

TechTopics No. 29

Derating factors for reclosing service

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Most Siemens vacuum circuit breakers are suitable for multiple-shot reclosing duty. Applications on overhead utility distribution circuits very often involve reclosing. For such circuits, experience suggests that many faults are of a temporary nature, as when phase lines blow together, tree limbs fall on two phase lines, or when animals bridge the gap from one phase to another or to ground. When this occurs, an overcurrent will result, which should be detected by protective relays. When the voltage source is removed, the lines have an opportunity to fall clear of each other, or the tree limb may fall away from the lines. Then, after the ionized gas in the vicinity of the fault location has been allowed to dissipate, it may be possible to successfully re-energize the line.

The rated duty cycle for circuit breakers has traditionally been CO – 15 s – CO, or two close-open operations separated by a 15-second interval of zero current. This duty cycle existed until the approval of ANSI/IEEE C37.04-1999. At that time, the standard duty cycle for reclosing service became O – 0.3 s – CO – 3 min – CO, or an instantaneous (actually, 0.3 s) reclosure followed by a second reclosure after a three-minute interval. With the change of standard duty cycles, the recommendations of the standards changed with respect to the degree of derating required for reclosing duty.

In the 1979 edition of ANSI/IEEE C37.04, the interrupting capability of the circuit breaker is derated for reclosing duty in accordance with the following:

- A derating factor (“d”, in percent) is calculated according to the interrupting capability of the circuit breaker at the rated system voltage. For a historic “constant MVA” rated circuit breaker (refer to TechTopics No. 4 and No. 23), the interrupting capability increases as the system voltage is reduced, until it reaches a maximum at V/K or below. The derating factor “d” is equal to the calculated interrupting capability at the system voltage, divided by six. Thus, for a nominal 500 MVA “constant MVA” circuit breaker (rated 18 kA at 15.0 kV, K factor = 1.3, V/K = 11.5), the calculated interrupting capability at 12.0 kV would be 22.5 kA, so that “d” would be 3.75 percent.
- The interrupting capability is derated by “d” for each interruption operation over two in a reclosing cycle.
- A reclosing cycle consists of all interruptions that occur within a 15-minute time period.
- The interrupting capability is derated by a fraction of “d” to the extent that any reclosing operation occurs in less than 15 seconds after the preceding interruption. Thus, an instantaneous reclosure would cause derating of $[(15-0)/(15)] \times “d” = “d”$ percent. Similarly, a reclosing operation with 10-second delay would involve derating of $[(15-10)/15] \times “d” = 0.333 “d”$ percent.

Answers for infrastructure.

- A reclosing cycle cannot include more than five opening operations.

For example, suppose we have a 500 MVA “constant MVA” circuit breaker, applied at 12.0 kV, in the following reclosing cycle:

O – 0.3 s – CO – 10 s – CO – 2 min – CO

For this condition, the calculated interrupting capability at 12.0 kV is 22.5 kA and “d” is 3.75 percent. The total derating adjustment would be as follows:

- Total interruptions equals four, less the standard capability of two interruptions, which gives an “excess” of two. Thus, derating for total interruptions is two “d” percent.
- The first reclose is an instantaneous (essentially zero) operation, for which the derating is $[(15-0)/(15)] \times “d” =$ one “d” percent.
- The second reclose has a 10-second delay, for which the derating is $[(15-10)/15] \times “d” = 0.333 “d”$ percent.
- The third reclose has a two-minute delay, so no derating for a “fast” operation is needed.
- The total derating required is $[2.00 + 1.00 + 0.33] [0.0375] = [3.33] [0.0375] = 0.125$, or 12.5 percent.
- The interrupting capability of the circuit breaker, adjusted to reflect the actual reclosing duty cycle, is $22.5 \text{ kA} \times 0.875 = 19.7 \text{ kA}$.

The preceding discussion describes the calculation of interrupting capability for reclosing duty, which is contained in ANSI/IEEE C37.04-1979. During the discussions that took place while the 1999 revisions of the standards were being discussed, it was recognized that the 1979 standards reflected the physics of historic (air-magnetic and oil) interruption technologies. Modern vacuum interrupters have capabilities well beyond those of the historic technologies. As a result, the calculation of derated interrupting capacity for reclosing duty for vacuum interrupters was eliminated in the 1999 edition of the applicable document (ANSI/IEEE C37.010). Thus, the user may now apply circuit breakers to reclosing duty without consideration of derating for either the number of interruptions in the reclosing cycle, or for “fast” operations.

It should be noted that the actual capabilities of the circuit breakers cannot be tested in the short-circuit laboratory to the extreme limits, because of limitations involved with short-circuit testing. Most short-circuit laboratories use a short-circuit generator as the source of fault current. The short-circuit generator is connected to the power system, and brought up to the desired speed. Then, it is disconnected from the power system, and the rotating inertia provides the motive power when the short-circuit is imposed. As a result of the short-circuit, the generator slows down, so that less inertia is available for a second short-circuit.

Most laboratories can adjust the machine to accommodate two opening operations in rapid sequence, but generally, a significantly longer time is required if a third or subsequent fault operation is required. This longer time is required so the generator can be reconnected to the power system, brought back up to speed, and then disconnected in advance of the short-circuit operation.

Because it is not possible to completely validate the approach in the 1999 edition of ANSI/IEEE C37.010, we favor a more conservative approach as in ANSI/IEEE C37.04-1979. Since ANSI/IEEE C37.010-1999 is an Application Guide, rather than a Standard, it is a matter of engineering judgement to be exercised by the user in determining the degree of adjustment (if any) applied to interrupting capacity under reclosing duty.

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