American National Standard

AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities

Approved 05/19/00

American National Standards Institute, Inc.

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Print: ISBN 0-7381-9594-1 SH95093
PDF: ISBN 0-7381-3595-x SS95093

American National Standard

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FOREWORD (This foreword is not part of American National Standard C37.06-2000.)

This standard is a revision of ANSI C37.06-1997. It reflects small editorial changes needed to coordinate with the final wording contained in the defining standards ANSI/IEEE C37.04-1999 and ANSI/IEEE C37.09-1999. Some ratings have also been updated. Because this revision is primarily editorial in nature, this Foreword describes the substantive and editorial changes between this revision and the 1987 version. The format of the tables remains very much the same, except that some ratings, which had been given in the notes (sometimes on a different page from the table of preferred ratings), have been listed explicitly in the tables.

The transmission voltage classes of 121 kV, 169 kV, and 242 kV have been changed to 123 kV, 170 kV, and 245 kV respectively to complete the harmonization with IEC. This harmonization was begun when IEC adopted 550 kV and 800 kV, replacing 525 kV and 765 kV respectively.

Editorial revisions in Tables 1, 2, and 3:

The individual lines and columns have been identified with numbers for easy reference. The preferred ratings for transient recovery voltage maximum rated peak voltage E_2 value, have been moved from the notes to the table itself for tables 1 and 2. Similarly, the maximum permissible tripping delay value (Y) has been moved from the notes to the table itself for tables 1, 2, and 3. The maximum symmetrical interrupting capability is no longer listed explicitly in the tables since it is now numerically equal to the rated short-circuit current (K=1.0). Further, the short-time current rating is also equal to the short-circuit current rating, but it is included in the title of Col. 4 in the tables. The closing and latching current is now listed as a rating (it had been a related required capability), and the preferred ratings (kA, peak) have been calculated at 2.6 times the rated short-circuit current. This has been reduced from 2.7 times in the 1987 edition to promote harmonization with other international standards. (If expressed in terms of rms total current, momentary current, the equivalent value of the closing and latching current is 1.55 times the rated short-circuit current.)

Throughout this document, the term traditionally associated with the maximum value of transient or periodic wave form, "peak" is used.

Table 1—The major revision in the ratings for indoor circuit breakers is that the preferred values for the rated voltage range factor K have been set to 1.0 for all indoor circuit breaker ratings. The principal reason for this change is that the capabilities of today's circuit breaker designs are better described by the K=1.0 value. The user will note that an additional benefit to the K=1.0 system is that the number of notes in Table 1 are reduced by half.

This change in no way affects the ratings and capabilities of circuit breakers manufactured and tested to the ratings in the 1987 edition, which should continue to be applied in accordance with the 1987 standards. For convenience, Tables 1 and 1A of the 1987 edition are reproduced in this standard as tables A1 and A1A. During a transition period from the previous ratings basis (K>1.0) to the new ratings basis (K=1.0), the industry can still use the previous revision of the tables in applications where they are more convenient.

Rated time-to-peak (T_2) values for transient recovery voltage (TRV) have been specified for the first time. The values are those recommended by the IEEE Switchgear Committee's working group on transient recovery voltages, and are consistent with the values given in IEC 56 sub-clause 4.102.3. (Note: For the 1-cosine standard waveform envelope, the time-to-peak (T_2) value is equal to 1.137 times the t_3 parameter value listed in IEC 56.) The time-to-peak values (T_2) for (general purpose) circuit breakers, are based on assumption that there is sufficient circuit capacitance to limit the prospective TRV rise time to a value slower than that specified. Note 4 recognizes that there are applications, such as for transformer secondary fault protection, where the circuit capacitance may be much less, so that the prospective TRV rise time will be much faster than these preferred values. Based on recommendations from the IEEE

Switchgear Committee, NEMA has developed a trial-use guide for (definite purpose) circuit breakers capable of switching circuits characterized by fast TRV rise times: ANSI C37.06.1.

Lines have been added for the new 27 kV voltage class, and the 2000 revision adds the 63 kA rating at 15 kV. The preferred short-circuit ratings at 38 kV have been updated to reflect the interrupting capabilities of present circuit breaker technologies.

Table 1A—Cable charging current has replaced overhead line current because most indoor circuit breakers are connected to their load circuits by cables rather than overhead lines. Cables typically have much greater capacitance than overhead lines and, therefore, normally draw somewhat greater currents. Also, capacitance current ratings have been added for the 27 kV class, and the capacitance current ratings have been revised for the 38 kV class. The preferred capacitance current switching ratings in Table 1A were chosen to be consistent with present values in Table 2A for outdoor circuit breakers. The 63 kA rating has been added at 15 kV in the 2000 revision.

Table 2—Editorial revisions similar to those in Table 1 have been made. The TRV rated rate and rated delay columns (which had been blank) have been deleted because they are not applicable to the two parameter (1-cosine) TRV envelope for circuit breakers rated 72.5 kV and below.

Table 2A—Only minor editorial changes have been made.

Table 3—Editorial revisions similar to those in Table 1 have been made. In addition, in the 2000 revision, rated TRV rate has been revised to 2.0 kV/μsec to harmonize with IEC. Also in the 2000 revision, the list of preferred ratings has been expanded, and some historic lower ratings have been eliminated.

Table 3A—For back-to-back capacitor switching applications, preferred ratings for inrush current peak and frequency have been specified for 550 kV circuit breakers, and minor editorial changes have been made. Additional changes have been made in the 2000 revision to coordinate with Table 3 changes.

Table 4–The interrupter full wave withstand was removed in the 1997 version, but reinstated (as a note) in the 2000 revision. New ratings for 27 kV indoor breakers were added, and minor editorial changes were made in the 1997 revision. In 2000, creepage distances have been revised to coordinate with ANSI/IEEE C37.010, and 3 μsec withstand requirements have been deleted.

Table 5–The interrupter full wave withstand is removed. A few minor editorial changes have been made.

Table 6—Figure 1 from the 1987 version was replaced by figures A1 and A2 in the 1997 version. As these TRV envelope curves have now been added to ANSI/IEEE C37.04, these figures have been eliminated in the 2000 revision.

Table 7—The table has been revised to reflect the characteristics of modern circuit breakers. Table 7 from the 1987 version became Table A2 in the 1997 version. Table 7 from the 1997 version had been Table 8 in the 1987 version.

Table 8—Editorial revisions only have been made. While control voltages are usually identified by their "nominal" values, the limits between which control voltage can range are specified in terms of the "Rated Range," that is, the minimum and maximum values. Table 8 from the 1997 version had been Table 9 in the 1987 version.

Table 9—The table has been revised to reflect the characteristics of modern circuit breakers. Table 9 from the 1997 version had been Table 10 in the 1987 version.

Appendix—For the convenience of those users who will be applying indoor circuit breakers with a rated voltage range factor K greater than 1.0, the 1987 revisions of Table 1 and Table 1A are included in the appendix as Table A1 and Table A1A, respectively.

Figures A1 and A2—(TRV envelope curves) were added in the 1997 version, but they have been eliminated in the 2000 revision as these curves are now in ANSI/IEEE C37.04.

Table A2—Formerly Table 7 of the 1987 revision. The switching surge factors rating table has been moved to the appendix (as Table A2) since the switching surge value is dependent upon the line parameters and surge arrester characteristics. When this table is published in C37.010, the table will be removed from the appendix.

Suggestions for the improvement of this standard are welcome. They should be sent to the Vice President, Engineering Department, National Electrical Manufacturers Association, 1300 N. 17th Street, Rosslyn, VA 22209.

This standard was processed and approved for submittal to ANSI by Accredited Standards Committee on Power Switchgear C37. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time of its approval, the C37 Committee had the following members:

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AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities

1 Scope

This standard applies to all indoor and outdoor types of AC high-voltage circuit breakers rated above 1000 volts and rated on a symmetrical current basis.

2 Referenced standards

2.1 Referenced American National Standards

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

ANSI C84.1-1995, *Voltage Ratings (60-Hz)—Electrical Power Systems and Equipment*

ANSI/IEEE C37.010-1999, *Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis*

ANSI/IEEE C37.011-1994, *Application Guide for Transient Recovery Voltage for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis*

ANSI/IEEE C37.012-1979 (R1988), *Application Guide for Capacitance Current Switching for AC High-Voltage Circuit Breakers Rated on Symmetrical Current Basis*

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

ANSI/IEEE C37.04-1999, *Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis*

ANSI C37.06.1-2000, *High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis Designated "Definite Purpose for Fast Transient Recovery Voltage Rise Times"*

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

ANSI/IEEE 32-1972 (R1997), *IEEE Standard Requirements, Terminology, and Test Procedures for Neutral Grounding Devices*

ANSI/NEMA MG1-1998, *Motors and Generators*

2.2 Other referenced standards

ANSI/IEEE Std. 4-1978, *IEEE Standard Techniques for High-Voltage Testing* (Note, the 1978 version is specifically referenced in this standard because the latest revision (1995) does not include critical test techniques needed for circuit breaker testing. When ANSI/IEEE Std. 4 is suitably revised, it will be officially recognized in ANSI C37.06).

Table 1 – Preferred ratings for indoor circuit breakers with voltage range factor K=1.0*

Line No.	Rated Maximum Voltage (1) kV, rms	Rated Voltage Range Factor K	Rated Continuous Current Amperes, rms	Rated Short-Circuit and Short-Time Current kA, rms	Rated Transient Recovery Voltage (3)		Rated Interrupting Time (5) ms	Maximum Permissible Tripping Time Delay Y sec	Rated Closing and Latching Current (2) kA, peak
					Rated Peak Voltage E_2 kV, peak	Rated Time to Peak T_2 (4) μ sec			
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9
1	4.76	1.0	1200, 2000	31.5	8.9	50	83	2	82
2	4.76	1.0	1200, 2000	40	8.9	50	83	2	104
3	4.76	1.0	1200, 2000, 3000	50	8.9	50	83	2	130
4	8.25	1.0	1200, 2000, 3000	40	15.5	60	83	2	104
5	15	1.0	1200, 2000	20	28	75	83	2	52
6	15	1.0	1200, 2000	25	28	75	83	2	65
7	15	1.0	1200, 2000	31.5	28	75	83	2	82
8	15	1.0	1200, 2000, 3000	40	28	75	83	2	104
9	15	1.0	1200, 2000, 3000	50	28	75	83	2	130
10	15	1.0	1200, 2000, 3000	63	28	75	83	2	164
11	27	1.0	1200	16	51	105	83	2	42
12	27	1.0	1200, 2000	25	51	105	83	2	65
13	38	1.0	1200	16	71	125	83	2	42
14	38	1.0	1200, 2000	25	71	125	83	2	65
15	38	1.0	1200, 2000, 3000	31.5	71	125	83	2	82
16	38	1.0	1200, 2000, 3000	40	71	125	83	2	104

*For preferred capacitance current switching ratings, see Table 1A.
For preferred dielectric ratings, see Table 4.
For circuit breakers with rated voltage range factor K greater than 1.0, see Tables A1 and A1A
See page 8 for notes.

Table 1A – Preferred capacitance current switching ratings for indoor circuit breakers with voltage range factor K=1.0*

Line No.	Rated Maximum Voltage kV, rms	Rated Continuous Current Amperes, rms	Rated Short-Circuit Current kA, rms	General Purpose Circuit Breakers (1) (2)		Definite-Purpose Circuit Breakers (2) (4) Back-to-Back Capacitor Switching				
				Rated Cable Charging Current Amperes, rms	Rated Isolated Capacitor Bank Current Amperes, rms	Rated Isolated Capacitor Bank Current Amperes, rms	Rated Cable Charging Current Amperes, rms	Rated Capacitor Bank Current Amperes, rms	Rated Inrush Current (3)	
									kA, peak	Frequency Hz
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10
1	4.76	1200	31.5, 40, 50	10	400	630	10	630	15	2000
2	4.76	2000	31.5, 40, 50	10	400	1000	10	1000	15	1270
3	4.76	3000	50	10	400	1600	10	1600	25	1330
4	8.25	1200	40	10	250	630	10	630	15	2000
5	8.25	2000	40	10	250	1000	10	1000	15	1270
6	8.25	3000	40	10	250	1600	10	1600	25	1330
7	15	1200	20, 25, 31.5	25	250	630	25	630	15	2000
8	15	2000	20, 25, 31.5	25	250	1000	25	1000	15	1270
9	15	1200	40, 50, 63	25	250	630	25	630	15	2000
10	15	2000	40, 50, 63	25	250	1000	25	1000	18	2400
11	15	3000	40, 50, 63	25	250	1600	25	1600	25	1330
12	27	1200, 2000	16, 25	31.5	160	400	31.5	400	20	4240
13	38	1200, 2000, 3000	16, 25, 31.5, 40	50	100	250	50	250	20	4240

*For preferred short-circuit ratings, see Table 1.
For preferred dielectric ratings, see Table 4.
For circuit breakers with rated voltage range factor K greater than 1.0, see Tables A1 and A1A
See page 9 for notes.

Table 2 – Preferred ratings for outdoor circuit breakers 72.5 kV and below, including circuit breakers applied in gas insulated substations*

Line No.	Ratings								
	Rated Maximum Voltage (1) kV, rms	Rated Voltage Range Factor K	Rated Continuous Current Amperes, rms	Rated Short-Circuit and Short-Time Current kA, rms	Rated Transient Recovery Voltage (3)		Rated Interrupting Time (5) ms	Maximum Permissible Tripping Time Delay Y sec	Rated Closing and Latching Current (2) kA, peak
					Rated Peak Voltage E_2 kV, peak	Rated Time to Peak T_2 (4) µsec			
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9
1	15.5	1.0	600, 1200	12.5	29	36	83	2	33
2	15.5	1.0	1200, 2000	20	29	36	83	2	52
3	15.5	1.0	1200, 2000	25	29	36	83	2	65
4	15.5	1.0	1200, 2000, 3000	40	29	36	83	2	104
5	25.8	1.0	1200, 2000	12.5	48.5	52	83	2	33
6	25.8	1.0	1200, 2000	25	48.5	52	83	2	65
7	38.0	1.0	1200, 2000	16	71	63	83	2	42
8	38.0	1.0	1200, 2000	20	71	63	83	2	52
9	38.0	1.0	1200, 2000	25	71	63	83	2	65
10	38.0	1.0	1200, 2000	31.5	71	63	83	2	82
11	38.0	1.0	1200, 2000, 3000	40	71	63	83	2	104
12	48.3	1.0	1200, 2000	20	91	80	83	2	52
13	48.3	1.0	1200, 2000	31.5	91	80	83	2	82
14	48.3	1.0	1200, 2000, 3000	40	91	80	83	2	104
15	72.5	1.0	1200, 2000	20	136	106	83	2	52
16	72.5	1.0	1200, 2000	31.5	136	106	83	2	82
17	72.5	1.0	1200, 2000, 3000	40	136	106	83	2	104

* For preferred dielectric ratings, see Tables 4 and 5.
See page 8 for notes.

Table 2A – Preferred capacitance current switching ratings for outdoor circuit breakers rated 72.5 kV and below, including circuit breakers applied in gas insulated substations

Line No.	Rated Maximum Voltage kV, rms	Rated Continuous Current Amperes, rms	Rated Short-Circuit Current kA, rms	General-Purpose Circuit Breaker (1) (2)		Definite-Purpose Circuit Breaker (2)(4)				
						Isolated		Back-to-Back		
				Rated Overhead Line Current Amperes, rms	Rated Isolated Capacitor Bank or Cable Current Amperes, rms	Rated Capacitor Bank Current Amperes, rms	Rated Overhead Line Current Amperes, rms	Rated Capacitor Bank Current Amperes, rms	Rated Inrush Current (3)(5)	
									kA, peak	Frequency Hz
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10
1	15.5	600, 1200	12.5	2	250	400	100	400	20	4240
2	15.5	1200, 2000	20	2	250	400	100	400	20	4240
3	15.5	1200, 2000	25	2	250	400	100	400	20	4240
4	15.5	1200, 2000, 3000	40	2	250	400	100	400	20	4240
5	25.8	1200, 2000	12.5	5	250	400	100	400	20	4240
6	25.8	1200, 2000	25	5	250	400	100	400	20	4240
7	38.0	1200, 2000	16	5	250	250	100	250	20	4240
8	38.0	1200, 2000	20	5	250	250	100	250	20	4240
9	38.0	1200, 2000	25	5	250	250	100	250	20	4240
10	38.0	1200, 2000	31.5	5	250	250	100	250	20	4240
11	38.0	1200, 2000, 3000	40	5	250	250	100	250	20	4240
12	48.3	1200, 2000	20	10	250	250	100	250	20	6800
13	48.3	1200, 2000	31.5	10	250	250	100	250	20	6800
14	48.3	1200, 2000, 3000	40	10	250	250	100	250	20	6800
15	72.5	1200, 2000	20	20	250	630	100	630	25	3360
16	72.5	1200, 2000	31.5	20	250	630	100	630	25	3360
17	72.5	1200, 2000, 3000	40	20	250	630	100	630	25	3360

See page 9 for notes.

Table 3 – Preferred ratings for outdoor circuit breakers rated 123 kV and above, including circuit breakers applied in gas insulated substations*

Line No.	Ratings									
					Rated Transient Recovery Voltage (6)					
	Rated Maximum Voltage (1) kV, rms	Rated Voltage Range Factor K	Rated Continuous Current Amperes, rms	Rated Short-Circuit and Short-Time Current kA, rms	Rated Time to Peak T_2 (4) µsec	Rated Rate R kV/µsec	Rated Delay Time T_1 µsec	Rated Interrupting Time (5) ms	Maximum Permissible Tripping Time Delay Y Sec	Rated Closing and Latching Current (2) kA, peak
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10
1	123	1.0	1200, 2000	31.5	260	2.0	2	50	1	82
2	123	1.0	1600, 2000, 3000	40	260	2.0	2	50	1	104
3	123	1.0	2000, 3000	63	260	2.0	2	50	1	164
4	145	1.0	1200, 2000	31.5	310	2.0	2	50	1	82
5	145	1.0	1600, 2000, 3000	40	310	2.0	2	50	1	104
6	145	1.0	2000, 3000	63	310	2.0	2	50	1	164
7	145	1.0	2000, 3000	80	310	2.0	2	50	1	208
8	170	1.0	1600, 2000	31.5	360	2.0	2	50	1	82
9	170	1.0	2000, 3000	40	360	2.0	2	50	1	104
10	170	1.0	2000, 3000	50	360	2.0	2	50	1	130
11	170	1.0	2000, 3000	63	360	2.0	2	50	1	164
12	245	1.0	1600, 2000, 3000	31.5	520	2.0	2	50	1	82
13	245	1.0	2000, 3000	40	520	2.0	2	50	1	104
14	245	1.0	2000, 3000	50	520	2.0	2	50	1	130
15	245	1.0	2000, 3000	63	520	2.0	2	50	1	164
16	362	1.0	2000, 3000	40	775	2.0	2	33	1	104
17	362	1.0	2000, 3000	50	775	2.0	2	33	1	130
18	362	1.0	2000, 3000	63	775	2.0	2	33	1	164
19	550	1.0	2000, 3000	40	1325	2.0	2	33	1	104
20	550	1.0	3000, 4000	50	1325	2.0	2	33	1	130
21	550	1.0	3000, 4000	63	1325	2.0	2	33	1	164
22	800	1.0	2000, 3000	40	1530	2.0	2	33	1	104
23	800	1.0	3000, 4000	50	1530	2.0	2	33	1	130
24	800	1.0	3000, 4000	63	1530	2.0	2	33	1	164

* For preferred dielectric ratings, see Tables 4 and 5.
See page 8 for notes.

Table 3A – Preferred capacitance current switching ratings for outdoor circuit breakers rated 123 kV and above, including circuit breakers applied in gas insulated substations

Line No.	Rated Maximum Voltage kV, rms	Rated Continuous Current Amperes, rms	Rated Short-Circuit Current kA, rms	General-Purpose Circuit Breaker (1) (2)		Definite-Purpose Circuit Breaker (2)(4)				
						Isolated		Back-to-Back		
				Rated Overhead Line Current Amperes, rms	Rated Isolated Current Amperes, rms	Rated Capacitor Bank Current Amperes, rms	Rated Overhead Line Current Amperes, rms	Rated Capacitor Bank Current Amperes, rms	Rated Inrush Current (3)(5) kA, peak	Rated Inrush Current (3)(5) Frequency Hz
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10
1	123	1200, 2000	31.5	50	50	315	160	315	16	4250
2	123	1600, 2000, 3000	40	50	50	315	160	315	16	4250
3	123	2000, 3000	63	50	50	315	160	315	16	4250
4	145	1200, 2000	31.5	80	80	315	160	315	16	4250
5	145	1600, 2000, 3000	40	80	80	315	160	315	16	4250
6	145	2000, 3000	63	80	80	315	160	315	16	4250
7	145	2000, 3000	80	80	80	315	160	315	16	4250
8	170	1600, 2000	31.5	100	100	400	160	400	20	4250
9	170	2000, 3000	40	100	100	400	160	400	20	4250
10	170	2000, 3000	50	100	100	400	160	400	20	4250
11	170	2000, 3000	63	100	100	400	160	400	20	4250
12	245	1600, 2000, 3000	31.5	160	160	400	200	400	20	4250
13	245	2000, 3000	40	160	160	400	200	400	20	4250
14	245	2000, 3000	50	160	160	400	200	400	20	4250
15	245	2000, 3000	63	160	160	400	200	400	20	4250
16	362	2000, 3000	40	250	250	500	315	500	25	4250
17	362	2000, 3000	63	250	250	500	315	500	25	4250
18	550	2000, 3000	40	400	400	500	500	500	25	4250
19	550	3000, 4000	63	400	400	500	500	500	25	4250
20	800	2000, 3000	40	900	500	500	900	--	--	--
21	800	3000, 4000	63	900	500	500	900	--	--	--

See page 9 for notes.

Notes for Tables 1, 2, and 3

(Numbers in parenthesis in the tables refer to the following correspondingly numbered notes.)

For service conditions, definitions, interpretation of ratings, tests, and qualifying terms, see ANSI/IEEE C37.04, ANSI C37.06.1, ANSI/IEEE C37.09, and ANSI/IEEE C37.100.

The preferred ratings are for 60-Hz systems. Applications at other system frequencies should receive special consideration, see ANSI/IEEE C37.010.

Current values have generally been rounded off to the nearest kiloampere (kA) except that two significant figures are used for values below 10 kA.

(1) The voltage rating is based on ANSI C84.1, where applicable and is the maximum voltage for which the breaker is designed and the upper limit for operation.

(2) Rated closing and latching current (kA, peak) of the circuit breaker is 2.6 times the rated short-circuit current. (If expressed in terms of kA, rms total current, the equivalent value is 1.55 times rated short-circuit current.)

(3) Tables 1 and 2 only. The rated transient recovery voltage envelope is the "one-minus-cosine" (1-cosine) shape. See TRV envelope curves in ANSI/IEEE C37.04.

(4) If the source of power to a circuit breaker is a single transformer or a bank of transformers and there are no substantial capacitors or loaded feeders connected to the source side of the circuit breaker, the transient recovery voltage may be more severe than those covered in these tables. T_2 values for these applications are being developed.

(5) The ratings in this column are the maximum time interval to be expected during a breaker opening operation between the instant of energizing the trip circuit and the interruption of the main circuit on the primary arcing contacts under certain specified conditions. The values may be exceeded under certain conditions as specified in ANSI/IEEE C37.04, sub-clause covering "Rated Interrupting Time."

(6) *Table 3 only*. The rated transient recovery voltage envelope is the "exponential-cosine" shape. E_2 = 1.49 times rated maximum voltage; $E_1 = 1.3\ \sqrt{2/3}$ times rated maximum voltage. See TRV envelope curves in ANSI/IEEE C37.04.

Notes for Table 1A, 2A, and 3A

(Numbers in parentheses in tables refer to the following correspondingly numbered notes.)

(1) For general-purpose circuit breakers, no ratings for back-to-back capacitor switching applications are established. The capacitor bank or cable shall be "Isolated" as defined in ANSI/IEEE C37.04, clause "Rated Capacitance Switching Current."

For general-purpose circuit breakers exposed to transient inrush currents from nearby capacitor banks during fault conditions, the capacitance transient inrush peak current on closing shall not exceed the lesser of either [1.41 times rated short-circuit current], or 50,000 peak amperes. The product of transient inrush current peak and transient inrush current frequency shall not exceed 2×10^7. The service capability and circuit breaker condition for this duty shall be as specified in ANSI/IEEE C37.04, clause "Interrupting Performance." For reference, see ANSI/IEEE C37.012.

(2) The circuit breaker shall be capable of switching any capacitive current in the range of 30% to 100% of the ratings listed at any voltage up to rated maximum voltage. All circuit breakers shall meet the general-purpose circuit breaker ratings values shown.

(3) The rated transient inrush current peak is the highest magnitude of current that the circuit breaker shall be required to close at any voltage up to the rated maximum voltage and shall be as determined by the system and unmodified by the circuit breaker. The rated transient inrush current frequency is the highest frequency that the circuit breaker shall be required to close at 100% rated back-to-back capacitor switching inrush current rating.

For application at less than 100% of rating, the product of the inrush current peak and natural frequency shall not exceed the product of the rated transient current peak and the rated transient inrush current frequency. (This product quantifies the maximum rate of change of inrush current and the minimum inductance between the banks or cables.)

(4) If the circuit breaker is identified as a "Definite Purpose Circuit Breaker for Capacitance Current Switching," it shall meet the specified ratings values.

(5) Tables 2A and 3A only. The transient inrush current in circuit breakers applied in GIS substations has a very high equivalent frequency (up to the MHz range, depending on the bus length) with an initial peak current of several thousand amperes (depending on the surge impedance of the bus). For reference, see ANSI/IEEE C37.012. Contact the manufacturer to determine the ability of the circuit breaker to withstand these inrush current stresses.

Table 4 – Preferred dielectric withstand ratings and external insulation (1)

Line No.	Rated Maximum Voltage kV, rms	Rating Table No.	Dielectric Withstand Test Voltages						Minimum Creepage(5) Distance of External Insulation to Ground mm
			Power Frequency		Impulse Test 1.2 x 50 μsec wave		Switching Impulse		
			1 Minute Dry kV, rms	10 Second Wet kV, rms	Full Wave (2)(6) Withstand kV, Peak	2 μsec Chopped Wave Withstand kV, Peak Minimum Time to Sparkover	Withstand Voltage Terminal to Ground With Breaker Closed kV, Peak	Withstand Voltage Terminal to Terminal on One Phase with Circuit Breaker Open kV, Peak	
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9
1	4.76	1	19	(3)	60	(3)	(3)	(3)	(3)
2	8.25	1	36	(3)	95	(3)	(3)	(3)	(3)
3	15.0	1	36	(3)	95	(3)	(3)	(3)	(3)
4	15.5	2	50	45	110	142	(3)	(3)	250
5	25.8	2	60	50	150	194	(3)	(3)	420
6	25.8 (4)	2	60	50	125	(3)	(3)	(3)	420
7	27.0	1	60	(3)	125	(3)	(3)	(3)	(3)
8	38.0	1	80	(3)	150	(3)	(3)	(3)	(3)
9	38.0	2	80	75	200	258	(3)	(3)	610
10	38.0 (4)	2	80	75	150	(3)	(3)	(3)	610
11	48.3	2	105	95	250	322	(3)	(3)	780
12	72.5	2	160	140	350	452	(3)	(3)	1170
13	123	3	260	230	550	710	(3)	(3)	1990
14	145	3	310	275	650	838	(3)	(3)	2340
15	170	3	365	315	750	968	(3)	(3)	2750
16	245	3	425	350	900	1160	(3)	(3)	3960
17	362	3	555	(3)	1300	1680	825	900	5850
18	550	3	860	(3)	1800	2320	1175	1300	8890
19	800	3	960	(3)	2050	2640	1425	1500	12900

NOTES
(1) For circuit breakers applied in gas insulated substations, see Table 5.
(2) 1.2 x 50 μ seconds positive and negative wave as defined in ANSI/IEEE Std. 4. All impulse values are phase-to-phase and phase-to-ground and across the open contacts.
(3) Not required.
(4) These circuit breakers are intended for application on grounded wye distribution circuits equipped with surge arresters.
(5) Minimum creepage corresponds to Light Pollution level. Refer to ANSI/IEEE C37.010 for special cases of pollution level, or to the manufacturer.
(6) For outdoor circuit breakers rated 123 kV and above and that have isolating gaps in series with the interrupting gaps, or have additional gaps in the resistor or capacitor circuits, the impulse test for interrupters and resistors shall be 75% of the value shown in column 5.

Table 5 – Preferred dielectric withstand ratings for circuit breakers applied in gas insulated substations

	Dielectric Withstand Test Voltages						
				Impulse Test 1.2 X 50 μsec Wave*		Switching Impulse	
	Rated Maximum Voltage kV, rms	Rating Table No.	Power Frequency 1 Minute Dry kV, rms	Full Wave Withstand kV, Peak	Chopped Wave, kV Peak Minimum Time to Sparkover 3 μsec Withstand	Withstand Voltage Terminal to Ground with Circuit Breaker Closed kV, Peak	Withstand Voltage Terminal to Terminal on One Phase with Circuit Breaker Open kV, Peak
Line No.	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7
1	72.5	2	140	300	300	--	--
2	72.5	2	160	350	350	--	--
3	123	3	215	450	450	--	--
4	123	3	260	550	550	--	--
5	145	3	260	550	550	--	--
6	145	3	310	650	650	--	--
7	170	3	310	650	650	--	--
8	170	3	365	750	750	--	--
9	245	3	365	750	750	--	--
10	245	3	425	900	900	--	--
11	362	3	425	900	900	720	800
12	362	3	500	1050	1050	825	900
13	550	3	615	1300	1300	1050	1175
14	550	3	740	1550	1550	1175	1300
15	800	3	860	1800	1800	1425	1550

* 1.2 x 50 μ seconds positive and negative wave as defined in ANSI/IEEE Std. 4. All impulse values are phase-to-phase, phase-to-ground, and across the open contacts.

Table 6 – Related required transient recovery voltage capabilities of circuit breakers at various interrupting levels for terminal faults (1)

Line No.	Percent of Interrupting Rating (2)	Multipliers for Rated Parameters				
		72.5 kV and Below (4)		123 kV and Above (4)		
		E_2	T_2	R (3)	E_2	T_2
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
1	100	1.00	1.00	1	1.00	1.00
2	60	1.07	0.67	2	1.07	0.50
3	30	1.13	0.40	0	1.13	0.20
4	10	1.17	0.40	0	1.17	0.20

Note: Interpolation between the above given points is linear.

(1) This table also applies to circuit breakers in gas insulated substation installations.

(2) Ratio of the symmetrical current component of the current being considered to the related required symmetrical interrupting capability (defined in ANSI/IEEE C37.04, clause "Symmetrical Interrupting Capability") is stated in percent.

(3) Applies only to circuit breakers rated 123 kV and above since the rated transient recovery voltage is defined as the envelope of a one minus cosine curve which has R = 0 for circuit breakers rated 72.5 kV and below.

(4) See TRV envelope curves in ANSI/IEEE C37.04.

Table 7 – Schedule of operating endurance capabilities for circuit breakers*

Line No.	Circuit Breaker Ratings			Number of Operations (Each Operation is Comprised of One Closing Plus One Opening)			
	Rated Maximum Voltage kV, rms	Rated Continuous Current Amperes, rms	Rated Short-Circuit Current kA, rms	Between Servicing (2)	No-Load Mechanical (8)	Rated Continuous Current Switching (9)	Inrush Current Switching (10)
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7
	Indoor Circuit Breakers						
1	4.76, 15	1200, 2000	20, 25, 31.5	2000	10000	1000	750
2	4.76, 8.25, 15	1200, 2000, 3000	40, 50	1000	5000	500	400
3	15	1200, 2000, 3000	63	500	2000	500	400
4	27	1200, 2000	16, 25	500	2500	200	100
5	38	1200, 2000, 3000	16, 25, 31.5, 40	250	1500	100	100
	Outdoor Circuit Breakers (11)						
6	15.5 and above	all	all	500	2000	100	100

* Notes (1) through (7) apply to the entire table.
See page 14 for notes.

Notes for Table 7

(1) Table 7 may be used as a guide for applying circuit breakers to switching conditions that differ from those specified. In such cases, the number of operations may differ from those tabulated, but the cumulative duty on the circuit breaker must be within the service capability as defined in ANSI/IEEE C37.04, clause on "Short-circuit Performance" and sub-clauses on "Interrupting Performance" and "Service Capability."

(2) Servicing consists of cleaning, tightening, adjusting, lubricating, dressing of contacts, etc. as recommended by the manufacturer and assumes usual service conditions. Maintenance intervals are usually based on both an elapsed time and a number of operations, whichever occurs sooner.

(3) With rated control voltage applied. See Table 8.

(4) For frequency of operation see ANSI/IEEE C37.04, clause on "Required Load Current Switching Capability and Life (Repetitive Operation)."

(5) No functional parts shall have been replaced prior to completion of the specified number of operations.

(6) After completion of the specified number of operations, the circuit breaker shall withstand rated maximum voltage in the open position, and the resistance of the current carrying circuit from terminal to terminal, measured with a current of at least 100 amperes flowing, shall not be greater than 200 percent of the maximum value given by the manufacturer for the circuit breaker when new. Under these conditions, the circuit breaker is considered capable of carrying rated continuous current, at rated frequency, without injurious heating until maintained, and of performing one interruption at rated short-circuit current or at a related capability. After completion of this series of operations, functional part replacement and general maintenance may be necessary.

(7) If a short-circuit operation occurs before the completion of the listed operations, maintenance is recommended and possible functional part replacement may be necessary, depending on previous accumulated duty, fault magnitude, and expected future operations.

(8) Requirements are based on specified maintenance intervals in accordance with Col. 4.

(9) When closing and opening current equal to rated continuous current at rated maximum voltage with power factor between 80 percent leading and 80 percent lagging.

(10) When closing current equal to 600 percent of rated continuous current at rated maximum voltage with power factor of 30 percent or less and when opening current equal to rated continuous current at rated maximum voltage with power factor between 80 percent leading and 80 percent lagging.

(11) These ratings also apply for circuit breakers in gas insulated substation installations.

Table 8 – Rated control voltages and their ranges for circuit breakers*

Operating mechanisms are designed for the rated control voltages listed with operational capability throughout the indicated voltage ranges to accommodate variations in source regulation, coupled with low charge levels, as well as high charge levels maintained with floating charges. The maximum voltage is measured at the point of user connection to the circuit breaker [see notes (12) and (13)] with no operating current flowing, and the minimum voltage is measured with maximum operating current flowing.

Line No.	(11) Rated Control Voltage	Direct Current Voltage Ranges (1)(2)(3)(5) Volts, dc (8)(9)			Rated Control Voltage (60 Hz)	Alternating Current Voltage Ranges (1)(2)(3)(4)(8) Closing, Tripping, and Auxiliary Functions
		Closing and Auxiliary Functions		Opening Functions All Types		
		Indoor Circuit Breakers	Outdoor Circuit Breakers		Single Phase	Single Phase
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
1	24 (6)	--	--	14-28	120	104-127 (7)
2	48 (6)	38-56	36-56	28-56	240	208-254 (7)
3	125	100-140	90-140	70-140		
4	250	200-280	180-280	140-280	Polyphase	Polyphase
5	–	–	–	–	208Y/120	180Y/104–220Y/127
6	–	–	–	–	240	208–254

* Note (10) applies to the entire table.
See page 16 for notes

Notes for Table 8

(1) Electrically operated motors, contactors, solenoids, valves, and the like, need not carry a nameplate voltage rating that corresponds to the control voltage rating shown in the table as long as these components perform the intended duty cycle (usually intermittent) in the voltage range specified.

(2) Relays, motors, or other auxiliary equipment that functions as a part of the control for a device shall be subject to the voltage limits imposed by this standard, whether mounted at the device or at a remote location.

(3) Circuit breaker devices, in some applications, may be exposed to control voltages exceeding those specified here due to abnormal conditions such as abrupt changes in line loading. Such applications require specific study, and the manufacturer should be consulted. Also, application of switchgear devices containing solid-state control, exposed continuously to control voltages approaching the upper limits of ranges specified herein, require specific attention, and the manufacturer should be consulted before application is made.

(4) Includes supply for pump or compressor motors. Note that rated voltages for motors and their operating ranges are covered in ANSI/NEMA MG-1.

(5) It is recommended that the coils of closing, auxiliary, and tripping devices that are connected continually to one DC potential should be connected to the negative control bus to minimize electrolytic deterioration.

(6) 24-volt or 48-volt tripping, closing, and auxiliary functions are recommended only when the device is located near the battery or where special effort is made to ensure the adequacy of conductors between battery and control terminals. 24-volt closing is not recommended.

(7) Includes heater circuits.

(8) Voltage ranges apply to all closing and auxiliary devices when cold. Breakers utilizing standard auxiliary relays for control functions may not comply at lower extremes of voltage ranges when relay coils are hot, as after repeated or continuous operation.

(9) Direct current control voltage sources, such as those derived from rectified alternating current, may contain sufficient inherent ripple to modify the operation of control devices to the extent that they may not function over the entire specified voltage ranges.

(10) This table also applies for circuit breakers in gas insulated substation installations.

(11) In cases where other operational ratings are a function of the specific control voltage applied, tests in C37.09 may refer to the "Rated Control Voltage." In these cases, tests shall be performed at the levels in this column.

(12) For an outdoor circuit breaker, the point of user connection to the circuit breaker is the secondary terminal block point at which the wires from the circuit breaker operating mechanism components are connected to the user's control circuit wiring.

(13) For an indoor circuit breaker, the point of user connection to the circuit breaker is either the secondary disconnecting contact (where the control power is connected from the stationary housing to the removable circuit breaker) or the terminal block point in the housing nearest to the secondary disconnecting contact.

Table 9 – Rated reclosing times for circuit breakers

Circuit Breaker Ratings	Reclosing Time Seconds (1)
Indoor Circuit Breakers (2)	
4.76 thru 38 kV, 1200 A	0.3
Outdoor Circuit Breakers	
15.5 kV and above	0.3

(1) Circuit breakers rated for reclosing shall be capable of reclosing within these times on an instantaneous reclosing cycle, O + 0 sec (no intentional delay beyond the inherent breaker operation time) + CO, when operating in conjunction with an automatic reclosing device. These time values are based on maintaining rated control voltage or operating pressure at the operating mechanism. In case the control voltage or pressure drops to 90 percent of rated voltage or pressure, the reclosing times will be increased to 110 percent of the above values. Consult the manufacturer for special reclosing requirements.

(2) Reclosing ratings for circuit breaker continuous current ratings greater than 1200 A have not been established.

ANNEX A

Table A1 – Preferred ratings for indoor circuit breakers with voltage range factor K>1.0*

Line No.	Rated Maximum Voltage (1) kV, rms	Rated Voltage Range Factor K (2)	Rated Continuous Current at 60 Hz (3) Amperes, rms	Rated Short-Circuit Current ** (at Rated Maximum kV) (4)(5)(6)(10) kA, rms	Transient Recovery Voltage (9)			Rated Interrupting Time (7) Cycles	Rated Maximum Voltage Divided by K kV, rms	Maximum Symmetrical Interrupting Capability and Rated Short-Time Current (4)(5)(8) kA, rms	Closing and Latching Capability 2.7 K times Rated Short-Circuit Current (4) kA, crest
					Rated Time to Point P T_2 *** μ sec	Rated Rate R kV/μ sec	Rated Delay Time T_1 μ sec				
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	Col 11
1	4.76	1.36	1200	8.8	-	-	-	5	3.5	12	32
2	4.76	1.24	1200, 2000	29	-	-	-	5	3.85	36	97
3	4.76	1.19	1200, 2000, 3000	41	-	-	-	5	4.0	49	132
4	8.25	1.25	1200, 2000	33	-	-	-	5	6.6	41	111
5	15.0	1.30	1200, 2000	18	-	-	-	5	11.5	23	62
6	15.0	1.30	1200, 2000	28	-	-	-	5	11.5	36	97
7	15.0	1.30	1200, 2000, 3000	37	-	-	-	5	11.5	48	130
8	38.0	1.65	1200, 2000, 3000	21	-	-	-	5	23.0	35	95
9	38.0	1.0	1200, 3000	40	-	-	-	5	38.0	40	108

* For rated dielectric test values, See Table 4.
** For the related required capabilities associated with the rated short-circuit current of the circuit breaker, see note 4.
*** These rated values are not yet standardized. Work is in progress.
See page A-2 for notes.

Notes for Table A1

(Numbers in parentheses in the tables refer to the following correspondingly numbered notes.)

For service conditions, definitions, and interpretation of ratings, tests, and qualifying terms, see ANSI/IEEE C37.04-1979, ANSI/IEEE C37.09-1979, and ANSI/IEEE C37.100-1981.

The interrupting ratings are for 60-Hz systems. Applications on 25-Hz systems should receive special consideration.

Current values have been rounded off to the nearest kiloampere (kA) except that two significant figures are used for values below 10 kA.

(1) The voltage rating is based on ANSI C84.1-1982, where applicable, and is the maximum voltage for which the breaker is designed and the upper limit for operation.

(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) The 25-Hz continuous current ratings in amperes are given herewith following the respective 60-Hz rating: 600-700; 1200-1400; 2000-2250; and 3000-3500.

(4) Related Required Capabilities. The following related required capabilities are associated with the short-circuit current rating of the circuit breaker.

(a) Maximum symmetrical interrupting capability (kA, rms) of the circuit breaker is equal to K times rated short-circuit current.

(b) 3-second short-time current carrying capability (kA, rms) of the circuit breaker is equal to K times rated short-circuit current.

(c) Closing and latching capability (kA, rms) of the circuit breaker is equal to 1.6 K times rated short-circuit current. If expressed in peak amperes, the value is equal to 2.7 K times rated short-circuit current.

(d) 3-second short-time current carrying capability and closing and latching capability are independent of operating voltage up to and including rated maximum voltage.

(5) To obtain the required symmetrical current interrupting capability of a circuit breaker at an operating voltage between 1/K times rated maximum voltage and rated maximum voltage, the following formula shall be used:

$$\text{Required symmetrical current interrupting capability} = \text{rated short-circuit current} \times \frac{(\text{rated maximum voltage})}{(\text{operating voltage})}$$

For operating voltages below 1/K times rated maximum voltage, the required symmetrical current interrupting capability of the circuit breaker shall be equal to K times rated short-circuit current.

(6) With the limitation stated in 5.10 of ANSI/IEEE C37.04-1979, all values apply for polyphase and line-to-line faults. For single phase-to-ground faults, the specific conditions stated in 5.10.2.3 of ANSI/IEEE C37.04-1979 apply.

(7) The ratings in this column are on a 60-Hz basis and are the maximum time interval 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 certain specified conditions. The values may be exceeded under certain conditions as specified in 5.7 of ANSI/IEEE C37.04-1979.

(8) Current values in this column are not to be exceeded even for operating voltages below 1/K times rated maximum voltage. For voltages between rated maximum voltage and 1/K times rated maximum voltage, follow (5) above.

(9) The rated values for T_2 are not standardized for indoor oilless circuit breakers, however, E_2 = 1.88 times rated maximum voltage.

(10) Rated permissible tripping delay time (Y) = 2 seconds.

Table A1A – Preferred capacitance current switching ratings for indoor circuit breakers with voltage range factor K>1.0

Line No.	Rated Maximum Voltage kV, rms	Rated Short-Circuit Current kA, rms	Rated Continuous Current (3) Amperes, rms	General-Purpose Circuit Breakers Rated Capacitance Switching Current (1) (2)		Definite-Purpose Circuit Breakers Rated Capacitance Switching Current (2)				
					Shunt Capacitor Bank or Cable		Shunt Capacitor Bank or Cable			
								Back-to-Back		
									Inrush Current (4)	
				Overhead Line Current Amperes, rms	Isolated Current (3) Amperes, rms	Overhead Line Current Amperes, rms	Isolated Current (3) Amperes, rms	Current (3) Amperes, rms	Peak Current kA	Frequency Hz
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10
1	4.76	8.8	1200	1	400	1	630	630	15	2000
2	4.76	29	1200	1	400	1	630	630	15	2000
3	4.76	29	2000	1	400	1	1000	1000	15	1270
4	4.76	41	1200, 2000	1	400	1	630	630	15	2000
5	4.76	41	3000	1	400	1	1000	1000	15	1270
6	8.25	33	1200	1	250	1	630	630	15	2000
7	8.25	33	2000	1	250	1	1000	1000	15	1270
8	15.0	18	1200	2	250	2	630	630	15	2000
9	15.0	18	2000	2	250	2	1000	1000	15	1270
10	15.0	28	1200	2	250	2	630	630	15	2000
11	15.0	28	2000	2	250	2	1000	1000	15	1270
12	15.0	37	1200	2	250	2	630	630	15	2000
13	15.0	37	2000	2	250	2	1000	1000	18	2400
14	15.0	37	3000	2	250	2	1600	1600	25	1330
15	38.0	21	1200, 2000, 3000	5	50	5	250	250	18	6000
16	38.0	40	1200, 3000	5	50	5	250	250	25	8480

See page A-5 for notes.

Notes for Table A1A

(Numbers in parentheses in the tables refer to the following correspondingly numbered notes)

(1) No ratings for back-to-back shunt capacitor bank or cable switching applications are established for general-purpose circuit breakers. The shunt capacitor bank or cable shall be electrically isolated as defined in 5.13.2 of ANSI/IEEE C37.04-1979.

For general-purpose circuit breakers exposed to transient inrush currents from nearby capacitor banks during fault conditions, the capacitance transient inrush peak current on closing shall not exceed the lower of either $\sqrt{2}$ times K times rated short-circuit current ($\sqrt{2}$ x K x I), or 50,000 peak amperes. The product of transient inrush current peak and transient inrush current frequency shall not exceed 2×10^7. The service capability and circuit breaker condition for this duty shall be as specified in ANSI/IEEE C37.012-1979, 4.10.2

(2) The capacitance switching current ratings are the highest values that the circuit breaker shall be required to switch at any voltage up to rated maximum voltage.

(3) When applied on shunt capacitor banks, the current rating shall be selected to include the effects of a positive tolerance in capacitance, system and capacitor bank grounding, and additional current magnitude and heating due to harmonics.

(4) The rated transient inrush current peak is the highest magnitude that the circuit breaker shall be required to close at any voltage up to the rated maximum voltage and shall be as determined by the system and unmodified by the circuit breaker. The rated transient inrush current frequency is the natural frequency that the circuit breaker shall be required to close at 100% of its rated back-to-back shunt capacitor bank or cable switching current.

For application at less than 100% of rating, the product of the inrush current peak and natural frequency shall not exceed the product of the rated transient current peak and the rated transient inrush current frequency. (This product defines a maximum rate of change of inrush current and a minimum inductance between the banks or cables.)

Table A2 – Rated line closing switching surge factors for circuit breakers specifically designed to control line closing switching surge maximum voltages, and parameters of standard reference transmission lines

Line No.	Rated Maximum Voltage kV, rms	Rated Line Closing Switching Surge Factor	Line Length, Miles	Percent Shunt Compensation Divided Equally at Line Ends	L_1	L_0/L_1	R_1	R_0	C_1	C_1/C_0
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10
1	362	2.4	150	0	1.6	3	0.05	0.5	0.02	1.5
2	550	2.2	200	0	1.6	3	0.03	0.5	0.02	1.5
3	800	2.0	200	60	1.4	3	0.02	0.5	0.02	1.5

L_1 = positive and negative sequence inductance in millihenries per mile
L_0 = zero sequence inductance in millihenries per mile
R_1 = positive and negative sequence resistance in ohms per mile
R_0 = zero sequence resistance in ohms per mile
C_1 = positive and negative sequence capacitance in microfarads per mile
C_0 = zero sequence capacitance in microfarads per mile

Notes

(1) Because of limitations in transient network analyzer and analog equipment, it is permissible to make studies with an X_1/R_1 ratio of 17 or greater for 550-kV lines and 20 or greater for 800-kV lines. Studies have shown that the effect of a low value of positive sequence resistance is minimal and X_1/R_1 ratios as specified above give results that are acceptable.

(2) Model simulation tests for 800-kV system should take into account the influence of the line shunt reactors on line trapped charge reduction. For this purpose, a linear reactor having a Q of 400 at 60 Hz should be assumed, and a circuit breaker reclosing time of 300 ms.

(3) This table also applies for circuit breakers in gas insulated substation installations.