STD.NEMA C37.54-ENGL 1996 ■ 6470247 0510691 362 ■

AMERICAN NATIONAL STANDARD

American National Standard

ANSI C37.54-1996

AMERICAN NATIONAL STANDARD CONFORMANCE TEST PROCEDURES FOR INDOOR ALTERNATING CURRENT MEDIUM-VOLTAGE CIRCUIT BREAKERS APPLIED AS REMOVABLE ELEMENTS IN METAL-ENCLOSED SWITCHGEAR

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Secretariat

National Electrical Manufacturers Association

Approved by:

American National Standards Institute

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American National Standard

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Published by

National Electrical Manufacturers Association
1300 N. 17th Street, Rosslyn, Virginia 22209

Approved by ANSI December 1996

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Printed in the United States of America

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FOREWORD (This Foreword is not a part of ANSI C37.54-1996 *Conformance Test Procedures for Indoor Alternating Current Medium-Voltage Circuit Breakers Applied as Removable Elements in Metal-Enclosed Switchgear.*)

This revision updates/corrects/improves many clauses to correlate with the present trends in standard usage as well as adding a 27kV rated maximum voltage circuit breaker to the tables.

This standard has been revised by the Power Switchgear Assemblies Technical Committee of the Switchgear Section, the National Electrical Manufacturers Association (NEMA 8SGV).

This standard was developed to describe selected tests and procedures to demonstrate conformance in accordance with clause 1.5 ANSI/IEEE C37.09. The scope of this standard is limited to Conformance Test Procedures for Indoor Alternating Current Medium Voltage Circuit Breakers Applied as Removable Elements in Metal Enclosed Switchgear Assemblies. 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 procedure standards 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 identified circuit breakers for use in installations subject to regulation by public authorities and similar agencies concerned with law ordinances, regulations, administrative orders and similar instruments. It is noted that certain utility installations have been excluded from the scope of this standard as a result of discussion among representatives from EEI and NEMA.

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:

E. Byron, Chairman
A.K. McCabe, Executive Vice-Chairman, HV Standards
J. Scott, Executive Vice-Chairman, LV Standards
D.L. Swindler, Executive Vice-Chairman, IEC Activities
M. Calwise, Secretary

Organizations Represented	*Name Of Representative*
Electric Light and Power Group	D.E. Galicia D.G. Komassa J.L. Koepfinger M.C. Mingoia J.H. Provanzana T.E. Bruck (Alt.)
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M. Beard	J. Laughlin	T. Olsen	F. Teufel
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Conformance Test Procedures for Indoor Alternating Current Medium-Voltage Circuit Breakers Applied as Removable Elements in Metal-Enclosed Switchgear

1 General

1.1 Scope

1.1.1 When conformance tests are required, this standard specifies tests to demonstrate that the circuit breaker being tested conforms with the ratings assigned to it in accordance with ANSI C37.06. As a requirement of conformance testing, the breaker shall have completed the design testing requirements of ANSI/IEEE C37.09. If ANSI/IEEE C37.09 tests have not been previously performed, the tests required by ANSI/IEEE C37.09 beyond tests described by this standard may be performed concurrently with conformance testing. Additional tests per ANSI/IEEE C37.09 need not be witnessed by the certifying party.

1.1.2 This standard applies to indoor alternating current medium voltage circuit breakers rated above 1000 volts used as removable elements in metal-enclosed switchgear assemblies in accordance with clause 2.1.9.3 of ANSI/IEEE C37.20.2.

1.1.3 This standard does not apply to 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, roads, etc., or outdoors by established rights on private property.

1.2 Definitions

1.2.1 Circuit breaker

Indoor alternating current medium voltage circuit breakers rated above 1000 volts used as removable elements in metal-enclosed switchgear assemblies, unless qualified by other descriptive terms.*

*This definition differs from that in ANSI/IEEE C37.100.

1.2.2 Design tests

Tests made by the manufacturer to determine the adequacy of the design of a particular type, style, or model of equipment or its component parts to meet its assigned ratings and to operate satisfactorily under normal service conditions or under special conditions if specified, and may be used to demonstrate compliance with applicable standards of the industry.*

*This definition differs from that in ANSI/IEEE C37.100.

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."

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1.2.3 Production tests

Test 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.*

*This definition differs from that in ANSI/IEEE C37.100.

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."

1.2.4 Conformance tests

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

*This definition differs from that in ANSI/IEEE C37.100.

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

1.3 Referenced American National Standards

This standard is intended to be used in conjunction with the following American National Standards. When American National Standards referred to in this document are superseded by a revision approved by the American National Standards Institute, Inc., the revision shall apply; except in the case of ANSI/IEEE Std 4, the 1978 edition shall apply.

ANSI/IEEE C37.04-1979 (R 1988), *Rating Structure for AC High Voltage Circuit Breakers*

ANSI C37.06-1987 (R 1994), *Preferred Ratings and Related Required Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis*

ANSI/IEEE C37.09-1979, *Test Procedure For Alternating Current High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis*

ANSI/IEEE C37.20.2-1993, *Metal-Clad and Station-Type Cubicle Switchgear*

ANSI C37.55-1989, *Metal-Clad Switchgear Assemblies—Conformance Test Procedures*

ANSI/IEEE Std 4-1978, *Techniques for High-Voltage Testing*

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

2 General test conditions

Tests shall be conducted under conditions prevailing at the test site which shall conform to "Usual Service Conditions" in accordance with clause 4.1 of ANSI/IEEE C37.04, except that continuous current tests shall be conducted within the ambient temperature range of 10°C (50°F) to 40°C (104°F).

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3 Conformance tests

3.1 General

3.1.1 Tests shall be conducted on representative circuit breakers selected from identified groups of ratings. For grouping of ratings for test purposes, refer to clause 3.4.

3.1.2 Consideration should be given to simultaneously conducting those tests which may be required for both the circuit breaker and the Switchgear Assembly (refer to ANSI C37.55).

3.1.3 Consideration may be given to conducting applicable design tests in lieu of performing the conformance tests of table 1 of this standard.

3.2 Test requirements

Each circuit breaker group selected for testing shall successfully complete the following tests when specified in the applicable test schedules in table 1.

a. Impulse withstand tests (3.5)
b. Continuous current tests (3.6)
c. No load mechanical operations tests (3.7)
d. Load current switching tests (3.8)
e. Short-time current carrying tests (3.9)
f. Short-circuit current tests (3.10)
g. Conductivity of current path tests (6.3)
h. Power frequency voltage withstand tests (6.2)

These tests may be applied separately to different circuit breakers, or they may be applied to the same circuit breaker unless otherwise specified in this document.

If there is more than one rating included in the identified group of circuit breakers, applicable test duties shall be applied to additional representative circuit breakers of each separate rating within the group whose conformance has not been completely demonstrated.

3.2.1 Test schedules (table 1)

3.2.1.1 Schedule A (initial test schedule)

Schedule A comprises an initial series of test duties which shall be used to demonstrate that one or more representative circuit breakers from an identified group of circuit breakers conforms to the ratings assigned from the appropriate schedule of preferred ratings in accordance with ANSI C37.06, and that the circuit breakers comprising the identified group will operate satisfactorily under usual service conditions. The test duties comprising Schedule A are listed in table 1.

a. This complete schedule shall not be required to be conducted more than once for an identified group of circuit breakers. (Refer to Schedules B, C, D and E for additional testing.)

b. Applicable portions of this schedule shall be permitted to be used to demonstrate conformance of modifications to previously tested designs of an identified group.

c. Before a newly identified group of circuit breakers is tested per Schedule A, the performance of similarly designed circuit breakers will be reviewed. Where tests have been previously made which can be extended to qualify the newly identified group of circuit breakers as specified in clause 3.4.2 it shall be permitted to certify the newly identified group without repeating the extended tests.

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Table 1–Test schedules(3)

Schedule	Test	Reference Section
A	Initial tests(1)	
	Impulse withstand tests (4)(6)	3.5
	Continuous current tests (5)	3.6
	No load mechanical operations tests (4)(8)	3.7
	Load current switching tests (4)	3.8
	Short-time current carrying tests (4)(9)	3.9
	Short-circuit current tests (4)(9)(11)(12)	3.10
	Conductivity of current path test (2)(12)	6.3
	Power frequency voltage withstand test (2)(10)	6.2
B	Retests(1)	
	Load current switching tests (4)	3.8
	Short-circuit current test duty SC2 (4)(9)	3.10
	Conductivity of current path test (2)(12)	6.3
	Power frequency voltage withstand test (2)(10)	6.2
C	Retests(1)	
	Impulse withstand tests (4)(6)	3.5
	Continuous current tests (7)	3.6
	Short-circuit current test duty SC1 (4)(9)	3.10
	Conductivity of current path test (2)(12)	6.3
	Power frequency voltage withstand test (2)(10)	6.2
D	Retests(1)	
	Short-time current carrying tests (4)(9)	3.9
	Short-circuit current test duty SC2 (4)(9)	3.10
	Conductivity of current path tests (2)(12)	6.3
	Power frequency voltage withstand test (2)(10)	6.2
E	Retests(1)	
	No-load mechanical operations tests (4)(8)	3.7

NOTES

(1) Each representative circuit breaker to be tested in accordance with Schedules A, B, C, D or E of table 1 shall have been previously tested in accordance with production tests contained in clause 6.

(2) Test enclosure not required.

(3) Tests required in table 1 shall be conducted in the schedule sequence A-B-C-D-B-C-D etc., and A-E-E-E etc., at an appropriate retest interval following completion of the previous schedule (ref. clause 7.3). Tests per schedule A shall be conducted first to initiate the sequence. Schedule A shall not be required to be conducted more than once (ref. clause 3.2.1.1(c)).

(4) A test enclosure per clause 3.3.1 is required.

(5) Continuous current tests shall be conducted in an appropriate switchgear assembly (ref. clause 3.3.1.1(c) and C37.55 clause 5.7). Separate tests shall be required on one representative circuit breaker for each continuous current rating within an identified group.

(6) One representative circuit breaker shall be selected from an identified group selected for impulse withstand tests. The circuit breaker selected shall be permitted to be a different circuit breaker than those selected for other tests in the same test schedule.

(7) The continuous current test shall be conducted in an appropriate switchgear assembly (ref. clause 3.3.1.1(c) and C37.55 clause 5.7). The test shall be made on one representative circuit breaker having the highest continuous current contained within the identified group.

(8) The no load mechanical operations test shall be made on one representative circuit breaker from an identified group. This shall be the circuit breaker which requires the largest number of no load mechanical operations (ref. C37.06, table 8, column heading "no-load mechanical").

(9) This test shall be conducted on a representative circuit breaker having the lowest continuous current rating within the identified group.

(10) This test shall be performed on the circuit breaker at the conclusion of the short circuit current tests. The power frequency withstand test shall be made at 60% of rated value.

(11) Short-circuit current tests are comprised of test duties SC1, SC3 and SC4 described in clause 3.10.

(12) Conductivity of current path tests shall be performed within the short-circuit test duty sequence (ref. clause 3.10) following short-circuit test duties SC1, SC2 and SC3 as indicated in the test schedules.

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3.2.1.2 Schedules B, C, D and E (retest schedules)

Schedules B, C, D and E are each comprised of a differing series of tests which shall be used to demonstrate that a representative sample of an identified group of circuit breakers taken from a production lot, at stipulated intervals, conforms to the ratings demonstrated by the tests specified in schedule A.

3.2.2 Sequence of test schedules

Schedules B, C, D and E shall be applied respectively to one or more representative circuit breakers from each identified group at the appropriate retesting interval following completion of Schedule A. Refer to 7.3 for retest intervals.

3.2.3 Severity of tests

No level of testing shall be required which increases the severity of a specified test duty, except at the option of the manufacturer.

3.3 Test arrangements

All circuit breakers tested in accordance with this standard shall be located within a test enclosure as specified in the relevant sub-clauses.

3.3.1 Test enclosures

Test enclosures, when specified in this document shall be constructed to surround the circuit breaker on all sides and on top with sheet metal. Access to the enclosures shall be provided by doors or covers. A portion of the enclosing metal covering shall be permitted to be one or more members attached to the circuit breaker frame or supporting structure. The metal enclosures shall be permitted to have ventilation openings, exhaust vents and other functional openings when required by design considerations providing such openings are arranged to prevent personnel from accidentally contacting live parts of the circuit breaker. Test enclosures shall be permitted to be either one of two types as defined in 3.3.1.1 and 3.3.1.2.

3.3.1.1 Switchgear assembly type

A circuit breaker shall be permitted to be tested in a single unit or a single vertical section of a metal-enclosed power switchgear assembly which has been specifically designed to accommodate the circuit breaker. Multiple unit or multiple section switchgear assemblies shall also be permitted to be used.

a. The switchgear compartment for housing the circuit breaker to be tested shall be equipped with such normally supplied items as metal barrier and doors; insulating barriers; safety shutters; wiring ducts; expansion chambers and ventilation means; disconnectible primary, secondary and grounding means; provisions for holding the circuit breaker in its connected position; and other items normally supplied which can be expected to have an influence on circuit breaker performance.

b. Primary and control power as well as ground shall be connected to the circuit breaker through means normally provided in the switchgear assembly.

3.3.1.2 Circuit breaker compartment type

A circuit breaker shall be permitted to be tested in a compartment type of test enclosure except as required in clause 3.6.

a. The compartment type of test enclosure shall meet the general requirements for test enclosures (see 3.3.1). It shall effectively duplicate or simulate all of those elements which have an influence

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on circuit breaker performance and which are present in the circuit breaker compartment of a single unit or a single vertical section of a metal-enclosed power switchgear assembly in which the circuit breaker is normally applied. The location of all elements of the compartment type test enclosure shall be spaced at no greater distances from the circuit breaker than equivalent elements are spaced with respect to the circuit breaker when it is located in the connected position in an appropriate assembled switchgear unit or vertical section.

b. The compartment type test enclosure shall include the following elements of the same configuration as normally found in the appropriate switchgear unit or vertical section.

   1. Expansion chambers and ventilation means which shall be no larger than those provided in the switchgear assembly.
   2. Means for holding the circuit breaker in its connected position.
   3. Disconnectible means for primary and secondary (control) power as well as ground connections.
   4. Shutters and barriers

3.3.2 Grounding of test enclosures

Test enclosures of all types shall normally be grounded for all tests unless permitted otherwise in the test description. A suitably sized conductor shall be connected directly between the enclosure and the test station ground. The suitability of the size of ground conductor will be dependent on the type of test. For impulse withstand tests the ground conductor shall not be less than #14 AWG copper wire. For test duties listed in table 3, the ground conductor shall not be less than #4/0 copper cable. Materials other than copper, bus bars and other means shall be permitted to be used for grounding provided they are at least equal in conductivity and current carrying capability to the wire and cable sizes specified above.

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3.4 Grouping of ratings for test purposes

3.4.1 Identified groups

All circuit breakers shall be assigned to identifiable groups for test purposes. It is recognized that the groups may vary with different manufacturers. Groups of common circuit breakers shall be established prior to testing.

a. All circuit breakers in an identified group shall be of the same general type (e.g., all air magnetic circuit breakers; all vacuum circuit breakers; etc.) and shall be similarly designed.
b. All circuit breakers in an identified group shall have commonalities as described in 3.4.2.
c. Typical groupings for test purposes are shown in table 2 for information and guidance in applying this section. Other groupings for test purposes shall be permitted.

Table 2–Typical groupings of ratings for test purposes (see 3.4.1)*

Group No.	Rated Maximum kV	Rated Short-Circuit	Rated Continuous Amperes
I	4.76	8.8	1200
II	4.76	29	1200
	4.76	29	2000
III	4.76	41	1200
	4.76	41	2000
IV	4.76	41	3000
V	8.25	33	1200
	8.25	33	2000
VI	15	18	1200
	15	18	2000
VII	15	28	1200
	15	28	2000
VIII	15	37	1200
	15	37	2000
IX	15	37	3000
X	27	16	1200
	27	25	1200
	27	25	2000
XI	38	21	1200
	38	21	2000
	38	21	3000
	38	40	1200
	38	40	2000
	38	40	3000

* Ratings are according to table 1 of ANSI C37.06

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3.4.2 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 circuit breakers, a test conducted on a representative circuit breaker from a particular identified group shall be extended to qualify other circuit breakers 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 circuit breaker performance, and the elements of the circuit breaker which will be affected. The typical examples below are intended for information and guidance in applying this section and shall not limit its applicability.

a. A short circuit current interrupting test conducted on a circuit breaker having a particular continuous current rating (e.g., 1200A) may be extended to qualify another circuit breaker of the same short circuit current rating but having a different continuous current rating (e.g., 2000A) providing that the interrupter assemblies are basically the same for both circuit breakers. For example, it may be possible to conduct a short circuit interrupting test on a circuit breaker from table 2 Group V with a continuous ampere rating of 1200 and to extend the test to qualify circuit breakers from table 2 Group V with a continuous ampere rating of 2000.

b. Continuous current tests on a particular type of circuit breaker having a given continuous current rating may be extended to all equally rated circuit breakers of similar type provided that the construction of contacts and primary current carrying parts are equivalent. For example, all of the 1200 Amp circuit breakers from table 2 Groups V, VI and VII may be qualified by a single test on one circuit breaker.

c. No load mechanical operation tests conducted on a particular circuit breaker may be extended to qualify other circuit breakers of similar construction provided the required number of operations applicable to the other circuit breakers is no greater than the number demonstrated by the test. For example, all of the circuit breakers from table 2 Groups I, II and III may be qualified by a single test on one circuit breaker.

3.5 Impulse withstand test

These tests demonstrate conformance with the full wave impulse withstand voltage rating assigned to a circuit breaker in accordance with table 4 of ANSI C37.06. The circuit breaker to be tested shall be new and clean and shall not have been subjected to prior tests, except for the production tests in clause 6.

The circuit breaker shall be tested in a grounded test enclosure in accordance with clauses 3.3.1 and 3.3.2 and shall be positioned in its connected position.

3.5.1 Description of tests

The impulse withstand test shall be conducted in accordance with ANSI/IEEE Std 4, unless otherwise specified.

a. The standard 1.2/50 impulse voltage wave with crest value equal to the rated impulse withstand voltage of the circuit breaker being tested shall be applied in accordance with ANSI/IEEE Std 4.

b. Tests shall be made under the conditions of the atmospheric temperature, pressure and humidity prevailing in the test laboratory. Suitable correction factors shall be applied to the actual measured values of impulse voltage to convert them to standard atmospheric conditions in accordance with clause 1.3.5 of ANSI/IEEE Std 4. Humidity correction factors shall be based on curves derived for rod gaps in accordance with figure 1.3 of ANSI/IEEE Std 4. The corrected crest value shall be permitted to have a tolerance of minus 5 percent. The

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virtual time front of the impulse wave shall be permitted to have a tolerance of ± 30% and the virtual time to half value shall be permitted to have a tolerance of ± 20%. Other wave shape tolerances in accordance with ANSI/IEEE Std 4 are applicable.

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

c. With the circuit breaker contacts in the normally open position, apply positive impulse voltage of appropriate level three consecutive times to each of the circuit breaker terminals individually. All other terminals, the frame of the circuit breaker and the test enclosure shall be grounded.

d. Apply tests in accordance with paragraph (c) except to utilize negative impulse voltage.

e. With the circuit breaker contacts in the normally closed position, apply positive impulse voltage of appropriate level three consecutive times to each of the phase terminal pairs. All other terminal pairs, the frame of the circuit breaker and the enclosure shall be grounded.

f. Apply tests in accordance with paragraph (e) except to utilize negative impulse voltage.

g. Where prior testing shows that tests of one polarity are more severe, tests using the opposite polarity may be omitted.

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

h. If flashover occurs on only one test during any group of three consecutive tests required by paragraphs (c) through (g), nine more tests shall be made (referred to as the 3 x 9 test). If the equipment successfully withstands all nine of the second group of tests, the flashover in the first group shall be considered as a random flashover, and the equipment shall be considered as having successfully passed the tests."

3.5.2 Performance

Based upon tests conducted according to clause 3.5.1, paragraphs (c), (d), (e) and (f) on individual terminals or pairs of terminals in several sequences, each sequence being comprised of three consecutive applications of impulse voltage, the evaluation of the performance of the circuit breaker shall be made on the basis of each of these sequences. If no disruptive discharge and/or flashover occurs during a particular sequence, the circuit breaker shall be judged to have passed that sequence. If a single disruptive discharge and/or flashover has occurred during a particular sequence, that sequence shall be repeated for the same terminal or terminal pair. During the repeated sequence if there is no disruptive discharge and/or flashover, the circuit breaker shall be judged to have passed the repeated sequence with the single disruptive discharge and/or flashover occurring in the first sequence being considered to have been a random occurrence. If a disruptive discharge and/or flashover occurs during the repeated sequence, the circuit breaker shall be judged to have failed that sequence only and the provisions of clause 5 shall be applied.

For a circuit breaker to be judged to have demonstrated the assigned rated impulse withstand test voltage, it shall have passed all of the required sequences in accordance with clause 3.5.1 and it shall not have sustained any damage as a consequence of the tests applied.

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3.6 Continuous current tests

These tests shall demonstrate the ability of a circuit breaker to carry its rated continuous current at rated power frequency without exceeding the allowable temperature limits in tables 2, 3, and 4 of ANSI/IEEE C37.04. The circuit breaker to be tested shall be clean and dry. If the circuit breaker has been subjected to prior tests, it shall be permitted to be maintained prior to start of test. The circuit breaker to be tested shall be installed in its connected position within a switchgear assemblies type test enclosure per 3.3.1.1. Its contacts shall be in the normal closed position.

3.6.1 Test circuit

The test shall be conducted by passing a three-phase alternating current of sinusoidal wave shape and rated power frequency through the primary conductors of the circuit breaker. The level of current shall be no less than the rated continuous current of the circuit breaker. 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 to avoid interference with temperature measuring equipment.

3.6.2 Duration of test

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 changed by more than 1.0°C as indicated by three successive readings at 30 minute intervals. The equipment is considered to have passed the test if the established temperature limits in clause 3.6 have not been exceeded in any of the three readings.

3.6.3 Method of measuring device temperatures

The temperatures of various parts of the circuit breaker shall be monitored with thermocouples connected to a suitable temperature measuring device.

3.6.3.1 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.

3.6.3.2 Thermocouples shall be used to monitor the temperature rise of insulating members which 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 inches (77 millimeters) of insulation as measured along the principal axis of the conductor.

3.6.3.3 Thermocouples used to monitor the temperature rise of separable primary contacts, of circuit breaker main contacts, and of hinged contacts in the continuous current path shall be located within approximately 0.5 inches (13 millimeters) of the actual contact area unless otherwise specified in this document. 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 inches (77 millimeters). For bridging type contact assemblies having actual contact areas further apart than 3 inches (77 millimeters), a single thermocouple shall be located in at least one bridging member approximately midway between actual

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contact areas in addition to the thermocouple required at both incoming and outgoing sides of the contact assembly.

3.6.3.4 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 inches (77 millimeters) of each other under provisions stated in clauses 3.6.3.2 and 3.6.3.3, the thermocouple adjacent to the near side of the contact area shall be omitted.

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

3.6.3.6 The temperature of parts of the circuit breaker 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 which 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.

3.6.3.7 The temperature rise of primary conducting parts and contact areas which are provided for functions other than the carrying of continuous current and which 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 circuit breaker opening operations and metallic supporting parts.

3.6.4 Performance

The circuit breaker shall be judged to have "passed" the test if the provisions of this section have been met and if none of the monitored locations has exceeded the maximum allowed temperature rise or total temperature limits in accordance with clause 5.4.2 of ANSI/IEEE C37.04. If a circuit breaker is judged to have "failed", the provisions of clause 5 shall apply.

3.7 No load mechanical operations tests

These tests shall demonstrate the ability of a circuit breaker to operate a stated number of times without replacement of major parts. The circuit breaker to be tested shall be clean and dry and shall be permitted to be maintained during the test. A test enclosure shall be required.

3.7.1 Description of test

3.7.1.1 The circuit breaker shall be operated without power being connected to the primary current carrying members. Each operation shall be comprised of closing the circuit breaker followed by opening the circuit breaker. The total accumulated number of operations to be demonstrated shall be in accordance with the number specified in table 8 of ANSI C37.06. Operations from prior tests may be included in the total.

3.7.1.2 Maintenance procedures shall be permitted to be performed at intervals which are equal to or longer than the intervals specified in accordance with table 8 of ANSI C37.06, based on total accumulated operations including prior tests when applicable.

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3.7.1.3 The control voltages for closing and tripping shall be at rated values in accordance with ANSI C37.06, table 9.

3.7.1.4 Circuit breakers utilizing compressed fluid for operation, insulation and/or interruption shall be tested with appropriate normal pressure measured at the circuit breaker prior to test.

3.7.2 Performance

The circuit breaker shall be judged to have "passed" the test if it has completed the required number of operations successfully and if no replacement of major parts has been required. If the circuit breaker is judged to have failed, the provisions of clause 5 shall be apply.

3.8 Load current switching tests

These tests shall demonstrate the ability of a circuit breaker to interrupt currents in the load current switching range within the required interrupting time. Required interrupting time is a capability related to rated interrupting time. Interrupting time is defined in clause 5.7 of ANSI/IEEE C37.04. The circuit breaker to be tested shall be clean and dry. If the breaker to be tested has been subjected to prior tests, it shall be permitted to be maintained prior to the test.

3.8.1 Description of tests

3.8.1.1 The tests shall consist of three phase opening operations at rated maximum voltage and rated power frequency with each of the currents to be interrupted defined as percentages of rated continuous current. The tests are listed in table 3 as test duties LS1, LS2 and LS3.

Alternatively, the tests shall be permitted to be made as single phase opening operations with all tests being performed on the same single pole at applied voltages equal to 87% of rated maximum voltage at rated power frequency. The Alternative tests are listed in table 3 as test duties LS4, LS5 and LS6.

Close-open operations shall be permitted to be substituted for opening operations for either three phase or single phase tests.

3.8.1.2 The tests shall be made under conditions prevailing at the test site providing such conditions are within usual service conditions as defined in clause 4.1 of ANSI/IEEE C37.04.

3.8.1.3 The tests shall be made with the circuit breaker located in its normal connected position within a grounded test enclosure (see 3.3).

3.8.1.4 The test circuit shall have a lagging power factor characteristic which shall not be greater than 80% and part or all of the load impedance shall be permitted to be located on the source side of the circuit breaker. The test circuit shall be permitted to be grounded at the neutral of the source or at the neutral of the load but not both.

3.8.1.5 The current interrupted shall be measured at the instant of contact separation in rms amperes and shall be of random asymmetry.

3.8.1.6 Power frequency recovery voltage shall be measured not less than one-half cycle nor more than one cycle following the interruption of the last phase current and shall not be less than .95V for three phase tests nor .83V for single phase tests, where V equals rated maximum line to line rms volts. Recovery voltage shall be maintained on the circuit breaker being tested for not less than six cycles after interruption.

NOTE: Since single phase tests are permitted as alternates to three phase tests, recovery voltage specified at 0.83V is required to demonstrate the condition which occurs in the first phase to interrupt in a three phase circuit. Maintenance of recovery voltage at 0.83V in a single-phase test for six cycles (60 Hz basis) after interruption is a more severe condition than prevails in three phase testing.

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3.8.1.7 The control voltages for closing and tripping shall be at rated values (± 5%) in accordance with ANSI C37.06, table 9.

3.8.1.8 Circuit breakers utilizing compressed fluid for operation, insulation and/or interruption shall be tested with appropriate minimum values of pressure measured at the circuit breaker prior to test.

NOTE: Nameplates, instruction books or other applicable information shall be permitted to be utilized in selecting the required minimum level of pressure which shall be used to perform the test which has been selected. Tests at minimum pressures tend to provide the most severe conditions. For example, a lower initial pressure may be appropriate for a dielectric withstand test than would be appropriate for a short circuit duty cycle test.

3.8.2 Performance

The circuit breaker shall be judged to have "passed" the tests if it has interrupted the specified currents at the specified voltages within the required interrupting times (see ANSI/IEEE C37.04, clause 5.7) in all of the appropriate test duties listed in table 3 for load current switching tests.

The circuit breaker shall not have been damaged as a consequence of the test. The circuit breaker shall have withstood the required level of power frequency recovery voltage for not less than six cycles (60 Hz basis) following final current interruption. If the circuit breaker is judged to have "failed", the provisions of clause 5 shall apply.

3.9 Short time current carrying tests

These tests shall demonstrate the capability of a circuit breaker to carry its maximum short circuit current (KI) for a period of time equal to its rated permissible tripping delay of two seconds (Y). Maximum short circuit current and rated permissible tripping delay are defined in clause 5.8 and clause 5.10 of ANSI/IEEE C37.04. The circuit breaker to be tested shall be clean and dry. If the circuit breaker selected for test has been subjected to prior tests it shall be permitted to be maintained prior to the test.

3.9.1 Description of test

3.9.1.1 The test shall consist of connecting the circuit breaker in a test circuit which has the capability of supplying the required level of short circuit current at rated power frequency through the circuit breaker for a duration of two seconds. This test is listed in table 3 as test duty ST1.

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Table 3–Test Duties

Test Duty Number	Number and Type of Operation	Phases	Initial & Recovery at Normal frequency, Volts rms Line-to-Line	Closing at First Major Peak, Amperes Peak	Interrupting Current at Instant of Contact Separation	Asymmetry, Percent	Notes
Load Current Switching Tests (see 3.8)					**Percent of Rated Continuous Current**		
LS1	(One) O-or-CO	3	V		7 to 25	Random	1,9
LS2	(One) O-or-CO	3	V		30 to 60	Random	1, 9
LS3	(One) O-or-CO	3	V		65 to 100	Random	1, 9
LS4	(Three) O-or-CO	1	0.87V		7 to 25	Random	1, 9
LS5	(Three) O-or-CO	1	0.87V		30 to 60	Random	1, 9
LS6	(Three) O-or-CO	1	0.87V		65 to 100	Random	1, 9
Short Time Current Carrying Test (see 3.9)							
ST1	Carry Current	1 or 3	Any convenient level				2
Short Circuit Current Tests (see 3.10)					**Ampheres rms**		
SC1	(One Duty Cycle) 0 + 15 Sec. + CO	3	V		I(O) I to SI (CO)	0 to 20 Random	3, 4, 7, 8, 9, 12, 13
SC2	(One Duty Cycle) 0 + 15 Sec. + CO	3	V/K		KI (O) KI to KSI (CO)	0 to 20 Random	3, 7, 8, 9, 11, 12
SC3	(Several) O	3	V/K to V		0.4 to 0.6 KSI	Random	4, 5, 6, 7, 8, 9, 12
SC4	(One) CO	3	V/K	2.66 KI	KSI	Random	7, 8, 9, 10, 12

See notes, next page

Symbols used in this table are in accordance with ANSI/IEEE C37.04.
V = Rated Maximum Voltage clause 5.1
I = Rated Short Circuit Current clause . 5.10
K = Rated Voltage Range Factor clause 5.2
S = Asymmetry Factor clause 5.10.2.2
Y = Rated Permissible Tripping Delay (2 seconds)
O = Circuit Opening Operation
C = Circuit Closing Operation
CO = Circuit Closing followed by Circuit Opening without intentional delay

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NOTES

1 Test duties LS1, LS2 and LS3 are three phase tests. Test duties LS4, LS5 and LS6 are single phase tests which shall be permitted to be made in place of corresponding three phase tests. Interrupting times shall be permitted to exceed Rated Interrupting Time in accordance with C37.04, clause 5.7.

2 For test duty ST1 the circuit breaker in the closed position shall be required to carry an integrated value of a current equivalent to KI for a time equal to Y seconds (see 3.9.1.4). The test shall be permitted to be either a three phase test or a single phase test (see 3.9.1.1).

3 In the duty cycle specified for test duty SC1 (or SC2) the second opening operation following closing shall be permitted to be delayed so that the current at the instant of contact separation does not exceed SI (or KSI) providing that the delay time does not exceed permissible tripping delay as defined in C37.04, clause 5.8. on Duty Cycle Tests the specified interrupting current shall be permitted to be demonstrated in only one of the opening operations.

4 When both test duties SC1 and SC3 are specified in the test schedule, the source side and load side terminals shall be reversed following completion of test duty SC1.

5 Test duty SC3 consists of a sufficient number of opening operations at voltages in the range from V/K to V and at currents in the range from 0.4 KSI to 0.6 KSI in order to permit the accumulation of not less than 400% KSI rms amperes on the same circuit breaker. The current from each operation to be totalized in the accumulation of 400% KSI shall be permitted to be taken from the phase producing the highest rms total current (including D.C. Component). If test duty SC3 is made in sequence with test duty SC1 on the same circuit breaker in accordance with clause 3.10.1.10(d), the currents interrupted in test duty SC1 shall be permitted to be totalized with those obtained in test duty SC3 to accumulate the required 400% KSI.

6 On the last test of test duty SC3 the normal frequency recovery voltage shall not be less than 0.95V when measured in the first cycle following interruption and shall be maintained on the circuit breaker for 6 cycles following interruption. For additional requirements refer to clauses 3.10.1.9(c) and 3.10.1.10(c).

7 Refer to sequence of tests (clause 3.10.1.10) for additional information.

8 The time interval specified for duty cycle tests in test duties SC1 and SC2 shall not be required to be less than 15 seconds. Longer intervals as required by laboratory conditions which limit re-energizing the test circuit at an appropriate voltage level for the second operation of the duty cycle shall be permitted. The interval between test duty SC3 and test duty SC4 shall not be required to be less than one hour.

9 The power frequency recovery voltage shall be permitted to have a tolerance to minus 5% and shall be maintained for not less than 6 cycles after the final phase interruption unless otherwise specified in this standard.

10 If the closing current obtained in test duty SC4 is less than 2.66 KI peak amperes, test duty SC4 shall be permitted to be accepted as performed providing all other test conditions have been met and providing that an additional closing test is made which demonstrates the capability of the circuit breaker to close in a test circuit which produces the closing current specified for test duty SC4. The Power Frequency Withstand Voltage Test normally performed after test duty SC4 (clause 3.10.1.10(d) shall be permitted to be delayed until after the additional closing test.

11 Test duty SC2 shall be required in retest schedules B and D only. For circuit breakers with rated voltage range factor K=1.0, SC2 may be omitted if SC1 is conducted instead.

12 Alternatively, single phase tests shall be permitted for test duties SC1, SC2, SC3, and SC4. These tests shall be made on a single pole with normal frequency recovery voltage not less than 83% of the line to line voltage specified for the respective three phase test. All other conditions shall be as specified for three phase tests. For test duties made in sequence (clause 3.10.1.10), the same pole shall be utilized for all tests.

13 Where test lab characteristics make it difficult to provide normal frequency recovery voltage within the specified tolerance of minus 5% in Note 9, the tolerance on recovery voltage shall be permitted to be greater than minus 5% but not more than minus 10% provided the product of the measured values of interrupted current and recovery voltage are not less than 0.95 VI.

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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 level of current specified in 3.9.1.4 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.

3.9.1.2 The tests shall be made under conditions prevailing at the test site providing such conditions are within usual service conditions as defined in clause 4.1 of ANSI/IEEE C37.04.

3.9.1.3 The tests shall be made with the circuit breaker located in its normal connected position within a grounded test enclosure (see 3.3).

3.9.1.4 The current shall be monitored throughout the duration of the test. The rms value of current shall be determined using the method described in clause 7.1.6 of ANSI/IEEE C37.09. This value squared times the duration of the test shall be no less than $2(KI)^2$. The rms value of current for the three phase test shall be no less than KI.

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

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

3.9.2 Performance

The circuit breaker shall be judged to have "passed" the test if it has carried the required rms value of current for the required time and has suffered no significant damage such as welding of contacts or part breakage as a consequence of the test. If the circuit breaker is judged to have "failed" the test, the provisions of clause 5 shall apply.

3.10 Short circuit current tests

These tests shall demonstrate the performance of a circuit breaker in successfully closing and interrupting specific levels of short circuit current within its ratings and related required capabilities as indicated in ANSI C37.06. The circuit breaker to be tested shall be clean and dry. If the circuit breaker selected has been subjected to prior tests it shall be permitted to be maintained before short circuit test duties unless otherwise specified in this document.

3.10.1 Description of tests

3.10.1.1 The tests shall be comprised of three phase operations at rated power frequency. The levels of current and voltage and the required operations shall be as described in test duties SC1, SC2, SC3 and SC4 of table 3.

3.10.1.2 The tests shall be made under conditions prevailing at the test site providing such conditions are within usual service conditions as defined in clause 4.1 of ANSI/IEEE C37.04.

3.10.1.3 The tests shall be made with the circuit breaker located in its normal connected position within a grounded test enclosure (see 3.3).

3.10.1.4 The test circuit shall have a lagging power factor characteristic which shall not be greater than 15%. The test circuit neutral shall be grounded either at the source or at the fault but not both.

3.10.1.5 When a circuit breaker closes to initiate a short circuit, the maximum stress on the circuit breaker occurs in the phase producing the largest offset current within the first 60 Hz cycle after the start of current flow. This current is identified as the closing or making current and shall be measured in peak amperes between the zero current line and the crest value of the first major amperes loop. (The closing

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current may also be measured in rms total amperes, if desired). The current which a circuit breaker interrupts is measured in rms amperes from the envelope of the current wave at the instant of primary contact separation, using the methods described in clause 7.1.3 and clause 7.1.4 of ANSI/IEEE C37.09.

a. When the current interrupted is symmetrical (0-20% asymmetry), the currents measured in each of the three phases shall be totaled and averaged to determine the level of current which has been interrupted. No single phase of current shall be less than 85% of the required level.

b. When the interruption is specified as asymmetrical (greater than 20% asymmetry) the level of current which has been interrupted shall be the rms total current including DC component measured in the phase producing the maximum offset at the instant of primary arcing contact separation.

c. When the current is to be totalized from several interruptions as specified in test duty SC3, the current from each interruption to be used in the totalization shall be the rms total current occurring in any phase, until at least one phase attains the required 400%.

3.10.1.6 Power frequency recovery voltage shall be measured not less than one half cycle nor more than one cycle following interruption of the last phase current. It shall not be less than 95% of the specified three phase line-to-line test voltage. When line to neutral voltage is being monitored it shall not be less than 95% of line-to-neutral test voltage. Power frequency recovery voltage shall be maintained on the circuit breaker being tested for not less than six cycles (60 Hz basis) after interruption of the last phase current.

3.10.1.7 The control voltages for closing and tripping shall be at rated values (±5%) in accordance with table 9 of ANSI C37.06.

3.10.1.8 Circuit breakers utilizing compressed fluid for operation, insulation and/or interruption shall be tested with appropriate minimum values of pressure measured at the circuit breaker prior to test.

NOTE: Nameplates, instruction books or other applicable information shall be permitted to be utilized in selecting the appropriate level of pressure which shall be required in order to perform the test which has been selected. For example, a lower initial pressure may be appropriate for a dielectric withstand test than would be appropriate for a short circuit duty cycle test.

3.10.1.9 Short circuit test duties

a. Test duty SC1 consists of one duty cycle test (0-15 sec. - CO) to be made at rated maximum voltage (V). Other conditions of the test shall be as specified in table 3. Test duty SC1 shall normally be performed in the test schedules as specified in table 1. This test demonstrates the ability of the circuit breaker to perform a duty cycle in which the first opening operation is at rated symmetrical current (**I**).

b. Test duty SC2 consists of one duty cycle test (0-15 sec.- CO) to be made at rated maximum voltage divided by the voltage range factor (V/K). Other conditions of the test shall be as specified in table 3. Test duty SC2 shall be performed in the test schedules as specified in table 1. This test demonstrates the ability of the circuit breaker to perform a duty cycle in which the first opening operation is at the maximum symmetrical current which the circuit breaker is required to interrupt. For circuit breakers with rated voltage range factor K=1.0, SC2 may be omitted if SC1 is conducted instead.

c. Test duty SC3 is a series of several opening tests which demonstrate the ability of a circuit breaker to interrupt in several operations a specified accumulation of short circuit current without maintenance being performed. The conditions of the test duty shall be specified in table 3. Test duty SC3 shall normally be performed as part of initial test schedule A.

d. Test duty SC4 is a close-open test (CO) used to demonstrate that the same circuit breaker which has successfully completed test duty SC3 without maintenance has the ability to perform at least

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one additional short circuit operation. Always performed in conjunction with test duty SC3, test duty SC4 shall normally be performed as part of initial test schedule A. The test conditions for test duty SC4 shall be as specified in table 3.

In addition, this test demonstrates the ability of the breaker to close and latch against maximum peak currents, withstanding the maximum forces mechanically.

3.10.1.10 Test sequences

When specified in this document, certain tests and test duties shall be made on the same circuit breaker in prescribed sequences.

a. When the circuit breaker to be tested is a new circuit breaker it shall have been tested in accordance with production tests (see 6.0) and no other tests shall be required prior to short circuit current tests.

b. When a circuit breaker which has been subjected to prior tests is maintained before being subjected to a short circuit test duty the conductivity of current path test (see 6.3) shall be permitted to be made to establish that the individual phase resistance or millivolt drop characteristics of the maintained circuit breaker do not exceed maximum values established by the manufacturer for new circuit breakers of the same type and rating.

c. When specified in the test schedules per table 1, short circuit tests duties SC3 and SC4 shall be performed in numerical sequence on the same circuit breaker without maintenance being performed from the start of test duty SC3 until after the power frequency voltage withstand test (see 6.2) following test duty SC4. A conductivity of current path test (see 6.3) shall be made at the conclusion of test duty SC3 and prior to test duty SC4 to establish that the individual phase resistances or millivolt drop characteristics do not exceed 200% of the maximum values established for new circuit breakers of the same type and rating. The power frequency voltage withstand test (see 6.2) following test duty SC4 shall be permitted to be made at 60% of the rated power frequency withstand voltage.

d. When specified in the same test schedule, test duties SC1, SC3 and SC4 shall be permitted to be made in numerical sequence on the same circuit breaker providing no maintenance is performed from the start of test duty SC1. The test sequence shall be permitted to be substituted in place of the test sequence specified in clause 3.10.1.10(c). Current conductivity and power frequency voltage withstand tests shall be performed following test duty SC3 and test duty SC4 respectively as described in clause 3.10.1.10(c). Between test duty SC1 and test duty SC3, the source side and load side terminals of the circuit breaker shall be reversed.

e. In retest schedules B, C and D of table 1 both the conductivity of current path test (see 6.3) and the power frequency voltage withstand test (see 6.2) shall be made on the same circuit breaker which has been subjected to test duty SC1 or SC2. These tests shall be made following the specified test duty and prior to any maintenance being performed. Either the conductivity test or the voltage withstand test shall be permitted to be performed first. Individual phase resistances or millivolt drops shall be permitted to be 200% of maximum values established for new circuit breakers of the same type and rating. Voltage withstand tests shall be permitted to be made at 60% of rated power frequency withstand voltage.

3.10.2 Performance

Circuit breaker performance shall be evaluated on the basis of individual test duties as well as on completion of all of the test duties within the test schedule being demonstrated. The circuit breaker shall be judged to have "passed" a test duty if it has closed the specified current, if it has interrupted the required currents at appropriate recovery voltages within rated interrupting times, and if it has otherwise operated satisfactorily within the appropriate conditions as indicated in table 3. Results of current

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conductivity tests and voltage withstand tests conducted as part of short circuit test sequences shall be considered in determining satisfactory operation. If a circuit breaker is judged to have "failed," the provisions of clause 5 shall apply.

4 Circuit breaker auxiliary devices

4.1 General

The primary functions of a circuit breaker are to close, to latch, to carry, and to interrupt all currents within its rated capability. Auxiliary devices are provided to perform secondary operations which supplement these primary functions. Since each design of circuit breaker may have unique characteristics, only those auxiliary devices most commonly found on circuit breakers will be referred to in the following sections. When auxiliary devices are supplied which have not been described, or which have special features not described, the manufacturer's instructions for operation, adjustment and testing shall be permitted to be used.

4.2 Auxiliary switches

4.2.1 There are two categories of auxiliary switches normally mounted on circuit breakers.

a. One category of auxiliary switches is comprised of those devices which are provided for operational control of the circuit breaker. Since the proper functioning of the circuit breaker is dependent upon this category of auxiliary switches, tests to demonstrate breaker functions; particularly, the no load mechanical operations test, shall be sufficient to verify the capability of this category of auxiliary switches.

b. A second category of auxiliary switches is comprised of those devices which are primarily provided for connection in external control circuits not directly associated with circuit breaker operational controls. Tests in accordance with 4.2.3 shall be required to demonstrate the performance capabilities of this category of auxiliary switches. Applicable production tests are included in clause 6.4.

c. The same auxiliary switch may include contacts of both categories.

4.2.2 Ratings and capabilities

a. General—Auxiliary switches supplied for external control circuits may be assigned various ratings by the manufacturer. More than one set of ratings may be assigned to the same auxiliary switch. When ratings have not been assigned, guides are provided for establishing auxiliary switch capabilities for demonstration purposes.

b. Voltage—The manufacturer may assign a voltage rating and/or a voltage range. When no voltage rating or voltage range has been assigned, one or more of the ratings and ranges in ANSI C37.06, table 9, will apply.

c. Continuous current rating—The manufacturer may assign a continuous current rating to an auxiliary switch, which shall be the maximum current that the auxiliary switch shall be required to carry continuously without exceeding the allowable temperature rise of the materials used in construction of the switch. When no continuous current rating has been assigned, the auxiliary switch shall be considered capable of continuously carrying a current equal to 50% of the maximum current drawn by the shunt trip device used on the circuit breaker on which the auxiliary switch is mounted. An assigned continuous current rating shall be permitted to be a higher value than an assigned contact interrupting rating.

d. Contact interrupting rating—The manufacturer may assign contact interrupting ratings at various voltages, which shall be classified as either non-inductive or inductive. The non-inductive rating

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shall be the maximum current that the switch shall be required to interrupt when carrying current at the maximum applicable voltage in a circuit which is primarily resistive in characteristics. The inductive rating shall be the maximum current that the switch shall be required to interrupt when carrying current at the maximum applicable voltage in a circuit which is primarily inductive in characteristics. When no contact interrupting rating has been assigned the auxiliary switch shall be considered to be capable of interrupting a current equivalent to 150% of its continuous current rating at its maximum applicable voltage in a circuit which is primarily resistive in characteristics.

4.2.3 Auxiliary switch tests

Auxiliary switches applied for use in control circuits external to the circuit breaker shall be tested to demonstrate their performance capabilities. These tests shall include continuous current tests, contact interrupting tests, and contact endurance tests. For production tests refer to clause 6.4.

a. Auxiliary switch tests shall be permitted to be made concurrently with appropriate tests on the circuit breaker.

b. When an auxiliary switch test is to be used to qualify a particular switch for use with several different sizes or types of circuit breakers, the test shall normally be made with the switch located on the circuit breaker which has the most constricted space for mounting. When the number of operations required varies depending on the circuit breaker rating, the auxiliary switch test shall be made using the largest applicable number (ANSI C37.06, table 8).

c. When more than one auxiliary switch can be mounted or when auxiliary switches having various numbers of contacts may be used, the combination to be tested shall be the one providing the largest number of contacts.

d. When auxiliary switches are provided which have individually reversible contacts, the tests shall be made with not less than half of the contacts of the category per 4.2.1(b) arranged to be closed when the breaker is closed.

e. The continuous current test shall normally be made concurrently with the continuous current test on the circuit breaker in test schedule A—table 1. For purposes of this test one auxiliary switch contact which is normally closed when the circuit breaker is closed shall be connected in a circuit which produces the highest continuous current for which the switch is rated. The remaining auxiliary switch contacts which are normally closed when the circuit breaker is closed shall be connected in a series circuit which produces not less than 50% of the highest continuous current for which the switch is rated. The currents of suitable levels shall be supplied from either a DC source or a single phase 50/60 Hertz AC source.

   The auxiliary switch shall be judged to have "passed" the test if while conducting the specified continuous currents under stabilized temperature conditions the allowed temperature rise has not been exceeded. If the auxiliary switch is judged to have "failed" the test, the provisions of clause 5 shall apply.

f. The contact interrupting test shall normally be made concurrently with the circuit breaker no load mechanical operations test (see 3.7) in test schedule A—table 1. This test shall be made prior to and as a prerequisite for the auxiliary switch endurance test (see 4.2.3(g)). If more than one contact interrupting rating for the auxiliary switch is to be demonstrated, contact interrupting tests shall be permitted to be run concurrently with a separate contact designated for each rating to be demonstrated. When an auxiliary switch has been rated at the same interrupting current and voltage for both AC and DC circuits, only the DC rating shall be required to be tested.

   1. The test shall consist of 50 interruptions on each contact. The frequency of operation shall be no less than one operation per minute for a group of five operations. Groups of operations shall be permitted to be separated by intervals not exceeding 15 minutes.

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2. The current, voltage and circuit conditions to be demonstrated shall be in accordance with appropriate line(s) from table 4.

3. The auxiliary switch shall be judged to have "passed" the test for a particular rating if it has successfully interrupted the required current at the required voltage 50 times, if no switch parts have been maintained or replaced and if the auxiliary switch endurance test can be started. If the auxiliary switch is judged to have "failed" the test, the provisions of clause 5 shall apply. When two or more current interrupting ratings are being demonstrated the failure of one contact shall not be a factor in judging the performance of others.

g. The contact endurance test shall be permitted to be made concurrently with the circuit breaker no load mechanical operations test (see 3.7) in test schedule A. This test shall be made on an auxiliary switch which has previously passed the contact interrupting test (see 4.2.3(f)). When more than one contact interrupting rating for the auxiliary switch is to be demonstrated, the tests shall be permitted to be made concurrently with separate contacts designated for each rating to be demonstrated.

1. The total number of operations to be demonstrated shall be equal to the number of no load mechanical operations required for the circuit breaker on which the auxiliary switch is mounted (see ANSI C37.06, table 8). Interruptions accumulated per clause 4.2.3(f) shall be permitted to be included in the total. The number of interrupting operations shall be 40% of the required total. Maintenance procedures shall be permitted to be performed at intervals which shall be in accordance with ANSI C37.06, table 8.

2. The current, voltage and circuit condition to be demonstrated shall be in accordance with appropriate line(s) from table 4.

3. The auxiliary switch shall be judged to have "passed" the test for a particular rating if it has successfully interrupted the required rated current at the required voltage for the number of times specified, if no switch parts have been replaced, and if the switch is capable of withstanding a power frequency voltage withstand test at a level 60% of the level required for a new auxiliary switch (see 6.4.2). If the auxiliary switch is judged to have "failed" the test, the provisions of clause 5 shall be applied. When two or more contact interrupting ratings are being demonstrated the failure of one contact shall not be a factor in judging the performance of others.

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Table 4–Auxiliary switch tests

Line	Assigned Contact Interrupting Rating	Test Circuit Conditions: Voltage†	Test Circuit Conditions: Current	Test Circuit Conditions: Power Factor* (AC)	Typical Circuit Components
Contact Interrupting Tests (see 4.2.3(f))					
1	None Assigned	Maximum of Range	150% of Continuous Current Rating	75-80% Lagging	Lamps Heaters
2	Noninductive	Maximum of Range	100% of Assigned Interrupting Current	75-80% Lagging	Lamps Heaters
3	Inductive	Maximum of Range	100% of Assigned Interrupting Current	30-35% Lagging	Electro-Magnetic Devices
Contact Endurance Tests (see 4.2.3(g))					
4	None	Rated	100% of Continuous Current Rating	75-80% Lagging	Lamps Heaters
5	Noninductive	Rated	100% of Assigned Interrupting Current	75-80% Lagging	Lamps Heaters
6	Inductive	Rated	100% of Assigned Interrupting Current	45-50% Lagging	Electro-Magnetic Devices

* Lower values shall be permitted to be used. Actual values shall be indicated on tests reports.
† See ANSI C37.06, table 9.

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4.3 Other components and features

4.3.1 Circuit breakers may include components and features such as:

a. Shunt trip device
b. Mechanism motor
c. Contact position indicator
d. Stored energy mechanism indicator
e. Manual trip device (independent of control power)
f. Power operated mechanism
g. Manual closing device
h. Latch checking switches, etc.
i. Nameplate (see ANSI/IEEE C37.04, clause 7)
j. Trip free
k. Closing and tripping speed independent of manual devices

No additional tests are required for components if adequate performance is demonstrated during tests on the circuit breaker (see 3.7, 3.8, 3.9, 6.4, and 6.8).

4.3.2 Insulating materials for use in circuit breakers are to be evaluated by the manufacturer with respect to their acceptability for the particular function performed. When a material is investigated to determine if it is acceptable, consideration is to be given to its mechanical strength, dielectric properties, insulation resistance, heat resistance qualities, the degree to which it is enclosed or protected and any other features having a bearing on electrical shock or dielectric failure, in conjunction with conditions of actual service. All of these factors are to be considered with respect to aging. Satisfactory field performance should also be considered.

5 Treatment of failures

5.1 Should a failure occur during the performance of any particular test, the cause of the failure shall be identified and shall be corrected. The test on which the failure occurred shall be repeated after corrective action has been taken.

5.2 The failure and corrective measures taken shall be described in adequate detail to provide the basis for continuing the test program.

5.3 Failures can result from such a large variety of causes that it would be impossible to anticipate all types. Each cause of failure identified shall be analyzed to determine, not only the corrective action to be taken, but also the influence such action may have on tests previously made.

NOTE: The following examples are provided for guidance:

Example 1: Redesign of a mechanism component which failed on a no load mechanical operations test would not normally require repeating of previous short circuit test if mechanism speed, energy and displacement are not changed.

Example 2: Redesign of a barrier component on a circuit breaker which failed an impulse voltage test might require repeating a prior continuous current test if the normal convection flow of cooling air is changed by the redesign of the barrier.

Example 3: Analysis of a failure during short circuit testing indicates an improper test circuit setting. Rebuilding of the circuit breaker without changing design would be permitted in order to repeat the short circuit tests using the proper setting. No prior tests would be affected.

5.3.1 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.

5.3.2 When analysis indicates that a particular corrective action might have caused a failure in tests previously completed, only those tests which might have failed shall be repeated on a circuit breaker to

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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.

6 Production tests

6.1 General

6.1.1 Production tests are those tests which shall be applied in the manufacturer's normal production facility to each circuit breaker produced prior to shipment from the factory.

Production tests shall not be required to be made in an enclosure. Provisions shall be made to assure that the circuit breaker will properly fit in the switchgear assembly for which it has been designed.

6.1.2 Production tests shall include the following items as may be appropriate for each type, style or model of circuit breaker. Tests shall be permitted to be made in any order or sequence, unless otherwise specified in this document.

a. Power frequency voltage withstand tests (6.2)
b. Conductivity of current path test (6.3)
c. Control devices and secondary wiring tests (6.4)
d. Bushing tests (6.5)
e. Mechanical operations tests (6.6)
f. Timing tests (6.7)
g. Pressure and leakage tests (6.8)

6.2 Power frequency voltage withstand tests

6.2.1 Purpose of tests

When these tests are applied to a new circuit breaker during production tests, they demonstrate the power frequency withstand voltage rating assigned to the circuit breaker in accordance with ANSI C37.06.

When these tests are applied to a circuit breaker in accordance with the schedules in table 1, they indicate whether or not the insulation of the circuit breaker has been reduced below an acceptable power frequency voltage withstand capability as a result of prior testing.

6.2.2 Description of tests

a. Power frequency voltage withstand tests shall be made in accordance with ANSI/IEEE Std 4 unless otherwise specified. No test enclosure shall be required.

b. For production tests the voltage to be applied for one minute shall be the rated power frequency withstand voltage (see ANSI C37.06, table 4).

c. The frequency of the test voltage shall be the rated power frequency of the circuit breaker plus/minus 20%.

d. The voltage shall be an alternating single phase voltage. The wave shape shall be essentially sinusoidal.

e. In making the test the initial voltage applied shall not be more than 50% of the appropriate test level. The voltage shall then be permitted to 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 then be permitted to be reduced uniformly to 50% of the test level or

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less before it is switched off. (Audible noises or partial discharges which can occur in high voltage testing are not necessarily indicative of failure.)

f. The test shall be made under dry conditions 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 clause 1.3.5 of ANSI/IEEE Std 4.

g. Several one-minute applications of test voltage are required to completely test the circuit breaker. During these tests, voltage shall be applied between one or more identified circuit breaker terminals and ground. The frame of the circuit breaker and all terminals not identified as having voltage applied shall be grounded during each test application:

   1. With the circuit breaker closed apply test voltage simultaneously between all terminals and ground.

   2. With the circuit breaker closed apply test voltage between the two terminals of the interior phase of the circuit breaker and ground.

   3. With the circuit breaker open apply test voltage between the three terminals on one side of the circuit breaker and ground.

   4. Repeat (3) except to apply voltage between the three opposite side terminals and ground.

   5. It is recognized that other suitable test terminal combinations may be used. These shall be permitted to be used if the tests prove the adequacy of the insulation structure.

6.3 Conductivity of current path tests

These tests shall be made to establish the D.C. resistances or millivolt drops of the primary current paths of the circuit breaker being tested. Individual phase resistances or millivolt drop characteristics shall not exceed the maximum values established by the manufacturer for new circuit breakers of the same rating. If this test is conducted as part of a test schedule (see table 1) after prior testing, the circuit breaker shall be considered to be in acceptable condition if the test values are not more than 200% of the maximum values established by the manufacturer for new circuit breakers of the same rating.

6.3.1 Description of tests

The circuit breaker contacts shall be in the closed position. With a direct current which shall not be less than 100 amperes flowing through the current conducting members of one phase, the resistance of the current path shall be determined. (When millivolt drop measurements are used to indicate resistance, the current at which the test was made shall be specified.) The test shall be repeated for each phase.

6.4 Control devices and secondary wiring tests

The objective of these tests shall be to verify that the circuit breaker has been wired in accordance with the applicable circuit diagram and that all secondary wiring and control devices are adequately insulated. Since there are a number of alternative test methods by which the purposes of this section can be fulfilled, the test methods and procedures described below are provided as guides. It is not the intent of this standard to limit the test methods used provided that alternate tests selected meet the required objectives.

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6.4.1 Wiring test methods

Circuit wiring shall be tested by using one of the following methods or by using an equivalent acceptable method:

a. Point-to-point wiring tests may be made using continuity testing devices. These devices are usually battery operated and utilize a lamp, a buzzer or other indicating means. Leads from the testing device are clipped or touched to terminals at each end of the circuit being tested. If the circuit being tested is continuous the indicating means is energized. Wires may be disconnected from terminal points if necessary to verify continuity.

b. Functional operation tests may be used to verify that circuits are correctly wired. With a suitable low current fuse or equivalent protective element connected in the output of an appropriate variable voltage source, the control circuitry to be tested is energized at a low level of voltage. The voltage is then raised slowly to the normal operating level and the controls are operated to verify that the circuits are functioning in accordance with the applicable circuit diagram. For those elements such as spare auxiliary switch contacts which are not completely wired into functioning control circuits, alternative tests shall be made. These alternatives may include the point-to-point test described in clause 6.4.1(a).

6.4.2 Voltage withstand test methods

All wiring and control devices shall be subjected to a power frequency voltage withstand test. Circuit elements, such as motors and coils, not rated for the level of the selected withstand test shall be isolated. Such elements shall then be tested separately at voltage withstand test levels appropriate for their respective ratings unless they have been previously tested as separate components. Mechanism motors, for example, are permitted to be tested at 900 volts AC and rated power frequency plus/minus 20% for one minute. The tests must be conducted by using one of the following methods or by using an equivalent acceptable method:

a. A power frequency voltage withstand test at 1500 volts AC and rated power frequency plus/minus 20% may be applied for one minute between all control wiring terminals tied together and ground.

b. A power frequency voltage withstand test at 1800 volts and rated power frequency plus/minus 20% may be applied for one second between each control wiring terminal separately and ground.

6.4.3 Post-test procedures

All wiring or control elements disconnected during the course of testing shall be reconnected and all temporary wiring added to facilitate testing shall be removed before the circuit breaker leaves the test station.

6.5 Bushing tests

When bushings are supplied on circuit breakers applied as removable elements in metal-clad switchgear (refer to clause 2.1.2 of ANSI/IEEE C37.20.2), they are normally indoor types integrally mounted on the circuit breakers. The production tests specified for the circuit breaker are suitable for demonstrating the adequacy of the bushings so that separate tests are not required. (see 6.2 and 6.3.)

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6.6 Mechanical operations tests

These tests shall be made to verify the ability of the circuit breaker to operate correctly over the applicable range of control voltage in accordance with table 9 of ANSI C37.06.

6.6.1 Description of tests

The tests shall include the following:

a. At minimum control voltage:
   1. Five close operations
   2. Five open operations

b. At maximum control voltage:
   1. Five close operations
   2. Five open operations

c. At rated control voltage:
   1. Five close operations
   2. Five open operations

During these operations the several external electrical elements which initiate closing and tripping shall be operated simultaneously and shall be "held" in the operated condition for a sufficient time to demonstrate that the circuit breaker does not "pump" (attempt to reclose). The sufficiency of the held time shall be determined by the inherent characteristics of the closing mechanism with which the circuit breaker is equipped. Inherent delays of several seconds may be required before a closing mechanism can reset after a close-open operation.

d. Operate the mechanical interlock provided in accordance with clause 6.2.4(2) of ANSI/IEEE C37.20.2 to the blocking position, and verify that the circuit breaker cannot be closed electrically or manually.

6.7 Timing tests

Timing tests shall be made to demonstrate that the circuit breaker being tested operates within the ranges of timing characteristics established by the manufacturer for circuit breakers of the same type, style, model or rating.

6.7.1 Test conditions

Attachments or other provisions as required by the timing equipment to be used shall be accommodated. The circuit breaker shall have previously been tested for correct operation in accordance with clause 6.6. (For gang-operated multiple pole circuit breakers having a single operating mechanism, the timing characteristics shall be permitted to be established on the basis of any single pole.)

6.7.2 Test methods

Any suitable method for making timing tests shall be permitted to be used. The following methods are for guidance and shall not limit the selection of a test method:

a. An oscillograph or an oscilloscope with suitable travel indicators attached to an appropriate point or points on the circuit breaker contacts or on the related linkage may be used.

b. An interval timer may be used to determine the time intervals between energizing of the closing or tripping circuit and the closing or separation of contacts respectively.

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c. A time-travel recorder may be used to graphically record as a function of time the position of the part to which it is attached.

6.8 Pressure and leakage tests

Circuit breakers using fluids at higher than atmospheric pressure or circuit breakers using vacuum devices shall be tested to demonstrate the operation and integrity of the appropriate systems. The tests shall be permitted to be conducted in accordance with the manufacturer's instructions. As a guide, these instructions shall include the following elements whenever applicable:

a. A pressure system leakage test.

b. A test to demonstrate system operation at normal operating pressure.

c. A test to demonstrate system operation at minimum operating pressure.

d. A test to demonstrate system operation at maximum operating pressure.

e. A test to demonstrate operation of pressure-related auxiliary devices such as low pressure alarm switches, pressure activated permissive closing switches, and minimum pressure tripping switches.

f. A test to demonstrate the integrity of vacuum devices.

Whenever applicable, tests under this section shall be permitted to be combined with tests specified in other sections.

7 Production monitoring and product retest requirements

7.1 General

The procedures described in this standard shall be implemented in the order indicated below:

a. Identification of particular groups of circuit breakers to be certified (see 3.4).

b. Production tests (see section 6).

c. Initial tests per test schedule A (see 3.2.1.1).

d. Production monitoring (see 7.2).

e. Retests per test schedules B, C, D and E (see 3.2.1.2 and 7.3).

7.2 Production monitoring

Production units from an identified group of circuit breakers shall be monitored to verify that the identified circuit breakers are being manufactured in accordance with the designs tested per section 3.

7.3 Product retest requirements

7.3.1 After tests per initial test schedule A (see 3.2.1.1) have been completed retests shall be made in accordance with retest schedules B, C, D or E at the retest intervals as determined in accordance with clause 7.3.2.

7.3.2 Retest intervals for an identified group of circuit breakers shall be determined either by the number of circuit breakers produced which have been certified to this standard, or by the elapsed time

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since completion of the immediately previous test schedule, whichever occurs sooner unless governed by the following provisions:

a. In no case shall the retest interval between schedules A and B; B and C; C and D; or D and B be required to be less than five years.

b. In no case shall the retest interval between schedules A and E or E and E be required to be less than two years.

7.3.3 In selecting the circuit breakers which will comprise an identified group either one of two options shall be permitted as described below.

a. The identity of the group of circuit breakers to be tested may be determined by selecting only those circuit breakers included in one of the typical groups shown in table 2.

   When this method of identification is utilized the appropriate retest intervals shall be taken directly from table 5 for the selected typical group.

b. The identity of the group of circuit breakers to be tested may be determined by selecting those circuit breakers which are included in two or more typical groups shown in table 2. Criteria for selecting circuit breakers in combined groups are specified in 3.4.1(a) and (b). When this method of identification is utilized, the appropriate retest intervals shall be determined on the basis of the typical group obtained from table 5. The method of determining retest intervals for an identified combined group is illustrated in the following example.

   An identified combined group of circuit breakers for which retest intervals are to be determined is comprised of all of the 4.76 kV air magnetic circuit breakers described in tables 2 and 5 for the typical groups represented within the combined group and derive the retest intervals applicable to the combined group as shown in table 6.

8 Conformance test records

8.1 Records of tests should include the following:

a. A description of the representative circuit breaker(s) and enclosures, where applicable, actually tested by number, style number, model number, rating, and/or other appropriate information, including the manufacturer's design test data, if applicable.

b. An identification of the group of circuit breakers from which representative circuit breakers were selected.

c. An identification of the test schedule used. Alternatively, specific tests may be identified.

8.2 Specific tests may be properly extended to qualify other identified groups of circuit breakers in accordance with clause 3.4.2.

8.2.1 In considering whether tests may be properly extended in accordance with clause 3.4.2, a test made to certify an identified first group of circuit breakers should be extended to certify an identified second group of circuit breakers if the test being considered for extension was performed not more than three years prior to completing all other tests required for certifying the identified second group of circuit breakers.

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a. This provision shall not be applicable to production tests.

b. This provision shall not be applicable in cases where the same identified group of circuit breakers is being retested in accordance with the established sequence of test schedules.

Table 5–Retest intervals for typical test groups

Number	Rated Maximum kV	Rated Short-Circuit kA	Units (3)	Years	Between Test Schedules
I	4.76	8.8	375	15	A&B
			250	10	B&C,C&D,D&B
			125	5	A&E,E&E
II	4.76	29	5100	15	A&B
			3400	10	B&C,C&D,D&B
			1700	5	A&E,E&E
III	4.76	41	1335	15	A&B
			890	10	B&C,C&D,D&B
			445	5	A&E,E&E
IV	4.76	41	300	15	A&B
			200	10	B&C,C&D,D&B
			100	5	A&E,E&E
V	8.25	33	1155	15	A&B
			770	10	B&C,C&D,D&B
			385	5	A&E,E&E
VI	15	18	4500	15	A&B
			3000	10	B&C,C&D,D&B
			1500	5	A&E,E&E
VII	15	28	1350	15	A&B
			900	10	B&C,C&D,D&B
			450	5	A&E,E&E
VIII(1)	15	37	390	15	A&B
			260	10	B&C,C&D,D&B
			130	5	A&E,E&E
IX(2)	15	37	195	15	A&B
			130	10	B&C,C&D,D&B
			65	5	A&E,E&E
X	27	16 & 25	1350	15	A&B
			900	10	B&C,C&D,D&B
			450	5	A&E,E&E
XI	38	21 & 40	105	15	A&B
			70	10	B&C,C&D,D&B
			35	5	A&E,E&E

NOTES
(1) 1200 and 2000 Amp Continuous Current Ratings only.
(2) 3000 Amp Continuous Current Ratings only.
(3) Units are determined in accordance with clause 7.3.2.

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Table 6–Retest intervals for combined groups

Groups	Units	Years		Between Test Schedules
		Max.	Min.	
I	375	15	5	A & B
II	5100	15	5	A & B
III	1335	15	5	A & B
Combined Group (2)	6810 (1)	15	5	A & B
I	250	10	5	B & C: C & D: D & B
II	3400	10	5	B & C: C & D: D & B
III	890	10	5	B & C: C & D: D & B
Combined Group (2)	4540 (1)	15	5	B & C: C: & D: D & B
I	125	5	2	A & E: E & E
I	1700	5	2	A & E: E & E
III	445	5	2	A & E: E & E
Combined Group (2)	2270 (2)	5	2	A & E: E & E

NOTES
(1) Refer to 7.3.2 (a) and 7.3.2 (b) for limitation of minimum retest interval.
(2) Combined groups are comprised of circuit breakers of the same general type (see 3.4.1 (a)). Under this provision, for example, a combined group consisting of both magnetic and vacuum circuit breakers would not be appropriate even if both types have identical ratings.

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