrate compliance with applicable standards of the industry.

NOTES—
(1) 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. These data from previous similar designs may also be used for current designs, where appropriate. Once made, the tests need not be repeated unless the design is changed so as to modify performance.
(2) Design tests are sometimes called "type tests."

1.2.2 Production tests

Production tests 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.

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."

1.2.3 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 Referenced Standards

2.1 Referenced American National Standards

This standard is intended to be used in conjunction with the following American National Standards. When these standards are superseded by a revision approved by the American National Standards Institute, Inc, the revision shall apply.

ANSI C37.55-2003, *Conformance Test Procedure for Metal-Clad Switchgear*[1]

ANSI C37.58-2003, *Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear – Conformance Test Procedures*

ANSI/IEEE C37.09-1999, *Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis*[2]

ANSI/IEEE C37.20.3-2001, *Metal-Enclosed Interrupter Switchgear*

ANSI/IEEE C37.20.4-2001, *Indoor AC Switches (1 kV-38 kV) for Use in Metal-Enclosed Switchgear*

[1] ANSI publications are available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.
[2] ANSI/IEEE publications are available from ANSI or from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331, USA.

ANSI C37.22-1997 (R2003), *Preferred Ratings and Related Required Capabilities for Indoor AC Medium-Voltage Switches Used in Metal-Enclosed Switchgear*

ANSI/IEEE C37.26-1972, *Guide for Methods of Power-Factor Measurement for Low-Voltage Inductive Test Circuits*

IEEE 4-1995, *Techniques for High-Voltage Testing, including IEEE 4a-2001, Amendment to IEEE Standard Techniques for High-Voltage Testing*

3 General Test Conditions

3.1 Ambient conditions

The conditions prevailing at the test site during tests on MEI switchgear shall be those usual service conditions in Section 4 of ANSI/IEEE C37.20.3, except that the temperature of the air surrounding the assembly (ambient) for the continuous current test shall be within the range of 10ºC to 40ºC.

4 Conformance Test Requirements

4.1 General

Tests are made on representative test arrangements of MEI switchgear as described in 4.3 to demonstrate the capability of the MEI switchgear design to meet its assigned ratings and to operate under normal service conditions as outlined in Section 4 of ANSI/IEEE C37.20.3. The interrupter switch design utilized shall be separately qualified in accordance with ANSI C37.58, or shall be tested simultaneously in accordance with this document and ANSI C37.58.

4.2 Test requirements

Representative test arrangements shall be subjected to the following tests, as described in the paragraphs indicated in parentheses, to prove the adequacy of the design:

(1) Dielectric test (4.5)
(2) Mechanical performance test (4.6)
(3) Continuous current test (4.7)
(4) Short-time withstand current test (4.8)
(5) Momentary withstand current test (4.9)

4.3 Test arrangements

Where power fuses are utilized, fuses of the maximum rating shall be included in the test. Two test arrangements are required to verify conformance of units provided with power fuses and similar units without power fuses. When current-limiting fuses are used, an overall rating may be assigned to the combination.

4.3.1 Stationary switch arrangement

The test arrangement shall contain a three-phase interrupter switch (and three power fuses if applicable) with necessary bus and bus supports located in a metal-enclosed structure.

The interrupter switch will be connected to a main bus of the appropriate rating, in accordance with section 5.4.2 of ANSI/IEEE C37.20.3.

The main bus, including a splice, will extend through an insulating plate on the side of the vertical section approximately 12 inches (305 mm) for test connection in accordance with Table 1.

Test connection shall be brought to the interrupter switch terminals (or load side of the fuse terminal) in accordance with Table 1. The connections shall either be brought through the bottom of the vertical section or through a cut-out, insulated and closed on one side near the floor line.

4.3.2 Drawout switch arrangement

If the design of the drawout interrupter switch structure is physically equivalent to the structure for metal-clad switchgear, the requirements of ANSI C37.55 apply.

If the design of the drawout interrupter switch structure is not physically equivalent to the structure for metal-clad switchgear, the test arrangement requirements for the stationary arrangement shall be utilized.

4.4 Commonalities of designs and tests

Due to similarities in design and construction of functional elements used on several different types, styles, models, sizes, or ratings of MEI 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 MEI switchgear performance, and the elements of the MEI switchgear that will be affected. Refer to ANSI/IEEE C37.20.3, ANSI/IEEE C37.20.4, and ANSI C37.22 for the preferred voltage and continuous current ratings of MEI switchgear and the associated interrupter switch fault-making and short-time withstand current capabilities. Representative test arrangements are to be selected from them. The criteria below are intended for information and guidance in the selection of the representative test arrangement for each test and shall not limit its applicability.

(1) Dielectric tests. One test arrangement for each voltage class or the combination of voltage classes that has the most highly electrically stressed insulation; for example, minimum air clearance or shortest creepage path.

(2) Mechanical performance tests. The highest continuous current rating of interrupter switch used with each type of interlocking arrangement.

(3) Continuous current test. The most compact design for each continuous current rating and having the highest current density.

(4) Short-time withstand current test. The highest short-time withstand current densities.

(5) Momentary withstand current test. For comparable bus and bus bracing and spacings, the smallest conductor size; or for comparable bus design, the highest short-time withstand current rating.

Representative test arrangements shall be determined prior to testing.

4.5 Dielectric tests

Power-frequency withstand voltage tests (4.5.2) and lightning impulse withstand tests (4.5.3) shall be made on MEI switchgear assemblies to determine the ability of the insulation system to withstand overvoltages.

4.5.1 General

The tests on the insulation system shall be made as follows:

(1) With the stationary interrupter switch in its normal, installed position or with the drawout switch in the connected position, apply the test voltage between primary circuits and ground:

(a) With the interrupter switch contacts closed: between each phase of the test arrangement individually with the frame and the other phases grounded.

(b) With the interrupter switch contacts open: between each terminal of the test arrangement individually with the frame and all other terminals grounded.

(2) If drawout, with the interrupter switch in the test position and closed, apply the test voltage to primary circuits simultaneously to the terminals on the incoming side of the test arrangement with the frame outgoing terminals grounded. Repeat tests by applying the test voltage to the outgoing side with the frame and incoming side terminals grounded.

4.5.2 Power-frequency withstand voltage tests

4.5.2.1 Purpose of tests

When these tests are applied to a new MEI switchgear, they demonstrate the power-frequency withstand voltage rating assigned to the MEI switchgear in accordance with ANSI/IEEE C37.20.3.

4.5.2.2 Description of Tests

(1) Power-frequency withstand tests shall be made in accordance with IEEE 4-1995 and IEEE 4a-2001, unless otherwise specified.

(2) The voltage to be applied for one minute shall be the rated power-frequency withstand voltage. (See ANSI/IEEE C37.20.3).

(3) The frequency of the test voltage shall be the rated power frequency of the MEI switchgear ± 20%.

(4) The voltage shall be an alternating single-phase voltage.

(5) In making the test, the initial voltage applied shall be permitted to be not more than 50% of the appropriate test level. The voltage shall be raised uniformly at a rate not greater than 750 volts per second to the test level. The voltage shall be held at the test level for not less than one minute. The voltage shall be reduced uniformly to 50% of test level or less before it is switched off.

(6) The test shall be made at the atmospheric temperature, pressure, and humidity prevailing at the test site. Suitable correction factors shall be permitted to be applied to the actual measured values of power-frequency withstand voltage to convert them to the standard atmospheric conditions in accordance with 1.3.4 of IEEE 4-1995 and IEEE 4a-2001. Humidity correction factors shall be based on Figure 1.4 of IEEE 4a-2001.

4.5.2.3 Performance

The MEI switchgear shall be judged to have passed the test if it has withstood the required level of test voltage for one minute in accordance with the tests specified in 4.5.2. (Audible noises or discharges associated with corona which are frequently encountered in high-voltage testing are not necessarily indicative of failure.)

If the MEI switchgear did not pass, the provisions of Section 7 shall apply.

4.5.3 Lightning-impulse withstand test

These tests demonstrate conformance with the full wave impulse withstand voltage rating assigned to an MEI switchgear in accordance with ANSI/IEEE C37.20.3. The MEI switchgear to be tested shall be new and clean and shall not have been subjected to prior tests, except as specified in Section 8, Production Tests, and in 4.9.4, Momentary Withstand Current Test.

NOTE—Some insulating materials retain a charge after an impulse test, and for these cases, care should be taken when reversing 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 voltages before tests, is recommended.

4.5.3.1 Description of tests

The impulse withstand test shall be:

(1) Conducted in accordance with IEEE 4-1995 and IEEE 4a-2001, unless otherwise specified.

(2) The standard 1.2/50 impulse voltage wave with crest value equal to the rated impulse withstand voltage of the MEI switchgear being tested shall be applied in accordance with section 7 of IEEE 4-1995. In these tests, three positive and three negative impulse voltages shall be applied to each point without causing damage or flashover; except, where prior testing shows that tests of one polarity are more severe, tests using the opposite polarity shall be omitted.

(3) Tests shall be made under dry conditions at the atmospheric temperature, pressure, and humidity prevailing in the test laboratory. Suitable correction factors shall be applied to the actual measured values of impulse voltages to convert them to standard atmospheric conditions in accordance with 1.3.4 of IEEE 4a-2001. Humidity correction factors shall be based on curves derived for rod gaps in accordance with Figure 1.4 of IEEE 4a-2001.

4.5.3.2 Performance

Based upon tests conducted with each test sequence being comprised of three consecutive applications of impulse voltage, the evaluation of the performance of the MEI switchgear shall be made on the basis of each of these sequences. If no disruptive discharge or flashover occurs during a particular sequence, the MEI switchgear shall be judged to have passed that sequence. If a single disruptive discharge or flashover has occurred during a particular sequence, that sequence shall be repeated for the same terminal or terminal grouping. During the repeated sequence if there is no disruptive discharge or flashover, the MEI switchgear shall be judged to have passed the repeated sequence with the single disruptive discharge or flashover occurring in the first sequence being considered to have been a random occurrence. If a disruptive discharge or flashover occurs during the repeated sequence, the MEI switchgear shall be judged to have failed that sequence only and the provisions of Section 7 shall be applied.

For an MEI switchgear to be judged to have demonstrated the assigned rated impulse withstand test voltage, it shall have passed all of the required tests in accordance with 4.5.1.

4.6 Mechanical performance tests

4.6.1 Removable interrupter switch

Mechanical endurance tests shall be performed to demonstrate proper operation of the following elements with all external primary connections removed.

(1) Separable primary contacts

(2) Separable control contacts (if provided)
(3) Interrupter switch removable element position interlocks
(4) Stored energy mechanism interlocks, as applicable
(5) Auxiliary switches
(6) Housing switches

The tests shall be performed with an interrupter switch incorporating a mechanism with fault-making capability. Tests are not required on interrupter switches having other types of mechanisms if the interlocks are the same for both. If they are not, the other designs shall be tested.

The test shall consist of 10 complete cycles of operation as described without repair or replacement of any functional parts.

The interrupter switch shall be open and in the disconnected position with the stored energy mechanism discharged. Separable contacts shall be lubricated according to the manufacturer's recommendations.

Each complete cycle of operation shall consist of the following steps:

Step 1. Move the interrupter switch to the test position.

NOTE—The test position may correspond to the disconnect position.

(a) Close the interrupter switch.
(b) Check to assure that the interrupter switch cannot be moved to the connected position while closed.
(c) Open the interrupter switch.

Step 2. Move the interrupter switch to a position approximately midway between the test and connection positions.

(a) Check to assure that the interrupter switch cannot be closed, either electrically or mechanically.

Step 3. Move the interrupter switch to the connected position.
(a) Close the interrupter switch.
(b) Check to assure that the interrupter switch cannot be moved out of the connected position while closed.
(c) Open the interrupter switch.

Step 4. Move the interrupter switch to a position approximately midway between the test and connected positions.

(a) Check to assure that the interrupter switch cannot be closed, either electrically or mechanically.

Step 5. Move the interrupter switch to the test position.
(a) Close the interrupter switch.
(b) Check to assure that the interrupter switch cannot be moved to the connected position while closed.
(c) Open the interrupter switch.

Step 6. Move the interrupter switch to the disconnect position.

NOTE—The disconnect positions may correspond to the test position.

After completion of 10 cycles, check to assure that if the mechanism can be left in the fully-charged condition, either the closing or racking function is blocked.

4.6.2 Stationary interrupter switch

Mechanical endurance tests shall be performed to demonstrate proper operation of the following interlocks:

(1) Interlock to prevent access to the fuses with the interrupter switch closed.
(2) Interlock to prevent closing of the interrupter switch if the access door to fuses is open.
(3) Interlock to prevent access to the fuses unless the interrupter switch is in open position and the closing mechanism is in the discharged or blocked position.

The tests shall be performed with an interrupter switch incorporating a mechanism with fault-making capability. Tests are not required on interrupter switches having other types of mechanisms if the interlocks are the same for both. If they are not, the other designs shall also be tested.

The test shall consist of 10 complete cycles of operation as described without repair or replacement of any functional parts.

The interrupter switch shall be open with the stored energy mechanism discharged.

Each complete cycle of operation shall consist of the following steps:

Step 1.
- (a) Close the interrupter switch.
- (b) Check to assure that the access door to the fuses cannot be opened.

Step 2.
- (a) Open the interrupter switch.
- (b) Open the access door to the fuses.
- (c) Check to assure that the interrupter switch cannot be closed with the door open.
- (d) Close door.

In addition, for mechanisms that prevent access to fuses when the closing mechanism is in the charged position:

Step 3.
- (a) Charge the closing mechanism.
- (b) Check to assure that the access door to the fuses cannot be opened with the closing mechanism charged.

4.6.3 Performance

At the completion of these tests, the mechanism parts and interlocks shall be in essentially the same condition as before the test. There shall be no galling of the separable primary or control contacts of drawout interrupter switches. If the MEI switchgear is judged to have failed, the provisions of Section 7 shall apply.

4.7 Continuous current test

The continuous current test is made to ensure that the MEI switchgear test arrangement can carry the continuous current rating assigned to the MEI switchgear in accordance with ANSI/IEEE C37.20.3, at rated power frequency without exceeding the allowable temperature limits specified in Tables 2 and 3 of ANSI/IEEE C37.20.3, and in Tables 1 and 2 of ANSI/IEEE C37.20.4.

The MEI switchgear test arrangement shall be tested using a three-phase source of power at a frequency of no less than rated power frequency. The MEI switchgear to be tested shall be clean and dry. If the test arrangement selected for continuous current tests has been subjected to prior tests, it shall be permitted to be maintained. The average of the three-phase currents is to be maintained at no less than the rated continuous current of the interrupter switch. A single-phase source of power (all phases in series with flow of current reversed with adjacent phases) may be used at the option of the manufacturer. Any convenient voltage shall be used.

NOTE—Usual practice is to supply the current by using transformers whose output voltages are less than 10 volts in order to avoid interference with temperature-measuring equipment. The current source may be connected to either the main bus or the switch (fuse) terminals.

4.7.1 Duration of tests

4.7.1.1 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°C over a one hour period, with readings being taken at not greater than 30-minute intervals. The equipment is considered to have passed the test if the temperature limits in ANSI/IEEE C37.20.3 have not been exceeded in any of the three readings over the one-hour period.

4.7.1.2 At the same time as three successive temperature measurements are being made for the purpose of determining the stability of temperature rise, the currents in each of the three phases of the MEI switchgear shall also be measured. The average of these nine current measurements shall not be less than the rated continuous current of the MEI switchgear. No individual current measurement shall be less than 90% or more than 110% of the rated continuous current. When the temperature is being monitored on only one phase of the MEI switchgear as specified in 4.7.2.5, the average of three currents shall be used and none of the current measurements on the monitored phase shall be less than the rated continuous current.

4.7.2 Method of measuring temperatures

The temperatures of various parts of the test arrangement shall be monitored with thermocouples connected to a suitable temperature-measuring device.

4.7.2.1 Thermocouples shall be held in intimate contact with the metallic parts whose temperature is being monitored by such methods as welding, drilling and peening, or cementing. Whenever possible, unless otherwise specified, thermocouples shall be located on or near the uppermost side of the part being monitored.

4.7.2.2 Thermocouples shall be used to monitor the temperature rise of insulating members that are in intimate contact with continuous current-carrying parts. These thermocouples shall be located in the current-carrying part as close as practical to the accessible junction of the insulation and the metallic part. Normally thermocouples shall be located near both incoming and outgoing ends of each insulating component where a continuous current-carrying part passes through more than 3 in. (77 mm) of insulation as measured along the principal axis of the conductor. For cable terminations, the thermocouples shall be located at the junction of the conductor and its insulation.

4.7.2.3 Thermocouples used to monitor the temperature rise of separable primary contacts (if drawout), of interrupter switch main contacts, and of hinged contacts in the continuous current path shall be located within approximately 0.5 in. (13 mm) of the actual contact area unless otherwise specified in this standard. It is recognized that thermocouples cannot be located directly in the actual contact area without destroying the functional effectiveness of the contact. Thermocouples shall be located on both incoming and outgoing sides of each single-contact area. Where a contact assembly is comprised of multiple segments cooperating in a parallel combination to perform a single-contact function, the multiple contact assembly shall be treated as a single contact for purposes of this section. Where a contact assembly is comprised of one or more bridging members, each functioning in a series combination with actual contact areas at both ends of the individual bridging element so that the multiple contact assembly performs a single-contact function, the contact assembly shall be treated as a single contact for purposes of this section if the distance between actual contact areas is less than 3 in. (77 mm). For bridging-type contact assemblies having actual contact areas further apart than 3 in. (77 mm), a single thermocouple shall be located in at least one bridging member approximately midway between actual contact areas in addition to the thermocouple required at both incoming and outgoing sides of the contact assembly.

4.7.2.4 Where insulation is disposed along the primary conductor adjacent to the near side of a contact area such that two thermocouples would be located within 3 in. (77 mm) of each other under provisions stated in 4.7.2.2 and 4.7.2.3, the thermocouple adjacent to the near side of the contact area shall be omitted.

4.7.2.5 Where prior tests indicate that stabilized temperature readings for corresponding locations on each of the phase-conducting components are not different from each by more than 5°C, it shall be permitted to monitor only the interior phase members of the test arrangement. If prior tests indicate that a particular location on any phase had a temperature rise within 5°C or less of the maximum allowed temperature rise for that location, all similar locations on each phase of the test arrangement shall be monitored.

4.7.2.6 The temperature of parts of the MEI switchgear accessible to an operator during the normal course of operation shall be monitored. A single thermocouple shall be permitted to be located at a position that shall reasonably reflect the average temperature of the several accessible parts.

If prior tests or experience indicates that the temperature rise of a given accessible part would be within 5°C or less of the maximum allowable temperature rise, the thermocouple shall be located at a mid-position on that particular part.

4.7.2.7 The temperature rise of primary conducting parts and contact areas that are provided for functions other than the carrying of continuous current and that are not directly in the continuous current path shall not be monitored even though such parts or contact areas may be in intimate contact with primary current-carrying conductors. Typical examples of such parts include, but are not limited to, auxiliary conductors and contacts for transferring current into interrupter assemblies during interrupter-switch-opening operations, and metallic supporting parts.

4.7.3 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:

(1) One level with the top of the structure.
(2) One 12 in. (305 mm) above the bottom of the structure.
(3) One midway between the two above positions.

All temperature-measuring devices shall be placed 12 in. (305 mm) from the structure, not in front of ventilation openings, 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 suitable liquid 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 placed inside it. A glass bottle may also be used as a container. The size of the container should be at least 1 in. (25.4 mm) in diameter and 2 in. (50.8 mm) high.

Table 1 – Copper conductor size for use in continuous current tests

Interrupter Switch or Device Rating		Copper Bars Per Terminal Size		Alternate Cable	
Rating	Quantity	(mm)	Inch	Quantity	Size
200 amperes	One	3.2 x 25.4	1/8" x 1"	One	#2/0
600 amperes	One	6.4 x 51	1/4" x 2"	Two	350 kcmil
1200 amperes	One	6.4 x 102	1/4" x 4"	Four	500 kcmil
2000 amperes	Two	9.5 x 101.6	3/8” x 4”	—	—

NOTE—Where multiple bars are used, they are to be spaced 3/8 in. (9.5 mm) apart. Configurations shall be vertical unless the design of the test arrangement requires them to be horizontal. The determination of the configuration shall be at the option of the manufacturer.

4.7.4 Copper conductors for use in continuous current tests

Bus bars or cables as specified in Table 1 shall be utilized for connection to the bottom interrupter switch or fuse terminals and the main bus. Conductors shall extend for a minimum length of 4 ft (1.2 m) from the main bus and terminals.

If test arrangement internal bus sizes are different than shown, external bus sizes equal to internal sizes may be substituted at the option of the manufacturer.

4.7.5 Performance

The MEI switchgear test arrangement shall be judged to have passed the test if the limits of observable temperature rise specified in Tables 2 and 3 of ANSI/IEEE C37.20.3 and in Tables 1 and 2 of ANSI/IEEE C37.20.4 are not exceeded. If the MEI switchgear is judged to have failed, the provisions of Section 7 shall apply.

4.8 Short-time withstand current test

A short-time withstand current test shall be made to demonstrate the ability of the MEI switchgear bus and connections to carry current equal to the rating assigned in accordance with ANSI/IEEE C37.20.3 for 2 seconds. The time period for the MEI switchgear assembly may be limited to a shorter time by a protective device, switch, or current transformer rating, but shall not reduce the requirement for the bus and connections. Refer to ANSI/IEEE C37.20.3, ANSI/IEEE C37.20.4, and ANSI C37.22 for preferred values. Components rated for a duration of less than 2 seconds shall not be tested in excess of their rating.

If the interrupter switch connections are physically equivalent to the interrupter switch test enclosure connections, only the main bus and ground bus require testing. If the MEI switchgear selected for test has been subjected to prior tests, it shall be permitted to be maintained.

The MEI switchgear shall be grounded with a minimum of 4/0 copper conductor.

4.8.1 Description of tests

4.8.1.1 The main bus incoming terminals shall be connected to the test circuit power source. Three-phase tests shall be made with shorting bar(s) connected as follows:

(1) For test of main bus only. At the opposite end of the main bus from the incoming terminals, to cause the current flow through the main bus and splice. The test shall be for a period of 2 seconds.

(2) For test of main bus and interrupter switch connections. At the interrupter switch/fuse outgoing terminals. The test shall be for a period of 2 seconds unless limited to a shorter time by the protective device within the assembly. Components rated for a duration of less than 2 seconds shall not be tested in excess of their rating.

The test shall be permitted to be either a three-phase test or a single-phase test. In case of a three-phase test, the rated current shall be required in only one of the phases. In case of a single-phase test, the current shall be permitted to be conducted through any two adjacent poles connected in series so that the current flows in opposite directions in each of the selected poles. Refer to ANSI/IEEE C37.20.3, ANSI/IEEE C37.20.4, and ANSI C37.22 for preferred ratings.

4.8.1.2 A single-phase test shall be made to prove the adequacy of the ground bus to also carry current equal to the interrupter switch short-time current rating for a 2-second period. For this test, a short-circuit connection shall be made between the ends of the ground bus and the nearest phase main bus at the end opposite the test arrangement main bus incoming terminals.

4.8.1.3 The short-circuit connections shall be made with bolted bars of cross-section equal to the bus being tested.

4.8.2 Test circuit conditions

4.8.2.1 The current shall be monitored throughout the duration of the test. The rms (root-mean-square) value of current shall be determined using the method described in 7.1.6 of ANSI/IEEE C37.09. This value squared times the duration of the test shall be no less than $2I^2$, and the duration of the short-circuit current shall be no greater than 125% of the specified time (2 seconds X 125% = 2.5 seconds or less).

To assure that the single-phase test is not required to be more severe mechanically than the three-phase test, its rms current level may be reduced to no less than 0.93 I, and the time is to be extended to provide an equivalent $2I^2$.

4.8.2.2 The test voltage may be any convenient level. (A test voltage of 600 volts or less is commonly used.)

4.8.2.3 The circuit power factor (*X/R* ratio) may be any convenient value since the amount of current asymmetry will have a negligible effect on heating during the required period.

4.8.2.4 If the test circuit meets the requirements of 4.9.3, this test may be combined with the momentary withstand current test (4.9).

4.8.3 Performance

The MEI switchgear shall be judged to have passed the test if it has carried the required rms level of current for the required time and has suffered no significant damage such as welding of drawout primary contacts or part breakage as a consequence of the test. If the MEI switchgear is judged to have failed the test, the provisions of Section 7 shall apply.

4.9 Momentary withstand current test

A momentary withstand current test shall be made to demonstrate the mechanical adequacy of the structure, buses, and connections to withstand the maximum short-circuit stresses that could occur due to the momentary current rating assigned to the MEI switchgear in accordance with ANSI/IEEE C37.20.3. The current shall be the rms value, including the DC component, at the major peak of the maximum cycle as determined from the envelope of the current wave of the maximum offset phase during a test period of at least 10 cycles. Refer to ANSI/IEEE C37.20.3, ANSI/IEEE C37.20.4, and ANSI C37.22 for preferred ratings.

NOTE—The momentary withstand current test is also known as the peak withstand current test for 10 cycles.

If the interrupter switch connections are physically equivalent to the interrupter switch test enclosure connections used in testing per ANSI/IEEE C37.20.4 or ANSI C37.58, only the main bus and ground bus require testing.

The MEI switchgear shall be grounded with a minimum of 4/0 copper conductor.

If the MEI switchgear selected for test has been subjected to prior tests, it shall be permitted to be maintained.

The incoming bus structure used in a switchgear assembly shall be considered as meeting the momentary withstand current requirements if its construction is equivalent to that of the main bus structure which was tested and found to meet the momentary withstand current requirements.

4.9.1 Description of tests

4.9.1.1 The main bus incoming terminals shall be connected to the test circuit power source. Three-phase tests shall be made with shorting bar(s) connected as follows:

(1) For test of main bus only. At the opposite end of the main bus from the incoming terminals, to cause current to flow through the main bus and splice. The test shall be for 10 cycles of power frequency.

(2) For test of main bus and interrupter switch connections. At the switch/fuse outgoing terminals. The test shall be for 10 cycles of power frequency unless limited to a shorter time by the protective device within the assembly.

Single-phase tests are permissible if it can be determined that they are at least as severe as the three-phase test.

4.9.1.2 A single-phase test shall be made to demonstrate the mechanical adequacy of the ground bus with respect to the nearest phase bus, to withstand the short-circuit stresses caused by carrying rated momentary current.Refer to ANSI/IEEE C37.20.3, ANSI/IEEE C37.20.4, and ANSI C37.22 for preferred ratings. The short-circuit connection shall be made between the ends of the ground bus and the nearest phase main bus at the end opposite the test arrangement main bus incoming terminals.

4.9.1.3 Insofar as possible the test connections shall not add intentional bracing nor impose additional loading to the bus structure being tested.

4.9.2 Test duration

The duration of current flow during the momentary withstand current test shall be for 10 cycles of power frequency unless limited to a shorter time by the protective device within the assembly. (See 4.9.1.1).

4.9.3 Test circuit conditions

4.9.3.1 The three-phase rms current, including dc offset, that verifies the momentary withstand current rating, shall be measured at the major peak of the maximum cycle as determined from the envelope of the current wave and calculated in accordance with ANSI/IEEE C37.09.

4.9.3.2 The power factor of the test circuit shall be 15 percent lagging or less *(X/R* ratio of 6.6 or greater) with *X* and *R* in series connection. See Table 2 of ANSI/IEEE C37.26.

4.9.3.3 The frequency of the test circuit shall be 60 Hertz ± 20 percent.

4.9.3.4 The test voltage may be any convenient level. (A test voltage of 600 volts or less is commonly used.)

4.9.4 Performance

The MEI switchgear test arrangement shall be judged to have passed the test if it has carried the required current for the required time and there is no breakage of the bus supports and either:

(1) No permanent deformation of bus bars, or
(2) Deformation of bus bars up to 10% of design spacing is permitted. Deformation above this allowance requires repeat of impulse withstand tests (4.5.3) to verify conformance.

Permanent deformation of bus bars and supports shall not impair mechanical performance as specified in 4.6. If the MEI switchgear is judged to have failed the test, the provisions of Section 7 shall apply.

5 MEI Switchgear Components

5.1 Accessory devices

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

5.1.2 Cell-mounted functional components (e.g., mechanism-operated auxiliary switches) and accessories (e.g., interrupter switch position 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.

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

5.2 Bus bar structures

Conformance testing of MEI switchgear test arrangements shall provide assurance that other bus bar structures (e.g., incoming bus, transfer bus, bus tie bus) are in conformance with this standard if it can be determined that the design criteria specified in 5.2.1 through 5.2.4 have been met.

5.2.1 Dielectric criteria

(1) Equal or greater bus bar insulation dielectric strength
(2) Equal or greater air clearance distances
(3) Equal or greater creepage distances phase-to-phase and phase-to-ground

5.2.2 Continuous current criteria

(1) Equal or greater conductor cross-sectional area
(2) Equal or greater ventilation
(3) Equal or greater conductor spacing

5.2.3 Short-time withstand current criteria

(1) Equal or greater conductor cross-sectional area

5.2.4 Momentary withstand current criteria

(1) Equal or greater conductor section modulus
(2) Equal or less bus support spacing
(3) Equal or greater bus support mechanical strength
(4) Equal or greater conductor spacing

6 Enclosure Conformance Tests

Enclosure conformance tests are only required if the manufacturer declares a specific category type in accordance with Appendix A of ANSI/IEEE C37.20.3.

These tests shall be conducted to complete the provisions of this standard as applicable to the specified Category Type A, B, or C.

6.1 Category A test requirements

6.1.1 Test terms

6.1.1.1 Enclosure security

The completely assembled apparatus will resist unauthorized entry when tested according to the procedure of this standard.

6.1.1.2 Axial force

Axial force is a force applied along the axis of the pry bar from its handle to its pry tip.

6.1.1.3 Prying leverage

Prying leverage is a force at right angles to the handle times the distance from this force to the point of insertion of the pry tip into a joint or crevice of the enclosure.

6.1.2 Test equipment

The tests for enclosure security shall be conducted with the following equipment, or equivalent, as specified in 6.1.2.1 through 6.1.2.4.

6.1.2.1 Pry bar

The pry bar, constructed according to Figure 1, is to be used for the pry tests. The force described below shall be applied to the handle.

(1) When an axial force is applied to the handle, the stack of Belleville washers is compressed. The amount of compression is a measure of the magnitude of the axial force applied. Using a scale or other force-measuring device, the pry bar shall be calibrated to measure the axial force used to force the tip into the joint under test.

(2) The prying leverage applied can be measured indirectly by measuring the deflection of the pry bar. The indicator is mounted on the pry bar and set to measure deflection of a certain length of the bar. A calibration can be made that will result in a table or curve showing prying leverage versus reading of the indicator.

6.1.2.2 Pull tool

The device shown in Figure 2 shall be used in the pull tests.

6.1.2.3 Push tool

A device that has a square face measuring 0.5 inch x 0.5 inch (12.7 mm x 12.7 mm), as shown in Figure 3, with associated indicator to measure axial force shall be used to perform the deflection test.

6.1.2.4 Probe wire

The probing wire shall be bare number 14 AWG soft drawn solid copper wire 10 ft (3 m) long.

6.1.3 Tests

6.1.3.1 General

The enclosure shall be mounted on a flat surface according to the manufacturer's specification. With the access doors closed and locked, the following sequence of tests shall be performed:

(1) Pry tests (6.1.3.2)
(2) Pull tests (6.1.3.3)
(3) Wire probe tests (6.1.3.4)
(4) Deflection tests (6.1.3.5)
(5) Operation test (6.1.3.6)

6.1.3.2 Pry tests

The pry bar shall be used on all joints, crevices, hinges, locking means, and the like, that exist between the enclosure components, including the enclosure/pad interface. The pry bar shall be permitted to be placed at any angle to the enclosure surface. The tip of the bar shall first be inserted in the opening being tested using the value of axial force specified in Table 2.

Table 2 – Test values

Inward axial force	223 N	50 lbs.
Prying leverage tests	102 N·m	900 in-lbs.
Pull test	668 N	150 lbs.
Deflection test	445 N	100 lbs.

NOTE—Test values are expressed in historic values with approximate metric equivalents.

Then, with the axial force being maintained, the prying force specified in Table 2 shall be applied. This force shall be applied alternately, first in one direction and then in the opposite direction (i.e., once in each direction). Applications of either or both axial and prying force shall be maintained so long as relaxation is occurring. When relaxation ceases, or if no relaxation occurs after the second test, the pry bar shall be removed and applied at an untested location.

6.1.3.3 Pull tests

A pulling force shall be applied to the critical points of all enclosure parts that can be engaged by the pulling hook. A pulling force not exceeding the values in Table 2 shall be permitted to be exerted at any angle to the enclosure surface. This force is to be maintained during any relaxation. When relaxation ceases, or if no relaxation occurs, the pull test shall be terminated. The hook shall then be inserted into any other part that it can engage, and the test shall be repeated at the new location. All parts that can be engaged by the pull hook shall be tested once.

6.1.3.4 Wire probe tests

Following the pry tests and pull tests described in 6.1.3.2 and 6.1.3.3, an attempt to penetrate the enclosure with the probe wire shall be made. This penetration shall be attempted at all crevices and joints. The wire shall be straight with no prebends and shall be gripped by the tester with his bare hands. If the wire enters the joint, the wire shall be continually pushed until either it can no longer be pushed or it has entered the enclosure completely. This test is passed if an inspection determines either that the probing wire has not entered the enclosure, or if visible, that the probing wire is restricted by a barrier from intrusion into the interior.

6.1.3.5 Deflection tests

The deflection test shall be applied to all sides and walls of the enclosure. This test is passed if the specified force (see Table 2) applied perpendicularly to the surface of the enclosure does not impair the dielectric, mechanical, or corrosion performance of the equipment.

6.1.3.6 Operation test

Following all of the tests set forth in 6.1.3.2 through 6.1.3.5, the enclosure shall be easily unlocked and opened and shall also be easily closed and locked.

6.1.4 Test values

The minimum test values for which entry shall be prevented are provided in Table 2.

6.2 Category B test requirements

The conformance test requirements for Category B equipment are included in Appendix A of ANSI/IEEE C37.20.3.

6.3 Category C test requirements

The conformance test requirements for Category C equipment are included in Appendix A of ANSI/IEEE C37.20.3.

7 Treatment of failures

When failures occur during testing, the failures shall be evaluated, corrected, and the equipment shall be retested. A design change made to the MEI switchgear to correct a failure in a test 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 failure in tests previously completed, only those tests that may have failed shall be repeated on the MEI 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 be based on the corrective action taken and not on the failure which actually occurred.

8 Production tests

Unless otherwise specified, all production tests shall be made by the manufacturer at the factory on the complete MEI switchgear or its component for the purpose of checking the correctness of manufacturing operations and materials. (See ANSI/IEEE C37.20.3).

Production tests shall include the following:

(1) Power-frequency withstand voltage tests (8.1)
(2) Mechanical operation tests (8.2)
(3) Grounding of instrument transformer cases test (8.3)
(4) Electrical operation and wiring tests (8.4)

8.1 Power-frequency withstand voltage tests

Power-frequency withstand voltage tests shall be made at the factory on each switchgear assembly in the same manner as described in 4.5.2 with the exception that tests across the open gap(s) (see 4.5.1(2)) are not required. Tests shall be made in accordance with 4.5.1(1) and 4.5.2.2. Drawout interrupter switch removable elements need not be tested in the assembly if they are tested separately. Control devices, potential transformers, and control power transformers, which are connected to the primary circuit, may be disconnected during the test.

8.2 Mechanical operation tests

Mechanical operation tests shall be performed to ensure the proper functioning of removable element operating mechanisms, shutter, mechanical interlocks, and the like. These tests shall ensure the interchangeability of removable elements designed to be interchangeable.

8.3 Grounding of instrument transformer cases test

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

8.4 Electrical operation and wiring tests

8.4.1 Control wiring continuity

The correctness of the control wiring of MEI switchgear shall be verified by (1) actual electrical operation of the component control devices, or (2) individual circuit continuity checks by electrical circuit testers, or by both (1) and (2).

8.4.2 Control wiring insulation test

A 60-Hz test voltage, 1500 volts to ground, shall be applied for 1 minute after all circuit grounds have been disconnected and all circuits wired together with small bare wire to short-circuit coil windings. The duration of the test shall be 1 second if a voltage of 1800 volts is applied. At the option of the manufacturer, switchgear mounted devices that have been individually tested may be disconnected during this test.

8.4.3 Polarity verification

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

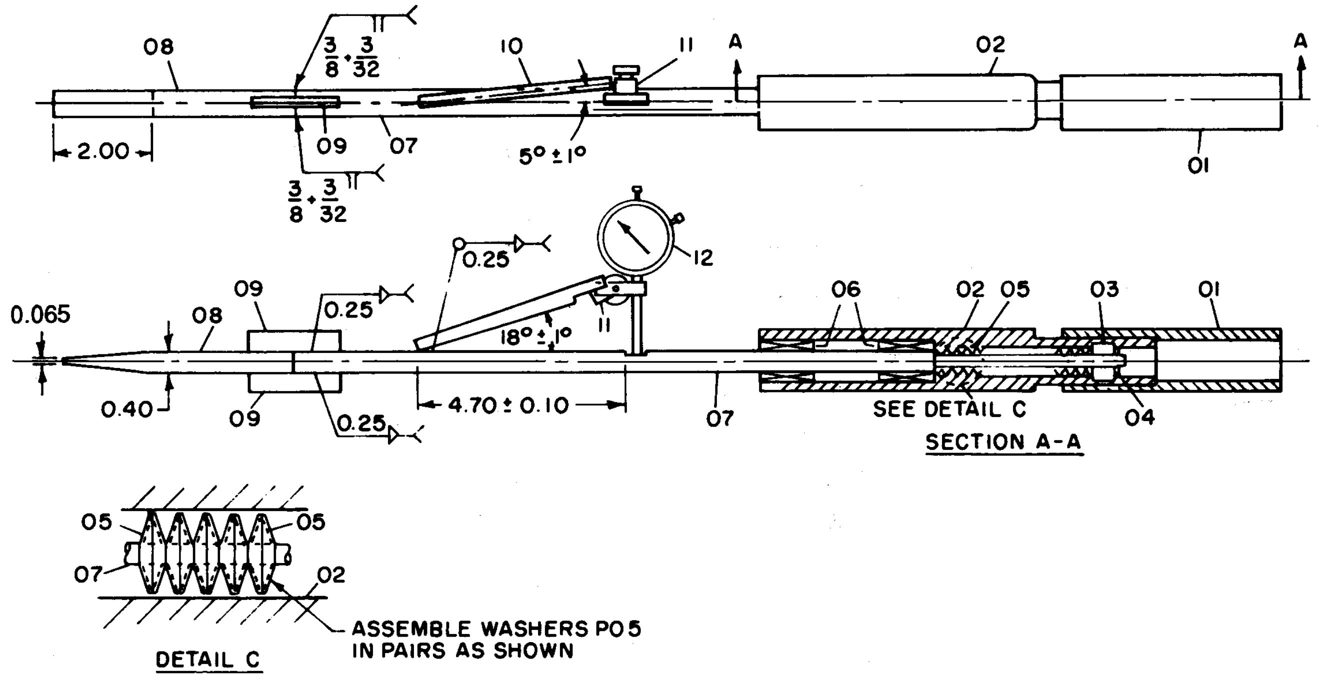
8.4.4 Sequence tests

MEI 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 MEI switchgear; however, this equipment may be simulated where necessary.

9 Retesting

Retesting is not required if the design has not changed. A design change made to the MEI 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.

See the Appendix for guidance in the evaluation of changes made in insulating materials and systems.



NOTES:

(1) All dimensions are in inches unless otherwise indicated.

(2) Quantity of Part Number 05 shall be permitted to vary from 90 to 100.

(3) Part Number 04 must extend into slot to restrict turning motion of Part Number 07.

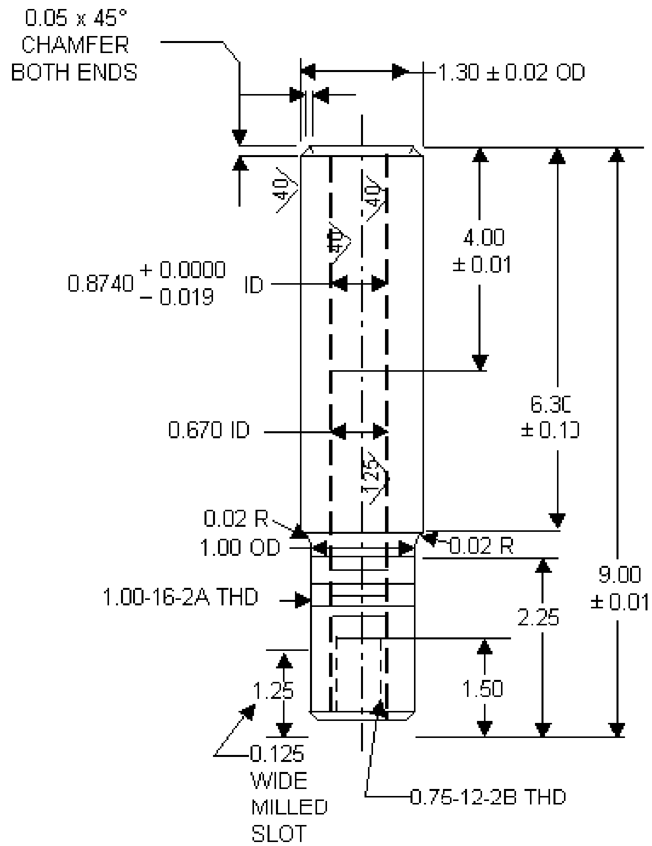
(4) Calibration Instructions – Before the pry (test) bar can be used to measure the axial and prying leverage forces described in the standard, the bar must be calibrated. This calibration is accomplished for the axial force by applying standard forces at the end of the handle (Part Number 01) and marking the compression of the pry bar handle along the pry bar shaft (Part Number 07).

Next, the prying leverage must be calibrated by holding the pry bar tip (Part Number 08) in place and applying a standard force on the handle (Part Number 02). The deflection of the dial indicator (Part Number 12) is recorded for steps in force on the handle. The results can be used to develop a calibration curve of deflection versus prying leverage. When the pry bar is used in a test, the calibration curve is used to determine the inch-pounds of force.

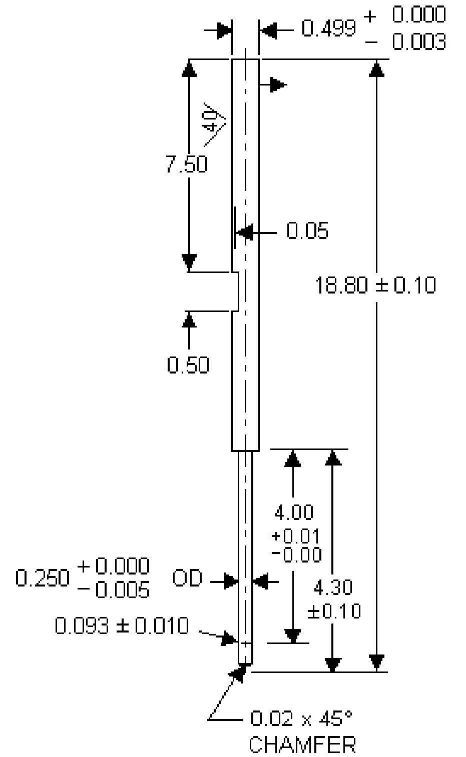
Bill of Materials

Part No.	Name	Quantity	Description
01	Handle	1	–
02	Spring Housing	1	–
03	Spring Housing	1	–
04	Roll Pin	1	Steel 0.093 OD × 0.750 Long
05	Spring Washer	100	Belleville Catalog #1B0500-022
06	Ball Bushing	2	Thompson Ball Bushing Catalog #A-81420
07	Shaft	1	–
08	Chisel	1	1/2 inch
09	Weld Pad	2	–
10	Hold Rod	1	Brown & Sharpe Catalog #599-7900
11	Slide Swivel	1	Brown & Sharpe Catalog #599-7906
12	Torque Indicator	1	Brown & Sharpe Catalog #8241-942

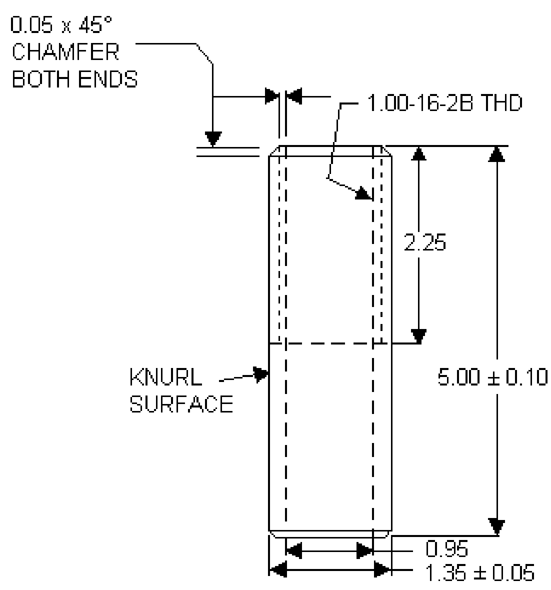
Figure 1
Pry Test Bar



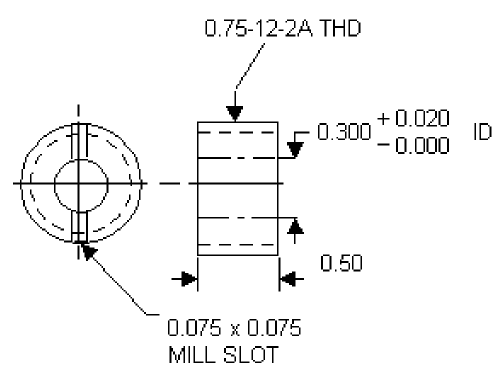
Part Number 02 - Steel 1.30 x 9.00



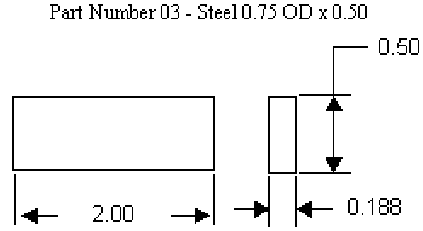
Part Number 07 - Drill Rod 0.50 x 18.80



Part Number 01 - Steel 1.35 OD x 5.00

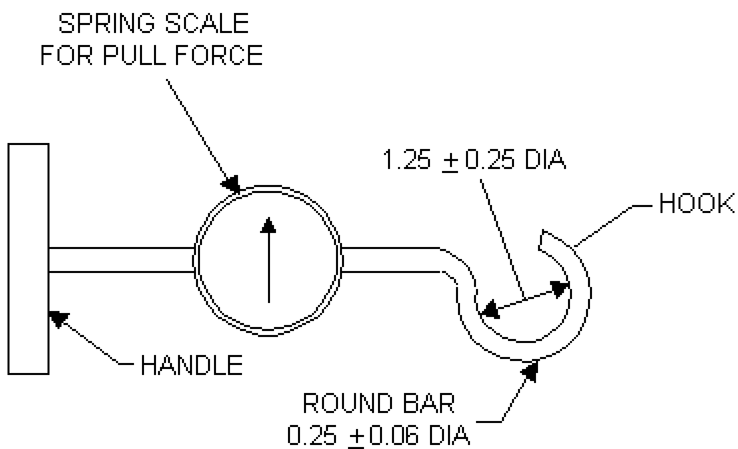


Part Number 03 - Steel 0.75 OD x 0.50



Part Number 09 - Steel 0.188 x 0.50 x 2.00

Figure 1
Pry Test Bar *(continued)*



NOTES:
(1) All dimensions are in inches.
(2) Typical device: Iron Man scales, capacity: 200 lb, No. 1756T4, or the equivalent.

Figure 2
Pull Hook

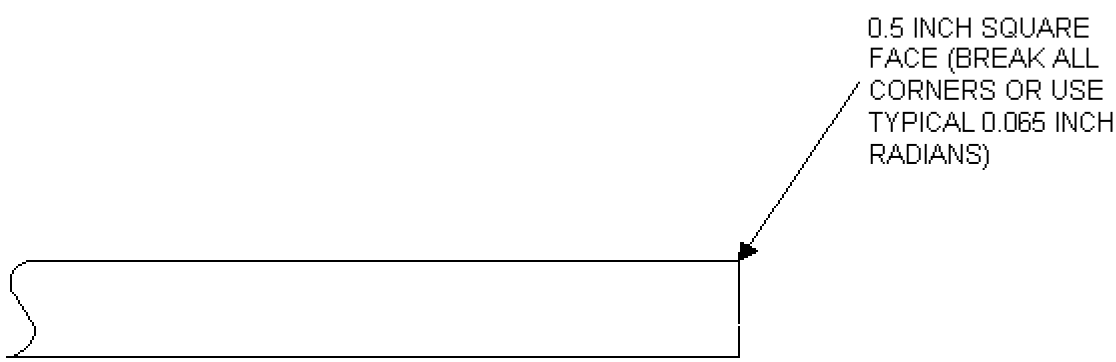


Figure 3
Face Detail for Deflection Tool

Appendix A
(informative)
(This Appendix is not part of American National Standard C37.57-2003, but is included for information only.)

Conformance guide for evaluation of changes made in insulating materials and systems

The procedures of this guide are recommendations and not mandatory requirements of American National Standard C37.57-2003.

A.1 Scope and purpose

A.1.1 Scope

This guide covers the conformance tests and requirements for evaluation of changes made in materials and insulation systems for metal-enclosed interrupter switchgear assemblies rated over 1000 volts through 38 kV AC.

The original design of the insulation system of the switchgear assembly should be in conformance with the requirements of American National Standard for Metal-Enclosed Interrupter Switchgear, ANSI/IEEE C37.20.3.

A.1.2 Purpose

The purpose of this guide 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.

A.2 Related standards

The following standards are intended for information or clarification only and are not essential to completing the requirements of this standard:

ANSI/IEEE C37.20.2-1999, *Metal-Clad Switchgear*

ANSI/IEEE C37.20.3-2001, *Metal-Enclosed Interrupter Switchgear*

ANSI/IEEE C37.100-1992 (R2001), *Definitions for Power Switchgear*

ANSI/UL 94-1996, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

ANSI/UL 746B-1996, *Polymeric Materials – Long-Term Property Evaluations*

ASTM D 149-1997, *Test Methods for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies*[3]

ASTM D 150-1998, *Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation*

ASTM D 229-2001, *Standard Test Methods for Rigid Sheet and Plate Materials Used for Electrical Insulation*

[3] ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (http://www.astm.org).

ASTM D 256-2002, *Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics*

ASTM D 257-1999, *Test Methods for D-C Resistance or Conductance of Insulating Materials*

ASTM D 648-2001, *Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in Edgewise Position*

ASTM D 790-2002, *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*

ASTM D 2303-2001, *Test Method for Liquid-Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials*

ASTM D 5628-1996 (R2001), *Test Method for Impact Resistance of Flat, Rigid Plastic Specimens by Means of a Falling Dart (Tup or Falling Mass)*

NEMA LI 1-1998, *Industrial Laminated Thermosetting Products*[4]

NEMA LI 6-1983 (R1999), *Relative Temperatures Indices of Industrial Thermosetting Laminates*

NEMA SG 6-2000, *Power Switching Equipment*

A.3 Definitions

The definitions of terms contained in this document, or in other standards referred to in this document, are not intended to embrace all legitimate meanings of the terms. They are applicable only to the subject treated in this guide. Refer to ANSI/IEEE C37.100 and ANSI/IEEE C37.20.3 for definitions not given in this document.

A.3.1 Ceramic insulation

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

A.3.2 Nonceramic insulation

Nonceramic insulation is insulation made of a material other than ceramic. This category includes all organic insulating materials.

A.3.3 Bus insulation

Bus insulation is insulating material optionally 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 prevent arc motoring and to allow closer spacing of conductors than would be possible with bare conductors. Bus insulation may also, as a secondary function, be part of the bus support insulation system.

A.3.4 Bus joint insulation

Bus joint insulation is insulating material optionally used to cover joints or connections in the primary voltage conductors. Bus joint insulation is otherwise similar to bus insulation.

[4] NEMA documents are available from the National Electrical Manufacturers Association,1300 North 17th Street, Suite 1847, Rosslyn, VA 22209, USA.

A.3.5 Bus tap insulation

Bus tap insulation is insulating material optionally used to cover low-current taps to the main primary voltage conductors. These taps include potential 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 especially insulated for this service, or in the form of an insulated wire or cable. Bus tap insulation is otherwise similar to bus insulation.

A.3.6 Bus support insulation

Bus support insulation is 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.

A.3.7 Barrier insulation

Barrier insulation is insulation material used primarily to separate one item or area from another item or area within equipment.

Examples are: (a) interphase barriers between poles of an interrupter switch; (b) bus barriers separating the bus compartment of one vertical section of switchgear from another vertical section; 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.

A.3.8 Drawout switch primary disconnects

Drawout switch primary disconnects 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 interrupter switch.

A.3.9 Entrance bushings

Entrance bushings are 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 (roof bushings) or horizontally mounted (wall bushings).

A.3.10 Relative thermal index

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

A.4 Requirements

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

A.4.1 Nonceramic insulation

A.4.1.1 Resistance to long-term aging

Resistance to long-term aging should be demonstrated by one or more of the methods specified in A4.1.1.1 through A4.1.1.4.

A.4.1.1.1 The relative thermal indexes of the material should be determined in accordance with ANSI/UL 746B for each thickness of material used. Under normal operating conditions, a material used for an insulation function should not be exposed to temperatures in excess of its relative thermal indexes for the thickness used. Table AI specifies which relative thermal indexes are to be considered for each insulating function.

A.4.1.1.2 Resistance to long-term aging may be demonstrated by a history of satisfactory field service. This history must be of sufficient duration to satisfactorily demonstrate the long-term capabilities of the material.

A.4.1.1.3 Resistance to long-term aging may be demonstrated by testing of samples aged in service or artificially aged to adequately demonstrate retention of required properties.

A.4.1.1.4 If it is desired to substitute a material for a previously qualified material, the substitute material will be considered to have satisfactorily 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 AI.

A.4.1.2 Thermal cycling withstand

Drawout switch primary disconnects, entrance bushings, and bus and bus tap insulation applied to conductors by dipping, molding, fluidized bed coating, or other processes that cause the insulation to adhere to the conductor, must not be damaged by variations in temperature. This capability should be evaluated by the thermal cycling withstand test, A5.1.

A.4.1.3 Dielectric withstand

A.4.1.3.1 Substitute bus insulation, bus joint insulation, and bus tap insulation

Substitute bus insulation, bus joint insulation, and bus tap insulation should pass the test for bus bar insulation in accordance with 6.2.1.3 of ANSI/IEEE C37.20.2 (foil test).

A.4.1.3.2 Bus support insulation and barrier insulation

If it is desired to substitute another insulating material for the one used in the impulse withstand 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 should be as described in the test method in ASTM D 149 using the short-term method in air. (The use of the short-term method under oil should be permitted if the two insulating materials being compared are of the same generic type.)

A.4.1.4 Flammability

A.4.1.4.1 Substitute flame-resistant sheet or cast insulating materials used in any application other than Type-1 barriers should meet the requirements for class 94 V-0 as set forth in ANSI/UL 94 or those set forth in Method II of ASTM D 229.

A.4.1.4.2 Substitute flame-resistant sheet or cast insulating materials used as Type-1 barrier should meet the requirements for class 94-HB as set forth in ANSI/UL 94 or those set forth in Method II of ASTM D 229.

A.4.1.4.3 Substitute flame-resistant applied insulation (such as fluidized bed systems, tape systems, or shrinkable-type tubing) should pass the tests specified in 6.2.7, Flame-Resistance Tests for Applied Insulation, in ANSI/IEEE C37.20.2.

A.4.1.5 Tracking resistance

Substitute bus support insulation, Type-2 barrier insulation, entrance bushings, and circuit breaker primary disconnects should pass the inclined plane tracking test in accordance with ASTM D 2303 and under condition A (see 6.4.1.1 in NEMA LI 1) with specimens of 6.4 mm (0.25 in.) in thickness. The time to track to the 25 mm (1 in.) mark with 2500 V applied should be at least 20 minutes for equipment rated at 5 kV or less and at least 300 minutes for equipment rated greater than 5 kV.

A.4.1.6 Volume resistivity or loss index

For drawout switch primary disconnects, the electrical losses of a substitute material will be judged acceptable, provided either the volume resistivity (ASTM D 257) is greater than (or the loss index [ASTM D 150] is less than) or equal to that of the previously acceptable material.

A.4.1.7 Deflection capability or flexural strength

A.4.1.7.1 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 of A5.2.

A.4.1.7.2 Entrance bushings

A substitute bushing for the one used in the momentary withstand 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 of A5.3.

A.4.1.7.3 Drawout switch primary disconnects

A substitute material for use in the same design will be considered to have adequate flexural strength if its flexural strength (ASTM D 790) equals or exceeds the value of the original material.

Table A.1 – Relative thermal indexes and insulating functions

	Relative Thermal Index		
	Electrical	**Mechanical without impact**	**Mechanical with impact**
Bus	X		X
Bus joint	X		
Bus tap	X		X
Bus support	X		X
Barriers Type 1	X	X	
Barriers Type 2	X		X
Entrance bushings	X		X
Drawout switch Primary disconnects	X		X

A.4.1.8 Impact strength

A.4.1.8.1 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 ball impact test (ASTM D 5628) equals or exceeds the impact strength of the original material.

A.4.1.8.2 Bus support insulation, type-2 barriers, and drawout switch primary disconnects

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 notched Izod impact strength as measured by the test method in ASTM D 256 equals or exceeds the impact strength of the original material.

A.4.1.9 Creep resistance

A.4.1.9.1 Bus and bus tap insulation

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

A.4.1.9.2 Drawout switch primary disconnects

A substitute material will be judged to have acceptable creep resistance, provided a bar with a 4-inch (101.6 mm) span loaded to 1000 psi (6895 kPa) maximum stress and tested at 105°C for 24 hours has equal or less creep than the original material. The specimen supports, deflection measuring device, and the weight necessary to obtain a maximum fiber stress of 1000 psi (6895 kPa) are adequately described in ASTM D 648.

A.4.1.10 Recognized materials

Substitute materials recognized as NEMA Grade GPO-3, as described in NEMA LI 1 paragraphs 5.07 through 15.15, and having thermal index in accordance with NEMA LI 6 should 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 should also be considered to be suitable for replacement of GPO-2 Type- 1 or Type-2 or bus support insulation without further testing.

A.4.2 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 A.5.3.

A.4.3 Indoor apparatus insulators

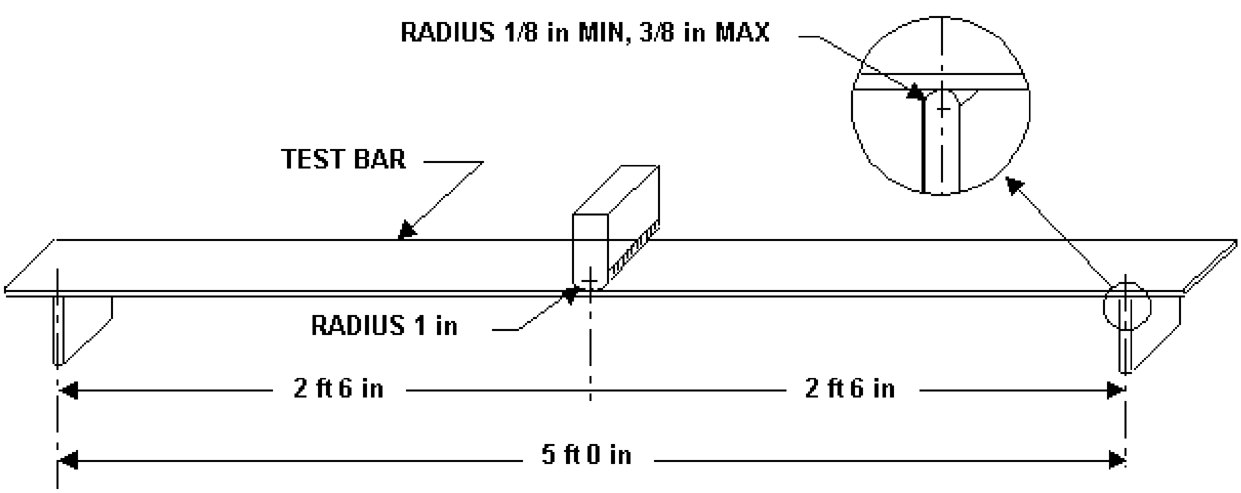
A special class of bus support insulators, indoor apparatus insulators, is available in both ceramic and nonceramic varieties. These insulators are defined and described in section 31 of NEMA SG 6.

If an indoor apparatus insulator of a particular voltage and strength class (e.g., 15 kV, 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 A4.1.4, A4.1.1, and A4.1.5 for flammability, resistance to long-term aging, and tracking resistance.

Insulators having the same height, electrical properties, and strength as indoor apparatus insulators described in NEMA SG 6 but differing in such properties as size, number, and location of bolt holes or diameter of insulating column, may be substituted for each other in accordance with the above rules.

A.4.4 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 should be determined which properties are required of material in the composite system. Only those properties required of the material being replaced should be required to be evaluated in accordance with this guide.



A.5 Tests

Most of the tests required under this guide are detailed in other standards, which are referenced under the requirements for each type and function of insulation in Section A.4 of this guide. Tests that are not described elsewhere are described in A.5.1 through A.5.3 and are referenced in the appropriate portions of Section A4.

A.5.1 Thermal cycling withstand

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

(1) Soak in a cold chamber at -30°C or lower for a minimum of 8 hours.
(2) Remove from cold chamber and allow to stand at room temperature for 2 hours.
(3) Place in oven at 105°C or above for 4 hours.
(4) Remove from oven and allow to stand at room temperature for 2 hours.

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

A.5.2 Deflection capability-bus insulation

Copper bars of ¼ in. x 4 in. (6.2 mm x 101.6 mm) size with a minimum length of 66 inches (1675 mm), or aluminum bars of 3/8 in. x 4 in. (9.3 mm x 101.6 mm) size with a minimum length of 66 in. (1675 mm), should be covered with the insulating material to be investigated and the original material. The tests should be made on the conductor material being used in the equipment. If both conductor materials are used, both must be tested. The test bars should be supported on two cylindrical supports having a minimum radius of 1/8 in. (3.2 mm) and a maximum radius of 3/8 in. (9.3 mm) and spaced 60 inches (1525 mm) apart. A cylindrical loading nose having a radius of 1 in. (25.4 mm) should be applied at the center of the 60-in. (1525 mm) span (see Figure A1) with sufficient force to deflect the test specimen 2 in. (51 mm) at the rate of 2 to 4 in. (51 to 102 mm) per minute. The force should then be removed at the same rate and the test specimen allowed to return to its normal position. The test specimen should then be turned over and similarly deflected in the opposite direction. It should be thus deflected five times in each direction, following which the center 12 in. (305 mm) of the specimen should pass a test for bus bar insulation in accordance with 6.2.1.3 of ANSI/IEEE C37.20.2 (foil test).

NOTE—If 2 in. (51 mm) is too great a deflection for the original qualified material to withstand, the maximum deflection should be reduced accordingly to provide a comparative test. The substitute material should provide equivalent or greater performance.

A.5.3 Deflection capability–bushings

The bushing should be rigidly mounted with 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 should be applied to the inner and outer terminals of the bushing but not simultaneously.

The specified load should be applied for a period of 1 minute. After the load has been removed for 1 minute, the permanent deformation, measured at the inner end, should not be greater than the deformation of the bushing used in the momentary withstand current test.