TechTopics Topic: Circuit Breaker Ratings – GMI Circuit Breakers

TechTopics No. 4 discussed the changes in the ratings structure for medium voltage circuit breakers used in Metal-Clad Switchgear. This issue of TechTopics includes more detailed versions of the ratings tables for type GMI circuit breakers, both for the "Constant MVA" and the "Constant kA" ratings.

The structure of ratings for these circuit breakers is defined in the following standards:

Standard	"Constant MVA" ratings"	"Constant kA" Ratings	Title
C37.04	1979	1999	Rating Structure for AC High-Voltage Circuit Breakers
C37.06	1979 1987	1997 2000	AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis--Preferred Ratings and Related Required 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

The 1999-2000 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. The 1964 rating structure reflects a "constant MVA" rating basis over a range of operating voltages. At the maximum design voltage, interrupting capacity is limited by the ability of the circuit breaker to withstand the transient recovery voltage across the circuit breaker contacts following interruption. As the operating voltage is reduced, the interrupting capability increases, as the arc chutes can handle the reduced transient recovery voltage. Finally, as voltage is decreased further, a limit is approached at which the contacts can not absorb further increases in heat during interruption. The maximum design voltage was designated as "V", and the range over which the interrupting current capability increases as voltage decreases is defined in terms of voltage range factor "K". The voltage V/K defines the associated lower limit of voltage. In the range of V/K to V, the interrupting current varies so that the product of voltage and interrupting current is a constant. Thus, interrupting MVA is constant over the range from V/K to V.

The "Constant MVA" rating structure does not conform to the physics of modern interrupting techniques. For today's interrupters, the interrupting capability of the interrupter does not increase significantly as the operating voltage is decreased from rated maximum design voltage. The 1999-2000 revisions to the standards recognized this by changing the voltage range factor (K) to equal 1.0, which effectively removes it from the rating structure.

Because there is a huge installed base of circuit breakers that are rated to the old standards, we expect that new circuit breakers and switchgear will be available with the old "Constant MVA" ratings for many years. "Constant MVA" circuit breakers must 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 will become 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 interrupters.

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Type GMI Circuit Breaker Ratings (Historic "Constant MVA" Rating Basis)

These ratings are in accordance with the following standards:

ANSI C37.04-1979	Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
ANSI C37.06-1987	AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis— Preferred Ratings and Related Required Capabilities
ANSI C37.09-1979	Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
ANSI C37.010-1979	Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

	Measured Parameter			Units	Circuit Breaker Type					
					5-GMI-250	5-GMI-350	7-GMI-500	15-GMI-500	15-GMI-750	15-GMI-1000
General	Nominal Voltage Class			kV	4.16	4.16	7.2	13.8	13.8	13.8
	Nominal 3-Phase MVA Class [9]			MVA	250	350	500	500	750	1000
Rated Values	Rated Voltage	Maximum Design Voltage (V) [2]		kV rms	4.76	4.76	8.25	15.0	15.0	15.0
		Voltage Range Factor (K) [3]		----	1.24	1.19	1.25	1.30	1.30	1.30
	Insulation Levels	Withstand Voltage Levels	Power Frequency	kV rms	19	19	36	36	36	36
			Lightning Impulse (BIL)	kV crest	60	60	95	95	95	95
	Rated Current	Continuous [4]		A rms	1200 2000	1200 2000 3000FC 4000FC	1200 2000 3000FC 4000FC	1200 2000	1200 2000 3000FC 4000FC	1200 2000 3000FC 4000FC
		Short-Circuit (at rated maximum design voltage) (I) [5 6 10]		kA rms sym	29	41	33	18	28	37
		Interrupting Time		Cycles	5	5	5	5	5	5
		Permissible Tripping Delay (Y)		Sec	2	2	2	2	2	2
Related Required Capabilities	Current	Rated Maximum Design Voltage (V) divided by K (= V/K)		KV rms	3.85	4.0	6.6	11.5	11.5	11.5
		Max. Sym Interrupting (K x I) [7]		kA rms sym	36	49	41	23	36	48
		Short-Time Current (K x I) (3 seconds)		kA rms	36	49	41	23	36	48
	Closing and Latching (Momentary)	Asymmetrical (1.6 x K x I) [8]		kA rms	58 78 opt[1]	78	66 77 opt[1]	37 58 opt[1]	58 77 opt[1]	77
		Peak (2.7 x K x I) [8]		kA peak	97 132 opt[1]	132	111 130 opt[1]	62 97 opt[1]	97 130 opt[1]	130

Footnotes

1 High close and latch (momentary) rating available for special application

2 Maximum voltage for which the circuit breaker is designed, and the upper limit for operation.

3 K is the ratio of the rated maximum design 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 the operating voltage.

4 3000FC and 4000FC indicates that fan cooling is included in the switchgear structure for these ratings. The circuit breaker for the 3000A rating may be located in the upper cell or in the lower cell of a vertical section. The circuit breaker for the 4000A rating must be located in the upper cell of the vertical section. 4000A rating is not available in outdoor equipment.

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

Required Symmetrical Interrupting Capability = Rated Short-Circuit Current (I) X [(Rated Maximum Design Voltage) / (Operating Voltage)]

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

6 Within the limitations stated in ANSI C37.04-1979, all values apply to polyphase and line-to-line faults. For single phase-to-ground faults, the specific conditions stated in clause 5.10.2.3 of ANSI C37.04-1979 apply.

7 Current values in this row are not to be exceeded even for operating voltage below 1/K times rated maximum design voltage. For operating voltages between rated maximum design voltage and 1/K times rated maximum design voltage, follow footnote 5 above.

8 Current values in this row are independent of operating voltage up to and including rated maximum design voltage.

9 "Nominal 3-Phase MVA Class" is included for reference only – this information is not listed in ANSI C37.06-1987.

10 Standard duty cycle is CO – 15s – CO

Type GMI Circuit Breaker Ratings (New "Constant kA" Rating Basis)

These ratings are in accordance with the following standards:

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

Rated Values		Units	Circuit Breaker Type								
			5-GMI-31	5-GMI-40	5-GMI-50	7-GMI-40	15-GMI-20	15-GMI-25	15-GMI-31	15-GMI-40	15-GMI-50
Maximum Design Voltage (V) [1]		kV rms	4.76	4.76	4.76	8.25	15.0	15.0	15.0	15.0	15.0
Voltage Range Factor (K) [2]		----	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Withstand Voltage Levels	Power Frequency	kV rms	19	19	19	36	36	36	36	36	36
	Lightning Impulse (BIL)	kV crest	60	60	60	95	95	95	95	95	95
Continuous [3]		A rms	1200 2000	1200 2000 3000FC 4000FC	1200 2000 3000FC 4000FC	1200 2000 3000FC 4000FC	1200 2000	1200 2000	1200 2000	1200 2000 3000FC 4000FC	1200 2000 3000FC 4000FC
Short-Circuit (I) [4] [5]		kA rms sym	31.5	40	50	40	20	25	31.5	40	50
Interrupting Time		ms Cycles	83 5	83 5	83 5	83 5	83 5	83 5	83 5	83 5	83 5
Permissible Tripping Delay (Y)		Sec	2	2	2	2	2	2	2	2	2
Max. Sym Interrupting (I)		kA rms sym	31.5	40	50	40	20	25	31.5	40	50
% dc Component		%	47	47	47	47	47	47	47	47	47
Short-Time Current (I) (3 seconds)		kA rms	31.5	40	50	40	20	25	31.5	40	50
Closing & Latching (Momentary) Asymmetrical (1.55 x I)		kA rms	49	62	78	62	31	39	49	62	78
Closing & Latching (Momentary) Peak (2.6 x I)		kA peak	82	104	130	104	52	65	82	104	130

Footnotes

1 Maximum voltage for which the circuit breaker is designed, and the upper limit for operation.

2 K is listed for informational purposes only. For circuit breakers rated on a "kA basis", the Voltage Range Factor is 1.0.

3 3000FC and 4000FC indicates that fan cooling is included in the switchgear structure for these ratings. The circuit breaker for the 3000A rating may be located in the upper cell or in the lower cell of a vertical section. The circuit breaker for the 4000A rating must be located in the upper cell of the vertical section. 4000A rating is not available in outdoor equipment.

4 All values apply to polyphase and line-to-line faults.

5 Standard duty cycle is O – 0.3s – CO – 15s – CO.