

TechTopics No. 06

Three-cycle versus five-cycle interrupting time

This issue of TechTopics discusses the rated interrupting time for circuit breakers used in metal-clad switchgear. Historically, ANSI/IEEE C37.04 (1979 or earlier) characterized circuit breakers with interrupting time classes, such as three cycle, five cycle and eight cycle. These classes always were rather gross approximations, because they made no allowance for production variations, and also because the rated interrupting time could be exceeded by up to 50 percent under certain conditions. Further, a circuit breaker that was just slightly in excess of one rating class would fall into the next higher (longer) class, giving the impression of a radical change in performance that does not necessarily reflect reality. Thus, there is a need to establish some facts pertinent to discussion of three-cycle versus five-cycle circuit breakers.

ANSI/IEEE standards no longer establish three-cycle and five-cycle classes, nor do they give assumed values for "contact-part time" associated with a particular interrupting time. Instead, rated interrupting time is now stated in terms of absolute time in milliseconds.

ANSI/IEEE C37.04-1999, clause 5.6 defines "rated interrupting time" as "the maximum permissible interval between the energizing of the trip circuit at rated control voltage and rated operating pressure for mechanical operation, and the interruption of the current in the main circuit in all poles."

This definition makes it clear that the rating must consider the 'worst-case' conditions for all variables. Thus, it must consider the longest arc duration under the most onerous conditions. Of equal importance, it must consider the longest opening time (including worst case production variations).

For Siemens type GMI, SDV and GMSG circuit breakers, the average arcing time is approximately 9 ms, which is representative of a very large number of interrupting tests in the short-circuit test laboratory. The longest arcing time observed during testing is typically 17 ms, which occurs on tests with maximum offset asymmetrical current interruptions. The latter are tests specifically intended to explore the outer limits of interrupting performance.

In accordance with ANSI/IEEE C37.09-1999, tests must explore both the shortest possible arcing time and the longest possible arcing time.

The longest possible arcing time results when contact part occurs just prior to a current zero that precedes a minor loop of current. Because the first current zero occurs in a fraction of a millisecond after contact part, and the second current zero occurs only a short time later (perhaps 1 ms to 2 ms), the interruption does not take place until the current zero that ends the major loop of current.

As stated, the purpose of these tests is to expose the circuit breaker to the worst conceivable set of circumstances, so as to establish that under this most extreme condition the circuit breaker successfully interrupts. These worst-case conditions rarely occur in actual installations.

Type GMI circuit breakers

For Siemens type GMI circuit breakers, the relevant data is detailed in Table 1.

If ANSI/IEEE C37.04 based rated interrupting time on nominal opening time and average arcing duration, our type GMI circuit breakers would be rated 42 ms (2.5 cycles). However, C37.04 states the rating has to be based on the worst-case conditions, which means that the type GMI circuit breakers are rated 58 ms (3.5 cycles). Actual interrupting times on production circuit breakers could range from 42 ms (25 ms opening time + 17 ms arcing duration) to 58 ms (41 ms opening time + 17 ms arcing duration), using the worst case arcing duration.

What does this mean to a user with respect to application of the circuit breakers? Basically, nothing. The reason for this relates to the way circuit breakers are tested in the short-circuit test laboratory. When circuit breakers are tested for short-circuit performance, they are tested to a philosophy that is completely reversed from the manner in which they are rated.

For ratings, the circuit breakers are rated in accordance with the worst-case (longest) times. For testing, actual test parameters are set up based on the worst-case short-circuit conditions, which means the shortest possible times.

What does this mean for the GMI circuit breaker? Using the data in Table 1, the circuit breaker is tested as though it is the fastest circuit breaker, for example, with the shortest opening time. Therefore, the short-circuit conditions are set up in the laboratory to expose the circuit breaker to the conditions that would occur if (for the GMI circuit breaker) it had an opening time of 25 ms. Therefore, the circuit breaker is tested as though it was a historic three-cycle circuit breaker (1.5-cycle contact part time in terms of C37.04-1979, clause 5.10.2.2).

The result is that the type GMI circuit breaker has the interrupting capability of a three-cycle circuit breaker, even though we must rate it as a five-cycle circuit breaker.

If you consider only the nominal value for operating time (33 ms opening) and worst-case arcing time (17 ms arcing), the circuit breaker is a three-cycle circuit breaker. However, under the limits of production tolerances, it varies between 2.5 cycles and 3.5 cycles. Since ANSI/IEEE uses the "maximum permissible interval," it's a five-cycle circuit breaker (since a 3.5-cycle class doesn't exist).

Type GMSG circuit breakers

For type GMSG circuit breakers, two rated interrupting times are offered: 83 ms (five cycles) and 50 ms (three cycles). The data for type GMSG (five-cycle) circuit breakers is the same as shown in table 1. For type GMSG (three-cycle) circuit breakers, the data is as shown in table 2.

Description	Average time	Range of values
Opening time	33 ms	25 ms to 41 ms
Arcing duration	9 ms	2 ms to 17 ms
Interrupting time	42 ms	27 ms to 58 ms

Table 1: Type GMI circuit breakers (also type GMSG (five-cycle) circuit breakers)

Description	Average time	Range of values
Opening time	29 ms	25 ms to 33 ms
Arcing duration	9 ms	2 ms to 17 ms
Interrupting time	38 ms	27 ms to 50 ms

Table 2: Type GMSG (three-cycle) circuit breakers

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Siemens Industry, Inc.
7000 Siemens Road
Wendell, NC 27591

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For more information, contact: +1 (800) 347-6659

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