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kA rated circuit breakers and switchgear

The rating structure for circuit breakers used in metal-clad switchgear underwent major revision with the completion of the new ANSI/IEEE standards in 1999 and 2000. The applicable standards (old and new) are detailed in Table 1.

C37.06-2000 is a minor editorial revision of the 1997 edition. The 1997 edition was published in anticipation of the changes in the ratings that were finally published in the 1999 versions of C37.04, C37.09 and C37.010. Together, these revisions comprise the first major structural change to the circuit breaker rating standards since the change from the total (asymmetrical) current basis of rating to the symmetrical current basis of rating in 1964. C37.06 was revised in 2009 with major organizational and technical changes.

The rating structure introduced in 1964 (and modified in 1979 and again in 1987) recognized the prevalent medium-voltage interruption technology (air magnetic) of the time.

The 1964 rating structure was based on a "constant MVA" interrupting capacity over a defined range of operating voltages. At the maximum design voltage of the air magnetic circuit breaker, the interrupting capacity was limited by the ability of the arc chutes to handle the transient recovery voltage that appears across the circuit breaker contacts following interruption. As the operating voltage was reduced, the interrupting capability of the circuit breaker would increase, as the contacts could cope with higher interrupting currents and transient recovery voltage became less of a concern. Finally, a limit would be approached at which the contacts could not absorb further increases in heat during interruption.

Standard	Previous version	New version	Title
C37.04	1979	1999	Rating structure for AC high-voltage circuit breakers
C37.06	1979 1987	1997 2000 2009	AC high-voltage circuit breakers rated on a symmetrical current basis - preferred ratings and related capabilities
C37.09	1979	1999	Test procedure for AC high-voltage circuit breakers rated on a symmetrical current basis
C37.010	1979	1999	Application guide for AC high-voltage circuit breakers rated on a symmetrical current basis

Table 1: The applicable standards

The maximum design voltage was designated as “V,” and the range over which the interrupting current capability increased as voltage decreased was defined in terms of voltage range factor “K.” The voltage V/K defined the associated lower limit of voltage. In the range of V/K to V, the interrupting current varied so that the product of voltage and interrupting current was a constant value. Stated more simply, the interrupting MVA (interrupting current X voltage X 1.732) was constant over this range. These relationships are summarized in Figure 1.

The “constant MVA” rating structure served the industry, both users and manufacturers, for many years. However, as new interrupting technologies became available, the “constant MVA” relationship became a poor representation of the actual physics of interruption. In particular, one of the desirable characteristics of a vacuum interrupter is the dielectric withstand capability across the open contacts recovers nearly instantaneously following an interruption. The practical effect of this is the interrupting capability of the interrupter does not increase significantly as the operating voltage is decreased from rated maximum design voltage. Relating this fact to the “constant MVA” rating structure, we see the voltage range factor of a vacuum interrupter is essentially equal to 1.0.

This is one of the principle reasons that restructuring of the circuit breaker ratings was undertaken by working groups within IEEE and NEMA over the decade of the 1990s.

Tables 2 and 3 briefly summarize the ratings in the 1987 and 2000 versions of C37.06.

It should be pointed out that the “historic MVA class” included in the 1964 and 1979 versions of ANSI C37.06 (but deleted in the 1987 version) were intended only as convenient labels, not as an arithmetically accurate calculation of the interrupting MVA for a given rating. For example, the calculated MVA interrupting capacity for the 350 “MVA class” is 338 MVA rather than 350 MVA.

TThe table of the new “constant kA” ratings has been kept in the same format as the table for “constant MVA” ratings to facilitate easy comparison. The “MVA class” is no longer relevant. The voltage range factor (K) is also eliminated from the new rating structure, but is shown as K = 1.00 in the new table for comparison.

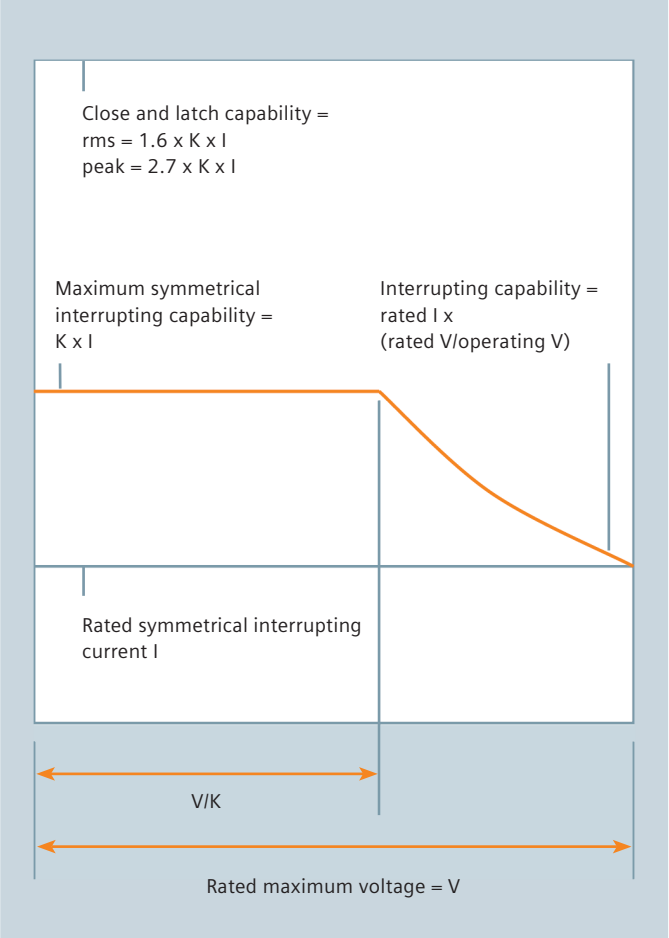
The close and latch ratings have been changed from 2.7 to 2.6 times the maximum symmetrical interrupting capacity (peak amperes) and from 1.6 to 1.55 times the maximum symmetrical interrupting capacity (rms amperes), to correct mathematical errors in earlier standards.

The new rating structure continues the movement towards harmonization of ANSI/IEEE requirements with those of IEC, a process that has been pursued since 1951.

What does this change imply for users of existing equipment rated to the 1987 (or earlier) ratings? Probably very little. There are hundreds of thousands of circuit breakers installed that are rated to the old standards, and it is expected that new circuit breakers and switchgear will be available with the old “constant MVA” ratings for many years. New or replacement circuit breakers with “constant MVA” ratings must continue to be designed, rated and tested to the old standards, as the new standards do not define the full rating structure or test requirements for the “constant MVA” circuit breakers.

Gradually, however, the new “constant kA” circuit breakers and switchgear are becoming more widely used. The use of the “constant kA” ratings simplifies the application of circuit breakers and switchgear, and also more accurately represents the true physics of modern vacuum interruption technology

Figure 1: Relation of interrupting capability, close and latch capability, rated maximum design voltage and rated symmetrical current "constant MVA basis"



Historic "MVA" class	Maximum kV	Rated kA	Maximum kA	Range factor	Continuous current	Dielectric kV		Close and latch kA	
						60 Hz	Impulse BIL	rms 1.6 KI	Peak 2.7 KI
250	4.76	29	36	1.24	1,200 2,000	19	60	58	97
350	4.76	41	49	1.19	1,200 2,000 3,000	19	60	78	132
500	8.25	33	41	1.25	1,200 2,000 3,000	36	95	66	111
500	15.0	18	23	1.30	1,200 2,000	36	95	37	62
750	15.0	28	36	1.30	1,200 2,000 3,000	36	95	58	97
1000	15.0	37	48	1.30	1,200 2,000 3,000	36	95	77	130
1500	38.0	21	35	1.65	1,200 2,000 3,000	80	150	56	95

Table 2: ANSI C37.06-1987 (and 1964 and 1979) circuit breaker ratings ("constant MVA" rating basis)

Historic "MVA" class	Maximum kV	Rated kA	Maximum kA	Range factor	Continuous current	Dielectric kV		Close and latch kA	
						60 Hz	Impulse BIL	rms 1.55 KI	Peak 2.6 KI
Not applicable	4.76	40 50 63	40 50 63	1.00	1,200 2,000 3,000	19	60	62 78 98	104 130 164
Not applicable	8.25	40 50 63	40 50 63	1.00	1,200 2,000 3,000	36	95	62 78 98	104 130 164
Not applicable	15.0	25	25	1.00	1,200 2,000	36	95	39	65
Not applicable	15.0	40 50 63	40 50 63	1.00	1,200 2,000 3,000	36	95	62 78 98	104 130 164
Not applicable	38.0	31.5 40	31.5 40	1.00	1,200 2,000 3,000	80	150	49 62	82 104

Table 3: ANSI/IEEE C37.06-2009 (also 1997 and 2000) circuit breaker ratings ("constant kA" rating basis)

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