

IEEE Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis

Circuits and Devices

Communications Technology

Computer

*Electromagnetics and
Radiation*

Energy and Power

Sponsored by the
Switchgear Committee of the
IEEE Power Engineering Society

Industrial Applications

*Signals and
Applications*

IEEE C37.013-1989



Published by the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, NY 10017, USA.

March 8, 1990

SH13094

IEEE Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis

Sponsor

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

Secretariat

**Institute of Electrical and Electronics Engineers
National Electrical Manufacturers Association**

Approved November 9, 1989

IEEE Standards Board

Abstract: IEEE C37.013-1989, *IEEE Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis*, defines specific requirements for power circuit breakers as applied directly to the terminals of large generators. It establishes a rating structure, establishes testing procedures for demonstrating compliance, and gives guidance for applying these circuit breakers within the rating structure.

Copyright © 1989 by

**The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street, New York, NY 10017-2394, USA**

*No part of this publication may be reproduced in any form,
in an electronic retrieval system or otherwise,
without prior permission of the publisher.*

IEEE Standards documents are developed within the Technical Committees of the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE which have expressed an interest in participating in the development of the standard.

Use of an IEEE Standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old, and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason IEEE and the members of its technical committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE Standards Board
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
USA

IEEE Standards documents are adopted by the Institute of Electrical and Electronics Engineers without regard to whether their adoption may involve patents on articles, materials, or processes. Such adoption does not assume any liability to any patent owner, nor does it assume any obligation whatever to parties adopting the standards documents.

Foreword

(This Foreword is not a part of IEEE C37.013-1989, IEEE Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis.)

This standard is new and covers the requirements for ac high-voltage generator circuit breakers as applied directly to the outgoing terminals of generators. The rating, testing, and application requirements of these specialized circuit breakers are not adequately covered by the existing standards IEEE C37.04-1979, ANSI C37.06-1987, IEEE C37.09-1979, and IEEE C37.010-1979 series for ac high-voltage circuit breakers rated on a symmetrical current basis. In order to avoid the detailed integration and possible confusion by introducing the specialized requirements into the existing documents, it was determined that a separate standard was the most effective method for covering these devices.

A Working Group of the IEEE Switchgear Committee, Subcommittee on High-Voltage Circuit Breakers created this standard with input from various sources on all requirements for these specialized devices. The same Working Group is presently developing an Application Guide that will become Section 6 of this standard.

These efforts have contributed valuable standards to the industry and further suggestions for improvement gained from the use of this standard will be welcomed.

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

W. E. Laubach, *Chairman*

C. H. White, *Secretary*

M. B. Williams, *Program Administrator*

A. K. McCabe, *Executive Vice-Chairman of High-Voltage Switchgear Standards*

S. H. Telander, *Executive Vice-Chairman of Low-Voltage Switchgear Standards*

D. L. Swindler, *Executive Vice-Chairman of IEC Activities*

<i>Organization Represented</i>	<i>Name of Representative</i>
Association of Iron and Steel Engineers	J. M. Tillman
Electric Light and Power Group	R. L. Capra
	G. R. Brandenberger (<i>Alt.</i>)
	T. E. Bruck (<i>Alt.</i>)
	D. A. Ditzler
	K. D. Hendrix
	J. H. Provanzana
	D. E. Soffrin (<i>Alt.</i>)
	D. T. Weston
Institute of Electrical and Electronics Engineers	H. W. Mikulecky
	S. C. Atkinson (<i>Alt.</i>)
	W. F. Hoenigmann
	D. G. Kumbera (<i>Alt.</i>)
	D. M. Larson
	E. W. Schmunk
	C. A. Schwalbe
National Electrical Manufacturers Association	R. A. McMaster
	T. C. Burtnett
	T. L. Fromm
	R. H. Miller
	H. L. Miller (<i>Alt.</i>)
	R. O. D. Whitt
Tennessee Valley Authority	R. B. Rotton

Testing Laboratory Group	L. Frier
	W. T. O'Grady
	R. W. Seelbach (<i>Alt.</i>)
US Department of Agriculture, REA	H. L. Bowles
<i>Western Area Power Administration</i>	G. D. Birney
US Department of the Army,	
<i>Office of the Chief of Engineers</i>	W. M. Jones
US Department of the Interior,	
<i>Bureau of Reclamation</i>	J. W. Reif
US Department of the Navy,	
<i>Naval Construction Battalion Center</i>	R. L. Clark

The Working Group of the High-Voltage Circuit Breaker Subcommittee of the IEEE Switchgear Committee that prepared this standard had the following members:

P. L. Kolarik, *Chairman*

C. J. Truax, *Secretary*

H. W. Anderl
J. E. Beehler
E. W. Boehne
R. D. Carson
R. L. Clark
R. D. Garzon
J. K. Greene
G. T. Hall
G. E. Heberlein

W. C. Huening, Jr.
D. M. Larson
A. A. Liebold
A. K. McCabe
G. F. Montillet
R. A. Pace
J. G. Reckleff
H. K. Reid
A. B. Rishworth

W. N. Rothenbuhler
E. M. Ruoss
M. J. Sulkowski
J. S. Tannery
E. E. Thuries
W. A. van der Linden
G. A. Votta
C. L. Wagner
D. A. Weber
B. F. Wirtz

The High-Voltage Circuit Breaker Subcommittee of the IEEE Switchgear Committee that reviewed and approved this standard had the following members:

S. Berneryd
J. H. Brunke
S. L. Carter
R. L. Clark
D. R. Crawford
C. J. Dvorak
P. W. Dwyer
R. D. Garzon
K. I. Gray
G. R. Hanks
W. E. Harper
H. L. Hess
P. L. Kolarik
R. K. Kozovich

S.R. Lambert
D. M. Larson
A. Leibold
G. N. Lester
J. A. Maneatis
J. T. Mao
R. Matulic
A. K. McCabe
G. J. Meinders
G. F. Montillet
D. F. Peelo
G. O. Perkins
J. E. Reed
A. B. Rishworth

H. C. Ross
W. N. Rothenbuhler
E. M. Ruoss
L. R. Saavedra
J. H. Simpson
H. M. Smith
G. St. Jean
D. L. Swindler
T. J. Tobin
E. F. Veverka
C. L. Wagner
J. H. Widdifield
W. R. Wilson
B. F. Wirtz

The following persons were on the Balloting Committee of the IEEE Switchgear Committee that reviewed and approved this standard for submission to the IEEE Standards Board:

C. S. Alexander	K. D. Hendrix	C. A. Popeck
R. J. Alton	H. L. Hess	R. Ranjan
J. G. Angelis	W. F. Hoenigmann	J. C. W. Ransom
R. H. Arndt	N. V. Holmgren	J. E. Reed
S. C. Atkinson	A. J. Kalvaitis	A. B. Rishworth
L. R. Beard	P. L. Kolarik	H. C. Ross
H. L. Bowles	D. G. Kumbera	W. N. Rothenbuhler
M. T. Brown	S. R. Lambert	L. H. Schmidt
J. H. Brunke	D. M. Larson	E. W. Schmunk
C. G. Burland	W. E. Laubach	C. A. Schwalbe
R. L. Capra	J. G. Leach	J. C. Scott
S. L. Carter	G. N. Lester	J. F. Sellers
L. V. Chabala	D. L. Lott	J. H. Simpson
A. Dixon	E. L. Luehring	H. M. Smith
G. W. Dolloff	P. C. Lyons	S. D. Smith
J. J. Dravis	J. A. Maneatis	E. M. Spencer
C. J. Dvorak	R. Matulic	G. St. Jean
P. W. Dwyer	P. C. Mayo	D. L. Swindler
F. C. Farrell	L. V. McCall	S. H. Telandier
L. W. Gaussa	R. A. McMaster	F. C. Teufel
G. Genest	H. W. Mikulecky	E. F. Veverka
K. I. Gray	D. C. Mills	C. L. Wagner
G. R. Hanks	A. F. Parks	J. H. Widdifield
W. E. Harper	G. O. Perkins	W. R. Wilson
		B. F. Wirtz

When the IEEE Standards Board approved this standard on November 9, 1989, it had the following membership:

Dennis Bodson, *Chairman*

Marco W. Migliaro, *Vice-Chairman*

Andrew G. Salem, *Secretary*

Arthur A. Blaisdell	Kenneth D. Hendrix	John E. May, Jr.
Fletcher J. Buckley	Theodore W. Hissey, Jr.	Lawrence V. McCall
Allen L. Clapp	John W. Horch	L. Bruce McClung
James M. Daly	David W. Hutchins	Donald T. Michael*
Stephen R. Dillon	Frank D. Kirschner	Richard E. Mosher
Donald C. Fleckenstein	Frank C. Kitzantides	Stig Nilsson
Eugene P. Fogarty	Joseph L. Koepfinger*	L. John Rankine
Jay Forster*	Michael Lawler	Gary S. Robinson
Thomas L. Hannan	Edward Lohse	Donald W. Zipse

*Member Emeritus

Contents

SECTION	PAGE
1. Scope and References	9
1.1 Scope.....	9
1.2 References.....	9
2. Definitions.....	9
2.1 Design Tests.....	10
2.2 Production Tests.....	10
2.3 Tests After Delivery.....	10
3. Service Conditions	10
3.1 Usual Service Conditions.....	10
3.2 Unusual Service Conditions.....	10
3.3 Impact on Environment.....	11
4. Ratings and Required Capabilities	11
4.1 Rated Maximum Voltage.....	11
4.2 Rated Voltage Range Factor K	13
4.3 Rated Frequency	13
4.4 Rated Continuous Current.....	13
4.5 Rated Dielectric Strength.....	15
4.6 Rated Short-Circuit Duty Cycle.....	17
4.7 Rated Interrupting Time	17
4.8 Rated Permissible Tripping Delay Y	17
4.9 Rated Closing Time.....	17
4.10 Short-Circuit Current Rating.....	17
4.11 Transient Recovery Voltage (TRV) Rating.....	21
4.12 Rated Load Current Switching Capability.....	21
4.13 Capacitance Switching Current	25
4.14 Out-of-Phase Switching Current	25
4.15 Excitation Current Switching Capability.....	25
4.16 Rated Control Voltage (Nominal Control Voltage).....	25
4.17 Rated Mechanism Fluid Operating Pressure	25
4.18 Nameplate Markings.....	25
5. Tests.....	26
5.1 General.....	26
5.2 Design Tests	27
5.3 Production Tests.....	42
5.4 Tests After Delivery	45
FIGURES	
Fig 1 Effect of Various Cooling Failures and Subsequent Load Reductions on Circuit Breaker Temperature Following Temperature Stabilization at Rated Continuous Current and Total Cooling Required for Rated Continuous Current	15
Fig 2 Ratio of Circuit Breaker Asymmetrical-to-Symmetrical Interrupting Capabilities for Three-Phase System-Source Short-Circuit Current	18
Fig 3 Ratios of Generator-Source Asymmetrical Current at 1/2 Cycle to the Required Generator-Source Symmetrical Interrupting Capability of Generator Circuit Breakers at the Contact Parting Times Shown.....	20

Fig 4 Dual Voltage Testing, 180°	40
Fig 5 Dual Voltage Testing, 120°	40
Fig 6 Single Voltage Testing with One Side Grounded	40

TABLES

Table 1 Altitude Correction Factors	11
Table 2 Preferred Ratings for Generator Circuit Breakers	12
Table 3 Temperature Limitations on Insulating Materials for Continuous Ratings	13
Table 4 Temperature Limitations on Main Contacts for Continuous Ratings	14
Table 5 Temperature Limitations on Conducting Joints for Continuous Ratings	14
Table 6 Schedule of Dielectric Test Values for AC Generator Circuit Breakers and External Insulation	16
Table 7 TRV Parameters for System-Source Faults	22
Table 8 TRV Parameters for Generator-Source Faults	22
Table 9 Operation Endurance Capabilities for Generator Circuit Breakers	22
Table 10 TRV Parameters for Load Current Switching	23
Table 11 TRV Parameters for Out-of-Phase Switching	23
Table 12 Rated Control Voltages and Their Ranges for Generator Circuit Breakers	24
Table 13 Test Duties to Demonstrate the Short-Circuit Current Rating of AC High-Voltage Generator Circuit Breakers—First Pole to Clear Values for Three-Pole Tests or Conditions for Single-Pole Tests	33
Table 14 Test Duties to Demonstrate Assigned Out-of-Phase Switching Rating of AC High-Voltage Generator Circuit Breakers—First Pole to Clear Values for Three-Pole Tests or Conditions for Single-Pole Tests	39

IEEE Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis

1 Scope and References

1.1 Scope. This standard applies to all ac high-voltage generator circuit breakers rated on a symmetrical current basis, with rated maximum voltage 15.8 kV and above with a continuous current rating of 6.3 kA and above that are applied to generator terminals. Pumped storage installations are considered a special application, and their requirements are not completely covered by this standard.

1.2 References

[1] ANSI C37.06-1979, Preferred Ratings and Related Required Capabilities for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.¹

[2] ANSI C37.11-1979, Requirements for Electrical Control for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis or a Total Current Basis.

[3] ANSI C84.1-1989, Voltage Ratings for Electric Power Systems and Equipment (60 Hz).

[4] IEEE C37.04-1979, Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (ANSI).²

[5] IEEE C37.082-1982, Standard Methods for the Measurement of Sound Pressure Levels of AC Power Circuit Breakers (ANSI).

[6] IEEE C37.09-1979, Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (ANSI).

[7] IEEE C37.100-1981, Definitions for Power Switchgear (ANSI).

[8] IEEE C57.13-1978, Standard Requirements for Instrument Transformers (ANSI).

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

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

[11] IEEE Std 100-1988, Dictionary of Electrical and Electronics Terms—Fourth Ed. (ANSI).

[12] IEEE Std 119-1974, Recommended Practice for General Principles of Temperature Measurement as Applied to Electrical Apparatus.

[13] NEMA SG-4-1975, AC High-Voltage Circuit Breakers.

[14] Documents of CIGRE Task Force 13002, *Transient Recovery Voltages on Generator Circuit Breakers*.

[15] 1989 ANSI/ASME Boiler and Pressure Vessel Code.³

2. Definitions

The terms and conditions applicable to this standard for ac high-voltage generator circuit breakers shall be in accordance with IEEE C37.100-1981 [7].⁴ These definitions are not intended to embrace all possible meanings of the

¹ANSI publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

²IEEE publications are available from the Institute of Electrical and Electronics Engineers, IEEE Service Center, Piscataway, NJ 08855-1331. ANSI publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

³ANSI/ASME publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018 or from the ASME Publications Order Department, 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300.

⁴The numbers in brackets correspond to the references listed in 1.2 of this standard.

terms. They are intended for the sole purpose of establishing those meanings of terms used in power switchgear. IEEE Std 100-1988 [11] should be referred to for other meanings that the terms properly may have when used in connection with other subjects.

2.1 Design Tests. Those tests made to determine the adequacy of the design of a particular type, style, or model generator circuit breaker to meet its assigned ratings and to operate satisfactorily under normal service conditions or under special conditions, if specified. Design tests are made only on representative circuit breakers of basically the same design, i.e., the same interrupters operating at the same contact speeds, and having at least the same dielectric strength. These tests are not intended to be used as a part of normal production.

The applicable portions of these design tests may also be used to evaluate modifications of a previous design and to assure that performance has not been adversely affected. Test data from previous similar designs may be used for current designs, where appropriate.

2.2 Production Tests. The term "production tests" refers to those tests made to check the quality and uniformity of workmanship and materials used in the manufacture of generator circuit breakers.

2.3 Tests After Delivery. Those tests made by the purchaser after delivery of the circuit breaker supplement inspection to determine whether the circuit breaker has arrived in good condition.

These tests may consist of timing tests on closing, opening, close-open no-load operations, and low-frequency voltage withstand tests at 75% of the rated low-frequency withstand voltage.

3. Service Conditions

3.1 Usual Service Conditions. Generator circuit breakers conforming to this standard shall be suitable for operating at their standard ratings under the following usual service conditions:

3.1.1 The ambient temperature for outdoor generator circuit breakers is not above 40 °C or below -30 °C; and ambient temperature for indoor generator circuit breakers is not above 40 °C or below +5 °C.

3.1.2 Altitude is not above 3300 feet (1000 meters).

3.1.3 Static forces applied to the generator circuit breaker do not exceed the equivalent force of a 0.5 g acceleration applied horizontally at the center of gravity of the breaker.

3.2 Unusual Service Conditions

3.2.1 Abnormal Temperatures. The use of apparatus in ambient temperatures outside the limits of those specified in 3.1.1 shall be considered as special.

3.2.2 Altitudes Above 3300 Feet (1000 Meters). For applications at altitudes higher than 3300 feet (1000 meters), the basic impulse insulation level, rated maximum voltage and rated continuous current shall be multiplied individually by correction factors in Table 1 to obtain values at which an application may be made.

The rated short-circuit current, related required capabilities, and the rated interrupting time are not affected by altitude.

3.2.3 Conditions Affecting Construction or Protecting Features. There are conditions that should receive special consideration.

Such conditions should be brought to the attention of those responsible for the application, manufacture, and operation of the equipment.

Apparatus for use in such cases may require special construction or protection. Among such conditions are:

3.2.3.1 Exposure to damaging fumes or vapors, excessive or abrasive dust, explosive mixtures of dust or gases, steam, salt spray, oil spray, excessive moisture, dripping water, and other similar conditions

3.2.3.2 Exposure to abnormal vibration, shock, tilting, or seismic forces

3.2.3.3 Exposure during transportation or storage to conditions beyond temperatures listed in 3.1.1.

3.2.3.4 Unusual space limitations

3.2.3.5 Unusual operating duty, frequency of operation, and difficulty of maintenance

3.2.3.6 Condensation, on dielectric surfaces, produced by the generator circuit breaker cooling medium

Table 1
Altitude Correction Factors

Altitude (ft) (m)	Rated Maximum Voltage and Insulation Level	Rated Continuous Current
3300 1000	1.00	1.00
5000 1500	0.95	Refer to manufacturer
10 000 3000	0.80	Refer to manufacturer

NOTE: Intermediate values can be obtained by interpolation.

3.3 Impact on Environment. Generator circuit breakers conforming to this standard shall have limited impact on the environment as follows:

3.3.1 When operated under standard conditions, with all three poles operating simultaneously, the generator circuit breaker shall not exceed a maximum peak sound pressure level of 140 decibels. (See IEEE C37.082-1982 [5].)

3.3.2 The effects of circulating currents induced by magnetic fields produced by continuous currents in the generator circuit breaker are addressed in Section 6, Application Guide, which is under development.

4. Ratings and Required Capabilities

The ratings and required capabilities of a generator circuit breaker are the designated limits of operating characteristics based on definite conditions and shall include the following items where applicable:

- (1) Rated maximum voltage (see 4.1)
- (2) Rated voltage range factor K (see 4.2)
- (3) Rated frequency (see 4.3)
- (4) Rated continuous current (see 4.4)
- (5) Rated dielectric strength (see 4.5)
- (6) Rated short-circuit duty cycle (see 4.6)
- (7) Rated interrupting time (see 4.7)
- (8) Rated permissible tripping delay Y (see 4.8)
- (9) Rated closing time (see 4.9)
- (10) Rated short-circuit current (see 4.10)
- (11) Rated Transient Recovery Voltage (TRV) (see 4.11)
- (12) Rated load current switching capability (see 4.12)

- (13) Capacitance switching current (see 4.13)
- (14) Out-of-phase switching current (see 4.14)
- (15) Excitation current switching capability (see 4.15)
- (16) Rated control voltage (see 4.16)
- (17) Rated mechanism fluid operating pressure (see 4.17)

For standard ratings of generator circuit breakers, see Table 2.

The establishment of the ratings and required capabilities and the assignment of them to a generator circuit breaker in accordance with these standards implies performance characteristics at least equal to those set forth in the following sections. The ratings and required capabilities assigned to a generator circuit breaker are based on test data in accordance with Section 5, Tests; but other equivalent or more effective methods of test are not precluded.

Alternatively, for designs existing prior to the adoption of these standards, the ratings and required capabilities can be based on other tests that are judged to be equally effective on the basis of the experience gained from previous design or development tests or by service performance experience.

4.1 Rated Maximum Voltage. The rated maximum voltage of a generator circuit breaker is the highest rms (root-mean-square) voltage for which the circuit breaker is designed and is the upper limit for operation. The rated maximum voltage is the same as the maximum design voltage rating referred to in ANSI C84.1-1989 [3].

Table 2
Preferred Ratings for Generator Circuit Breakers

												Related Required Capabilities			
												Current Values			
Rated Values												Max Symmetrical Interrupting Capability	1 Second Short-Time Current Carrying Capability (6)	Closing and Latching Capability	
Current															
Voltage		Insulation Level		Rated Short-Circuit Current (at Rated Max kV) (4)	Transient Recovery Voltage			Rated Interrupting Time (5) Cycles	Rated Permissible Tripping Delay Y Seconds	Rated Max Voltage Divided by K kV, rms					
Rated Max Voltage (1)(7) kV, rms	Rated Voltage Range Factor K (2)	Rated Withstand Test Voltage	Rated Continuous Current at 60 Hz Amperes, rms		Rated Time to Point P T ₂ μs	Rated Rate R kV/μs	Rated Delay Time T ₁ μs								
Line No.			Low Frequency kV, rms	Impulse (3) kV, Crest											
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15
1	15.8	1	{ See Table 6 }	{ See Table 6 }	•	†	{ See Tables 7, 8, 10 and 11 }	{ See Tables 7, 8, 10 and 11 }	{ See Tables 7, 8, 10 and 11 }	‡	0.25	15.8	{ See 4.10.2 }	{ See 4.10.2 }	{ See 4.10.2 }
2	27.5	1			•	†				‡	0.25	27.5			
3	38.0	1			•	†				‡	0.25	38.0			

*Typical values in kA: 6.3, 8.0, 10.0, 12.0, 16.0, 20.0, 25.0, 30.0, 40.0

†Typical values in kA: 63, 80, 100, 120, 160, 200, 250, 275

‡Typical values in cycles: 4, 5, 6 (Actual time depends on rated short-circuit current.)

NOTES FOR TABLE 2:

For service conditions, definitions, and interpretation of ratings, tests, and qualifying terms, see Sections 4 and 5 and IEEE C37.100-1981 [7]. The interrupting ratings are for 60 Hz systems. Current values have been rounded off to the nearest kiloampere (kA) except below 10 kA where two significant figures are used.

- (1) The voltage rating is based on ANSI C84.1-1989 [3], where applicable, and is the maximum voltage for which the breaker is designed and the upper limit for operation. Other rated maximum voltage ratings are available.
- (2) The rated voltage range factor, K , is the ratio of rated maximum voltage to the lower limit of the range of operating voltage in which the required symmetrical and asymmetrical current interrupting capabilities vary in inverse proportion to the operating voltage.
- (3) 1.2×50 microsecond positive and negative wave. All impulse values are phase to phase and phase to ground and across the open contacts.
- (4) With the limitation stated in 4.10, all values apply for polyphase and line-to-line faults. For single-phase-to-ground faults, see specific conditions stated in 4.10.2.3.
- (5) The ratings in this column are on a 60 Hz basis and are the maximum time intervals to be expected during a breaker opening operation between the instant of energizing the trip circuit and interruption of the main circuit on the primary arcing contacts under specified conditions. The values may be exceeded under certain conditions as specified in 4.7.
- (6) Current values in this column are independent of operating voltage up to and including rated maximum voltage.
- (7) The rated maximum voltage of the generator circuit breaker is the maximum operating voltage of the generator.

4.2 Rated Voltage Range Factor K . The rated voltage range factor K is the ratio of rated maximum voltage to the lower limit of the range of operating voltage in which the required symmetrical and asymmetrical interrupting capabilities vary in inverse proportion to operating voltage. The value of K is equal to 1 for generator circuit breakers.

4.3 Rated Frequency. The rated frequency of a generator circuit breaker is the frequency at which it is designed to operate. Standard frequency is 60 Hz. Applications at other frequencies should receive special consideration.

4.4 Rated Continuous Current. The rated continuous current of a generator circuit breaker is the designated limit of current in rms amperes at rated frequency, which it shall be required to carry continuously without exceeding any of the limitations designated in 4.4.1 and 4.4.2.

For rated continuous currents, please see Table 2.

4.4.1 Conditions of Continuous Current Rating. The conditions on which continuous current ratings are based are as follows:

- (1) Circuit breakers are used under the usual service conditions defined in 3.1.
- (2) Current ratings shall be based on the total temperature limits of the materials used for circuit breaker parts. A tem-

perature rise reference is given to permit testing at reduced ambient temperature.

- (3) Breakers designed for installation in enclosures shall have their ratings based on the ventilation of such enclosures and a 40 °C ambient temperature outside the enclosure. (See 5.2.1.1 (2).)
- (4) Circuit breakers designed for operation with forced air cooling assistance shall have the ratings based on a 40 °C ambient temperature with the forced air cooling system operating.

4.4.2 Temperature Limitations for Continuous Current Ratings

4.4.2.1 Limitations on Insulating Material. The temperature of materials used to insulate the main power circuit conducting parts from phase to ground or from terminal to terminal of an open circuit breaker shall be limited to the values listed in Table 3.

4.4.2.2 Limitations of Main Contacts. The temperature of main contacts used in generator circuit breakers shall not exceed values listed in Table 4.

Contacts may be operated at other temperatures providing it can be shown by experience or tests acceptable to the user that accelerated deterioration will not occur.

4.4.2.3 Limitations on Conducting Joints. The temperature of conducting joints in the main power circuit of a generator circuit breaker shall not exceed the values listed in Table 5.

Table 3
Temperature Limitations on Insulating Materials for Continuous Ratings

Insulating Class and Main Power Circuit Limits

Class of Material	Hottest Spot Total Temperature (°C)
O	90
A	105
B	130
F	155
H	180
C	220

NOTE: If gaseous insulating material is used as conforming to one of the above classes, the manufacturer shall establish that it will not cause accelerated deterioration of other parts.

Table 4
Temperature Limitations on Main Contacts for Continuous Ratings

Contact Surfaces	Limit of Hottest Spot Temperature Rise (°C)	Limit of Hottest Spot Temperature Total (°C)
Copper	30	70
Silver, Silver Alloy, or Equivalent	65	105

Table 5
Temperature Limitations on Conducting Joints for Continuous Ratings

Conducting Joint Surfaces	Limit of Hottest Spot Temperature Rise (°C)	Limit of Hottest Spot Total Temperature (°C)
Copper	30	70
Silver, Silver Alloy, or Equivalent	65	105

Conducting joints may be operated at other temperatures providing it can be shown by experience or tests acceptable to the user that accelerated deterioration will not occur.

4.4.2.4 Limitations for Parts Subject to Contact by Personnel. Circuit breaker parts handled by the operator in the normal course of work duties shall have no higher total temperature than 50 °C.

Circuit breakers having external surfaces accessible to an operator in the normal course of work duties shall have no higher total temperature on the surfaces than 70 °C. If the bus duct connected to the circuit breaker is designed for a total temperature of 80 °C on the surfaces, then the circuit breaker surface temperature can be 80 °C.

Circuit breakers having external surfaces not accessible to an operator in the normal course of work duties shall have no higher total temperature on the surfaces than 110 °C.

4.4.2.5 Limitations on Other Materials. Other materials shall be chosen so that the maximum temperature to which they may be

subjected shall not cause accelerated deterioration.

4.4.3 Emergency Current Ratings During Loss of Cooling. The operating considerations for generator circuit breakers require that emergency ratings are established to enable the circuit breaker to remain in service following loss of normally required auxiliary forced cooling systems.

- (1) It is possible to operate the circuit breaker for limited time periods with circuit breaker parts at a higher total temperature than the limits specified for the continuous current rating.
- (2) The difference between the emergency temperature limits and the normal operating temperatures provide a definite allowable time period during which full load may be carried before the reduction in load current must be accomplished.
- (3) The circuit breaker may remain in service at a reduced rating, the value of which will depend on the type of emergency condition prevailing.