SIEMENS

TechTopics No. 112

Use of R-rated fuses in lieu of E-rated fuses for transformers

TechTopics No. 58 discussed the differences between E-rated fuses and R-rated fuses in general terms. R-rated fuses are designed primarily to provide motor protection, while E-rated fuses are designed primarily to provide transformer protection. The difference in the load served (motor or transformer) results in differences in the shape of the time current curves.

In the application of current-limiting fuses to NEMA E2 combination medium-voltage controllers, Siemens prefers to provide R-rated fuses for motor protection and E-rated fuses for transformer protection. However, a number of factors must be considered in selecting a fuse for the application, of which the major issues are continuous current-carrying capability, fuse let-through current, and coordination with the load characteristics.

Of particular interest is the let-through current of the fuse. Due to design differences, the let-through currents of R-rated and E-rated fuses of comparable continuous current may be quite different. The let-through current of the fuse must be no higher than the demonstrated peak withstand of the contactor proven during the design interrupting tests conducted to fulfill the requirements of UL 347, "Standard for Medium-Voltage AC Contactors, Controllers, and Control Centers". This determines maximum fuse sizes for a particular type of fuse, R-rated or E-rated, which can be used in combination with the controller.

For example, consider two fuses of essentially equal continuous current capability, a 24R fuse and a 450E fuse. Both fuses are capable of 450 A when tested in open air (to the fuse standards) and must be reduced in capacity by 20 percent for use inside a medium-voltage controller unit (to allow for the higher ambient temperature inside the enclosure). Therefore, inside the enclosure, both fuses are capable of 450 x 0.80 = 360 A.

However, using 50 kA symmetrical system short-circuit capacity, the 24R fuse has a let-through current of 47 kA whereas the 450E fuse has a let-through current of 78 kA. The 24R fuse falls within the proven peak withstand of the contactor, whereas the 450E fuse considerably exceeds it.

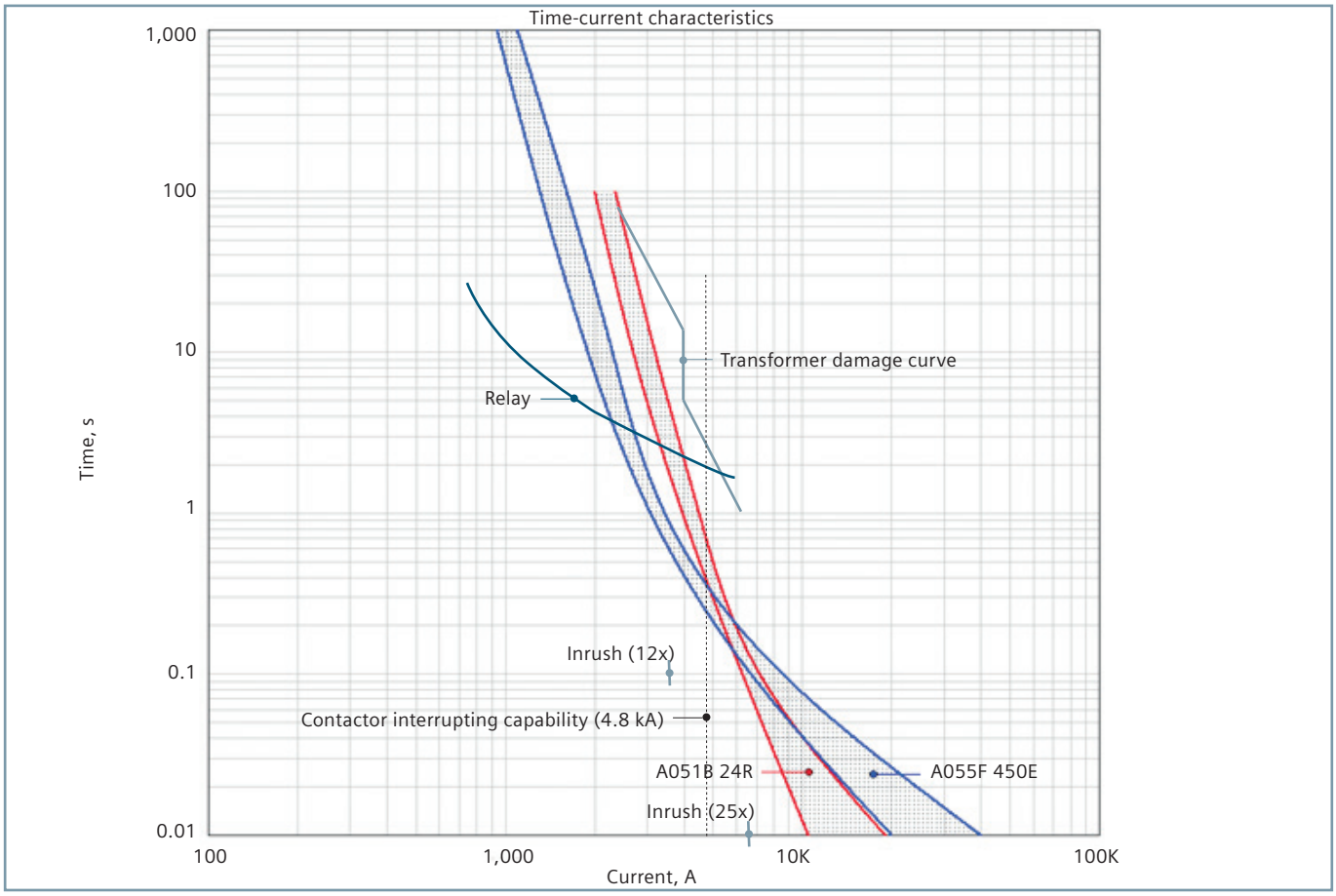
When fuse is applied to protection of a transformer, a number of key elements should be considered:

- The transformer inrush current on energizing, usually considered as 12 times self-cooled FLA current at 0.1 s, and 25 times FLA current at 0.01 s
- The transformer damage curve, obtained from IEEE Std C57.109 (for liquid-filled transformers) or IEEE Std C57.12.59 (for dry-type transformers)
- The overcurrent relay protective settings
- The maximum (unfused) interrupting capacity of the contactor
- The peak let-through current of the current-limiting fuse at the system short-circuit current level.

Consider the following example:

- Liquid-filled transformer, 2000 kVA, with 4160 V primary, 278 A FLA, and impedance of 6 percent.
- Transformer inrush, 12 times (3,336 A) for 0.1 s, 25 times (6,950 A) for 0.01 s
- Fuse characteristics for a 24R fuse and for a 450E fuse
- Contactor interrupting capacity (unfused) of 4.8 kA
- Overcurrent relay, Siemens 7SJ62, very inverse, time pickup 360 A, time dial 15.

The resulting time current curve, showing both the 24R and the 450E fuse characteristics, is as follows:



In this time-current coordination curve, either the 450E fuse or the 24R fuse is seen, in combination with appropriate settings of the overcurrent relay, to provide proper protection of the transformer. In particular, note the following:

- The fuse curve lies to the left of the transformer damage curve, as does the protective relay characteristic curve.
- The fuse allows the transformer inrush current (both the 12 times and the 25 times values) without resulting in nuisance fuse operation.
- The protective relay allows the fuses to interrupt the current for fault values exceeding 4.0 kA (below the unfused interrupting capacity of the contactor, 4.8 kA).

This example illustrates that proper protection of the transformer and coordinated overcurrent operation of the class E2 medium-voltage controller can be achieved with either R-rated or E-rated current-limiting fuses.

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

Subject to change without prior notice.
Order No.: IC1000-F320-A269-X-4A00

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

www.usa.siemens.com/techtopics