TechTopics No. 23
Circuit breaker ratings - type 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:

<table>
<thead>
<tr>
<th>Standard</th>
<th>&quot;Constant MVA&quot; ratings</th>
<th>&quot;Constant kA&quot; ratings</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI/IEEE C37.04</td>
<td>1979</td>
<td>1999</td>
<td>Rating structure for AC high-voltage circuit breakers</td>
</tr>
<tr>
<td>ANSI C37.06</td>
<td>1979</td>
<td>1997</td>
<td>AC high-voltage circuit breakers rated on a symmetrical current basis--preferred ratings and related required capabilities</td>
</tr>
<tr>
<td>ANSI/IEEE C37.09</td>
<td>1979</td>
<td>1999</td>
<td>Test procedure for AC high-voltage circuit breakers rated on a symmetrical current basis</td>
</tr>
<tr>
<td>ANSI/IEEE C37.010</td>
<td>1979</td>
<td>1999</td>
<td>Application guide for AC high-voltage circuit breakers rated on a symmetrical current basis</td>
</tr>
</tbody>
</table>

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" ratings basis over a range of operating voltages, and reflects the air-magnetic interruption technology then common. 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 air-magnetic arc chutes can more readily handle the reduced transient recovery voltage.

Finally, as voltage is decreased further, a limit is approached at which the contacts cannot absorb further increases in heat during interruption. The maximum design voltage was designated as "V," and the range (the "constant MVA" region) 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 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 vacuum interrupters, the interrupting capability of the vacuum 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.
Type GMI circuit breaker ratings (historic “constant MVA” rating basis)

These ratings are in accordance with the following standards:
- ANSI/IEEE C37.04-1999 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/IEEE C37.09-1979 standard test procedure for AC high-voltage circuit breakers rated on a symmetrical current basis
- ANSI/IEEE C37.010-1999 application guide for AC high-voltage circuit breakers rated on a symmetrical current basis

<table>
<thead>
<tr>
<th>Measured parameter</th>
<th>Units</th>
<th>Circuit breaker type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5- GMI-250</td>
</tr>
<tr>
<td>General</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal voltage class</td>
<td>kV</td>
<td>4.16</td>
</tr>
<tr>
<td>Nominal 3-phase MVA class</td>
<td>MVA</td>
<td>250</td>
</tr>
<tr>
<td>Rated voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum design voltage (V)</td>
<td>kV rms</td>
<td>4.76</td>
</tr>
<tr>
<td>Voltage range factor (K)</td>
<td></td>
<td>1.24</td>
</tr>
<tr>
<td>Rated current</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>A rms</td>
<td>1,200</td>
</tr>
<tr>
<td>Short-circuit (at rated maximum design voltage) (I)</td>
<td>kA rms sym</td>
<td>29</td>
</tr>
<tr>
<td>Interrupting time</td>
<td>Cycles</td>
<td>5</td>
</tr>
<tr>
<td>Permissible tripping delay (Y)</td>
<td>Sec</td>
<td>2</td>
</tr>
<tr>
<td>Rated required capabilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated maximum design voltage (V) divided by K (=V/K)</td>
<td>KV rms</td>
<td>3.85</td>
</tr>
<tr>
<td>Max. sym interrupting (K x I)</td>
<td>KA rms sym</td>
<td>36</td>
</tr>
<tr>
<td>Short-time current (K x I) (three seconds)</td>
<td>kA rms</td>
<td>36</td>
</tr>
<tr>
<td>Closing and latching (momentary)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asymmetrical (1.6 x K x I)</td>
<td>kA rms</td>
<td>58</td>
</tr>
<tr>
<td>Peak (2.7 x K x I)</td>
<td>kA peak</td>
<td>97</td>
</tr>
</tbody>
</table>

Footnotes:
1 High closing and latching (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 4,000FC indicates that fan cooling is included in the switchgear structure for this rating. The circuit breaker for the 3,000 A rating may be located in the upper cell or in the lower cell of a vertical section. The circuit breaker for the 4,000 A rating must be located in the upper cell of the vertical section. 4,000 A rating is not available in outdoor equipment. Some models use fan cooling for 3,000 A.
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/IEEE 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/IEEE 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 – 15 s – CO.
Type GMI circuit breaker ratings (new “constant kA” rating basis)

These ratings are in accordance with the following standards:
- ANSI/IEEE C37.04-1999 standard rating structure for AC high-voltage circuit breakers
- ANSI/IEEE C37.06-2009 AC high-voltage circuit breakers rated on a symmetrical current basis – preferred ratings and related required capabilities
- ANSI/IEEE C37.09-1999 standard test procedure for AC high-voltage circuit breakers rated on a symmetrical current basis
- ANSI/IEEE C37.010-1999 application guide for AC high-voltage circuit breakers rated on a symmetrical current basis

<table>
<thead>
<tr>
<th>Rated values</th>
<th>Units</th>
<th>Circuit breaker type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum design voltage (V)</td>
<td>kV rms</td>
<td>4.76</td>
</tr>
<tr>
<td>Voltage range factor (K)</td>
<td>-----</td>
<td>1.0</td>
</tr>
<tr>
<td>Withstand voltage levels</td>
<td>Power frequency</td>
<td>kV rms</td>
</tr>
<tr>
<td></td>
<td>Lightning impulse (BIL)</td>
<td>kV crest</td>
</tr>
<tr>
<td>Continuous</td>
<td>A rms</td>
<td>1,200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-circuit (I)</td>
<td>kA rms sym</td>
<td>31.5</td>
</tr>
<tr>
<td>Interrupting time</td>
<td>ms cycles</td>
<td>83</td>
</tr>
<tr>
<td>Permissible tripping delay (Y)</td>
<td>Sec</td>
<td>2</td>
</tr>
<tr>
<td>Max. sym interrupting (I)</td>
<td>kA rms sym</td>
<td>31.5</td>
</tr>
<tr>
<td>% dc component</td>
<td>%</td>
<td>47</td>
</tr>
<tr>
<td>Short-time current (I) (three seconds)</td>
<td>kA rms</td>
<td>31.5</td>
</tr>
<tr>
<td>Closing and latching (momentary) asymmetrical (1.55 x I)</td>
<td>kA rms</td>
<td>49</td>
</tr>
<tr>
<td>Closing and latching (momentary) peak (2.6 x I)</td>
<td>kA peak</td>
<td>82</td>
</tr>
</tbody>
</table>

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 4,000FC indicates that fan cooling is included in the switchgear structure for this rating. The circuit breaker for the 3,000 A rating may be located in the upper cell or in the lower cell of a vertical section. The circuit breaker for the 4,000 A rating must be located in the upper cell of the vertical section. 4,000 A rating is not available in outdoor equipment. Some models use fan cooling for 3,000 A.
4 All values apply to polyphase and line-to-line faults.
5 Standard duty cycle is O – 0.3 s – CO – 15 s – CO.