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K>1.0 vs. K=1 ANSI circuit breaker standards

Written by:

R. William Long, Eaton Technology and Quality Center, Pittsburgh, PA USA

James J. Benke, Eaton Technology and Quality Center, Pittsburgh, PA USA

Abstract

The ratings structure for AC high voltage circuit breakers have seen significant revisions with the introduction of new ANSI C37 standards in 1999 and 2000. ANSI C37 standards cover low, medium, and high voltage power circuit breakers and switchgear, and are the first changes to high voltage standards in over 20 years. The new applicable ANSI C37 standards are as follows:

- C37.04—1999 Standard Rating Structure for AC High Voltage Circuit Breakers
- C37.06—2000 AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities
- C37.09—1999 Standard Test Procedure for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- C37.010—1999 Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis

Rating structure changes have caused some concerns and misunderstandings because the ratings assigned to circuit breakers, in accordance with the 1987 ratings edition of C37.06, seem to be no longer valid. The new values are in **Table 1** and **Table 1A** for "Preferred Ratings" of high voltage circuit breakers in the new 2000 edition of ANSI C37.06. Unfortunately, this might lead to the assumption that the new ratings supersede the original ratings, and that the original ratings are invalid or out-of-date, which is not necessarily true.

Eaton has dedicated years of research, design, enhancement, and testing to provide an ongoing stream of circuit breakers that meet, and exceed, rigorous requirements of ANSI and applicable IEC standards. From the well-established VCP-W line of vacuum circuit breakers, to the newest VCP-T and T-VAC state-of-the-art line of vacuum circuit breakers, Eaton provides customers with a peace-of-mind with compliance and understanding of applicable standards.

This publication aims to clarify and remove confusion that may exist with the latest ANSI changes to ratings based on the Voltage Range Factor, K=1.0, versus the former ratings based on K>1.0. Please keep in mind, K=1.0 does not supersede K>1.0 capabilities, both ratings are valid.

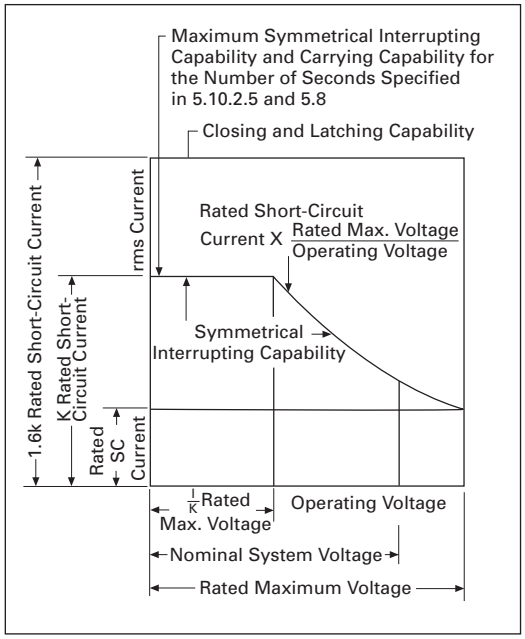

Figure 1. Relation of Symmetrical Interrupting Capability, Closing Capability, Latching Capability, and Carrying Capability to Rated Short-Circuit Current [ref: ANSI Standard C37.04-1979]

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Introduction

To understand the intent of the revisions, look at the Foreword of the new C37.06 edition.

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 does not affect the ratings for circuit breakers manufactured and tested to the 1987 edition. This is still applicable 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 based on K>1.0 to the K=1.0 ratings, the industry should still use the previous revision of the tables in applications where they are applicable.

The intent here is twofold

- First, when new circuit breakers are designed, they should be rated and tested to the new preferred ratings
- Second, any existing circuit breaker designs do not need to be re-tested just to assign and establish new ratings in accordance with the new K=1.0 values

The original tables are still included in the new standard. For reference and comparison purposes, new tables (1 and 1A) along with the original tables (A1 and A1A) are presented at the end of this document. Compare and know that both sets are still correct. Depending upon the specific application, a "K>1.0" rating may be the better choice, or a "K=1.0" rating may be the better choice. However, for most applications, there will be both "K>1.0" and "K=1.0" solutions available.

Why change?

First, keep in mind that K, known as the Voltage Range Factor, was originally established to take advantage of the increasing short-circuit current interrupting capabilities of oil and air circuit breakers, with decreasing operating voltage. (See **Figure 1**.) The original K>1.0 ratings were selected to reflect the actual capabilities of the air and oil circuit breaker interrupting technologies.

As new SF_6 and vacuum interrupting technologies were developed, scientists discovered that reducing the operating voltage did not increase the short-circuit current interrupting capability of new interrupters. In fact, as the operating voltage is reduced, the short-circuit current interrupting capability changes only little, and therefore the K>1.0 basis of rating no longer accurately reflects the true interrupting characteristics of today's circuit breaker designs.

The best way for both users and manufacturers to take advantage of the short-circuit interrupting capabilities of today's modern circuit breaker technologies is to assign interrupting ratings based on K=1.0.

However, there is nothing "wrong" or "inferior" in any way with circuit breakers that are rated with K-Factors greater than 1.

Illustrated differences

Figures 2, **3**, **4**, and **5** are offered on the following pages to illustrate the differences between the new K=1.0 ratings and the original K>1.0 ratings.

Conclusion

Standards do change, as they take best advantage of the capabilities of improving interrupting technologies; however, the transition does not need to be a cause for concern. One should continue to apply existing circuit breakers with K>1.0 ratings; they should not be superseded by K=1.0 ratings.

Existing traditional ratings continue to be fully acceptable. It is now time to include ratings based on K=1.0 for new circuit breaker designs; however, there is certainly no reason to disregard K>1.0.

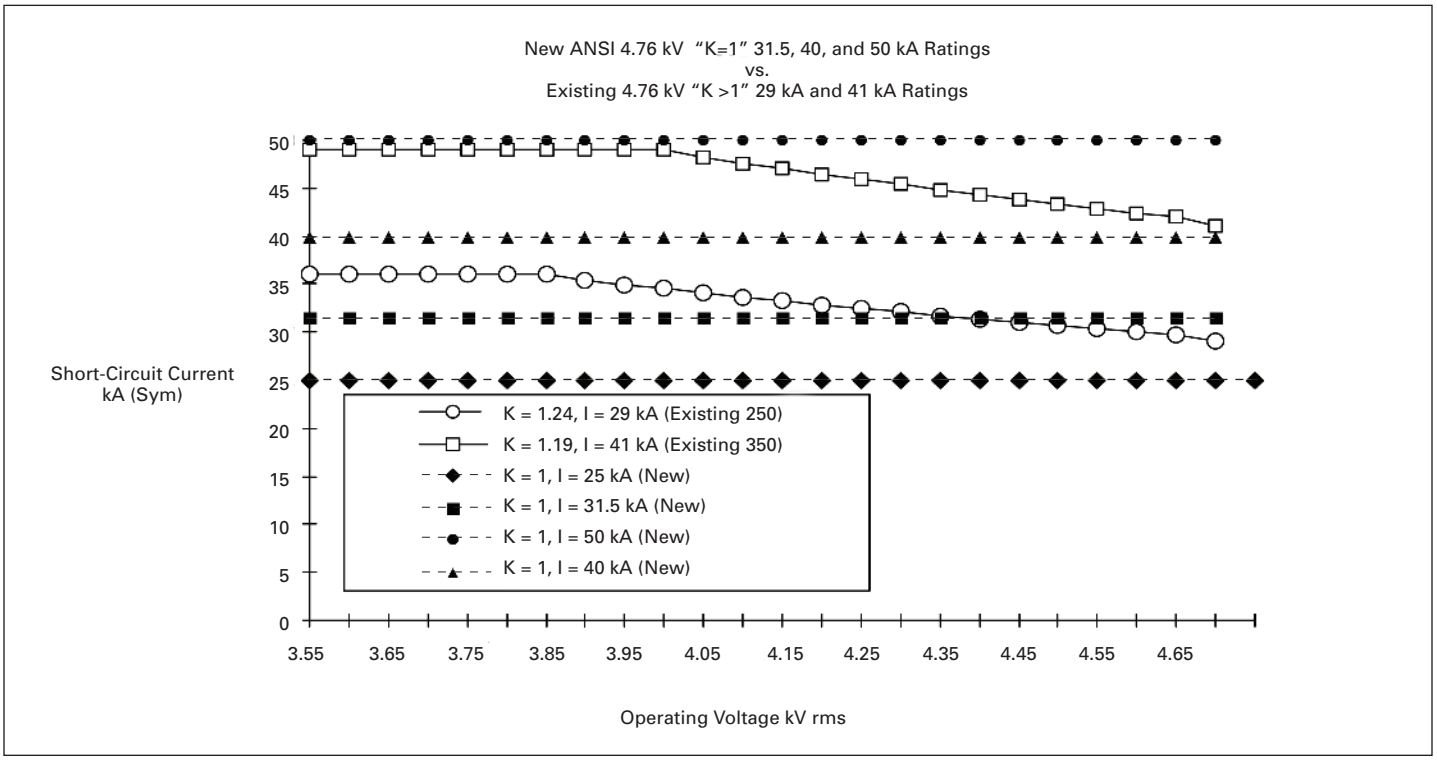

Figure 2. Current vs. Voltage Ratings for 4.76 kV Class

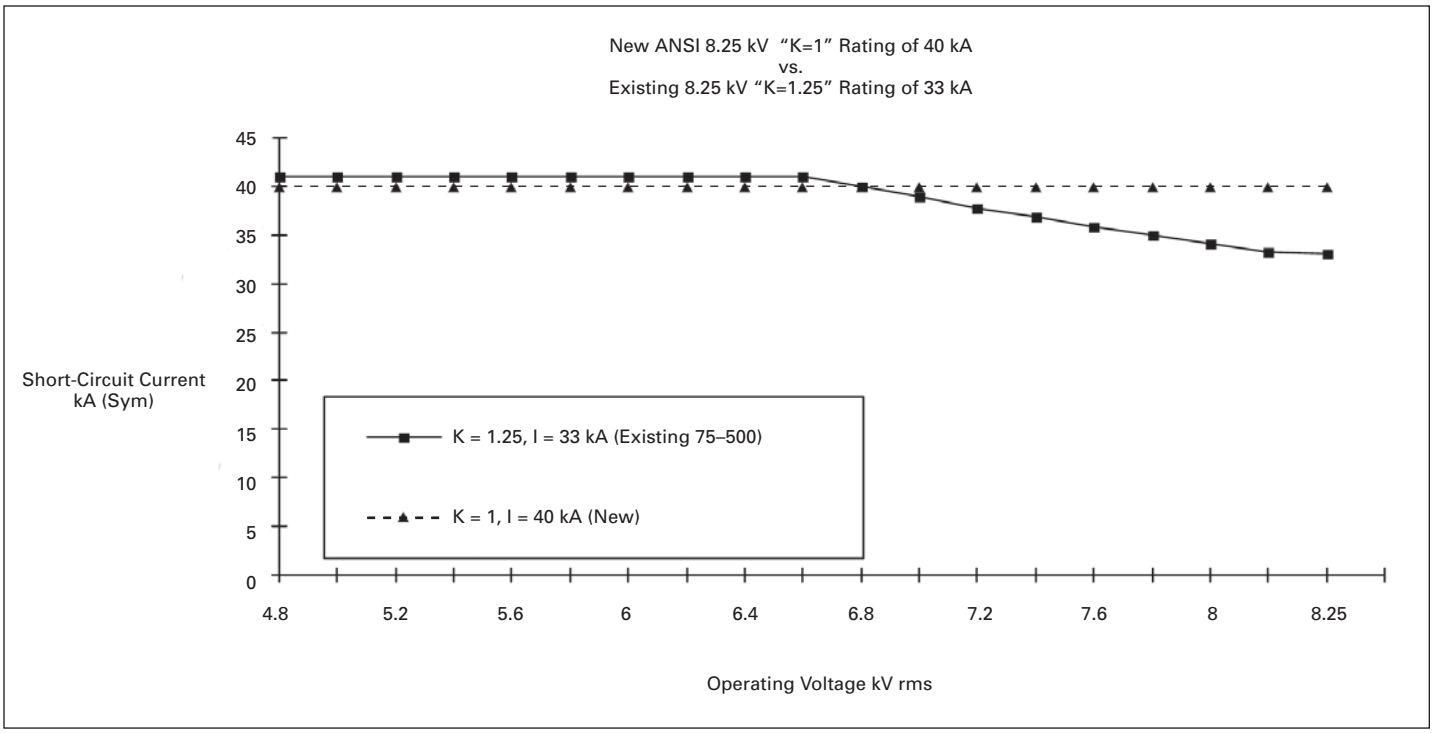

Figure 3. Current vs. Voltage Ratings for 8.25 kV Class

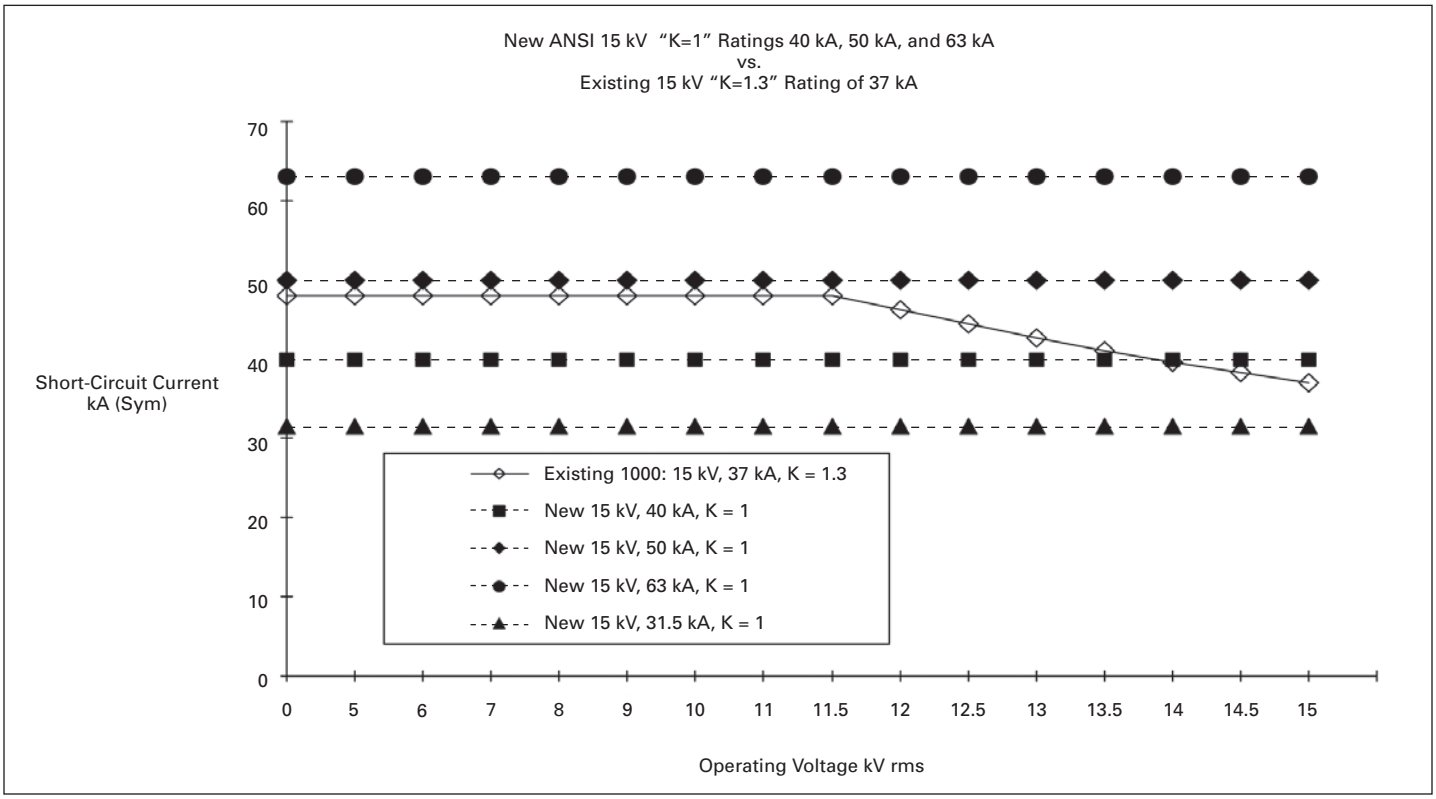

Figure 4. Current vs. Voltage Ratings for 15 kV Class (1000 MVA)

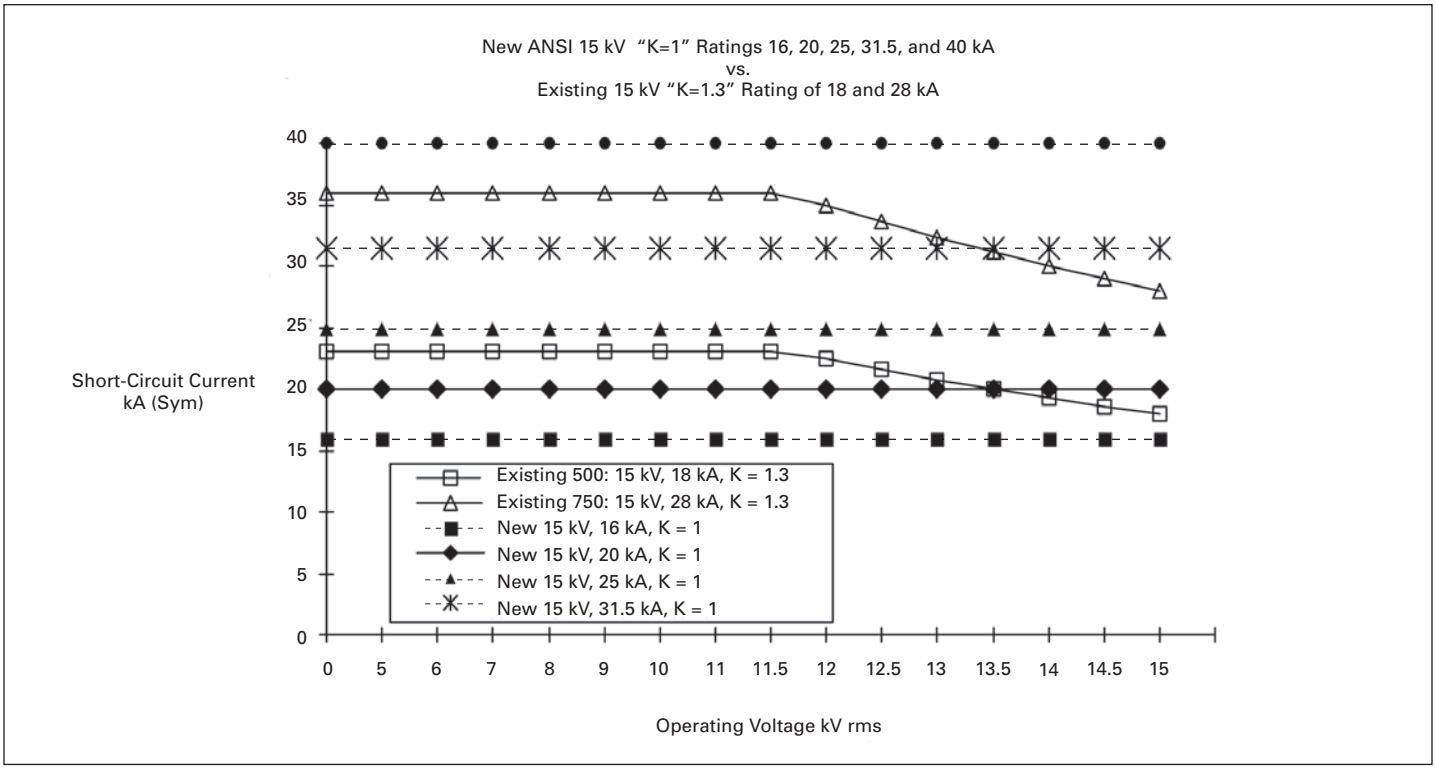

Figure 5. Current vs. Voltage Ratings for 15 kV Class (500/750 MVA)

Table 1. Preferred Ratings for Indoor Circuit Breakers with Voltage Range Factor K=1.0 ①

Line No.	Rated Maximum Voltage 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: Rated Peak Voltage E_2 kV, Peak	Rated Transient Recovery Voltage: Rated Time to Peak T_2 µ Sec	Rated Interrupting Time ms	Maximum Permissible Tripping Time Delay Y Sec	Rated Closing and Latching Current kA, Peak
	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	40.0	8.9	50	83	2	104
3	4.76	1.0	1200, 2000, 3000	50.0	8.9	50	83	2	130
4	8.25	1.0	1200, 2000, 3000	40.0	15.5	60	83	2	104
5	15	1.0	1200, 2000	20.0	28	75	83	2	52
6	15	1.0	1200, 2000	25.0	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	40.0	28	75	83	2	104
9	15	1.0	1200, 2000, 3000	50.0	28	75	83	2	130
10	15	1.0	1200, 2000, 3000	63.0	28	75	83	2	164
11	27	1.0	1200	16.0	51	105	83	2	42
12	27	1.0	1200, 2000	25.0	51	105	83	2	65
13	38	1.0	1200	16.0	71	125	83	2	42
14	38	1.0	1200, 2000	25.0	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	40.0	71	125	83	2	104

① For preferred capacitance current switching ratings, see **Table 1A**.

Notes: For circuit breakers with rated voltage range factor K greater than 1.0, see **Tables A1** and **A1A.**

Table A1. Preferred Ratings for Indoor Circuit Breakers with Voltage Range Factor K>1.0

Line No.	Rated Maximum Voltage kV, rms	Rated Voltage Range Factor K	Rated Continuous Current at 60 Hz Amperes, rms	Rated Short-Circuit Current (at Rated Maximum kV) kA, rms	Transient Recovery Voltage: Rated Time to Point P T_2 µ Sec	Transient Recovery Voltage: Rated R kV/µ Sec	Transient Recovery Voltage: Rated Delay Time T_1 µ Sec	Rated Interrupting Time Cycles	Rated Maximum Voltage Divided by K kV, rms	Maximum Symmetrical Interrupting Capability and Rated Short-Time Current kA, rms	Closing and Latching Capability 2.7 K Times Rated Short-Circuit Current kA, Crest
	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

Table 1A. Preferred Capacitance Current Switching Ratings for Indoor Circuit Breakers with Voltage Range Factor K=1.0 ①

				General Purpose Circuit Breakers		Definite-Purpose Circuit Breakers Back-to-Back Capacitor Switching				
									Rated Inrush Current	
Line No.	Rated Maximum Voltage kV, rms	Rated Continuous Current Amperes, rms	Rated Short-Circuit Current kA, rms	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	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

① For preferred short-circuit ratings, see **Table 1**.

Note: For circuit breakers with rated voltage range factor K greater than 1.0, see **Tables A1** and **A1A.**

Table A1A. Preferred Capacitance Current Switching Ratings for Indoor Circuit Breakers with Voltage Range Factor K>1.0

				General-Purpose Circuit Breakers Rated Capacitance Switching Current		Definite-Purpose Circuit Breakers Rated Capacitance Switching Current				
					Shunt Capacitor Bank or Cable		Shunt Capacitor Bank or Cable			
								Back-to-Back		
									Inrush Current	
Line No.	Rated Maximum Voltage kV, rms	Rated Short-Circuit Current kA, rms	Rated Continuous Current Amperes, rms	Overhead Line Current Amperes, rms	Isolated Current Amperes, rms	Overhead Line Current Amperes, rms	Isolated Current Amperes, rms	Current 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

Authors

R. William Long is a Consultant Engineer at the Eaton Technical Center in Pittsburgh, PA. Bill has more than 35 years of experience in the design, analysis, and testing of medium voltage circuit breakers, and is a member of IEEE®, IEC, and NEMA® Technical Committees for the development of industry standards for MV/HV equipment. He currently serves as Chair of the IEEE HV Circuit Breaker Sub-committee, and Chair of the Generator Breaker Working Group.

James J. Benke, B.S.M.E. (1990)—University of Pittsburgh, PA; MBA (2001) University of Phoenix, Pittsburgh, PA. Jim has more than 15 years of R&D experience in the field of LV/MV circuit breaker development. He is Manager, Fuse/MV Vacuum Circuit Breaker Development at Eaton in Pittsburgh, PA. He is a member of IEEE.

Eaton Corporation
Electrical Sector
1111 Superior Ave.
Cleveland, OH 44114
United States
877-ETN-CARE (877-386-2273)
Eaton.com

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