Introduction
Following up the previous issue of Tech Spec on feeder tap rules, this issue will focus on the protection of transformer secondary tap conductors. With transformer secondary conductors, it is important to realize that typically transformer secondary conductors are “tap conductors”. This is because overcurrent protection is often not provided on the transformer secondary terminals. In addition, the provisions of 240.21(C)(1), protection by primary overcurrent device, are typically not met. 240.21(C)(1) does not require secondary overcurrent protection for single-phase 2-wire or three-phase 3-wire, delta-delta transformers, since protection is effectively provided by the primary overcurrent device if:

- The transformer primary side is protected in accordance with 450.3
- The fuses or circuit breakers on the primary of the transformer does not exceed the ampacity of the secondary conductor multiplied by the secondary to primary voltage ratio

Thus, in most cases, the provisions of 240.21(C)(2), transformer secondary conductors not over 10 feet or 240.21(C)(6), transformer secondary conductors not over 25 feet must be met. Regardless of which rule is used, besides the tap conductor rules, short-circuit protection of the transformer secondary conductors should be analyzed.

Transformer Tap Conductors – 240.21(C)(2)
240.21(C)(2) permits fuses or circuit breakers not to be required on the secondary of a transformer if secondary conductors are not over 10 feet long and:

- Secondary conductor ampacity is not less than the combined computed loads, and
- Secondary conductor ampacity is not less than the rating of the device they supply or the rating of the fuses or circuit breakers at their termination, and
- Secondary conductors do not extend beyond the enclosure of the equipment they supply, and
- Secondary conductors are enclosed in a raceway.

Figure 1 illustrates an example that meets the requirements of 240.21(C)(2). Notice that termination in an overcurrent device is not necessarily required, however, in most cases, this will terminate in a panelboard that will require a main overcurrent protective device. In addition, it is useful to analyze for short-circuit protection of the conductors.

Transformer Primary
Fuse sized per 450.3 (70A)

45 KVA Transformer
3Φ, (delta-wye)
480V to 120/208V

Secondary conductor:
10 ft in length, enclosed
in raceway, 3 AWG,
75°C, Cu (100A ampacity)

100A, 208/120V
Panelboard w/ 100A Main
Computed Loads = 80A
Complies with 408.16(A)

Per ICEA, the 3 AWG conductor can withstand 21,579 amps for 1 cycle. This would represent a current of 9,351 amps on the primary (21,579 X 208/480).

Thus, if a fault were to occur in the secondary conductor and generated more than 21,579 amps on the secondary (or more than 9,351 amps on the primary) and the primary overcurrent device took 1 cycle or longer, damage to the insulation of the secondary conductor could occur. However, in this example, given the small transformer size, it would be difficult for the available fault current on the secondary side of the transformer to reach this fault current level.

Transformer Tap Conductors – 240.21(C)(6)
240.21(C)(6) permits fuses or circuit breakers on the secondary of a transformer to provide conductor protection where the length of the secondary conductors does not exceed 25 ft and complies with all of the following.

- Secondary conductors have an ampacity that, when multiplied by the ratio of the secondary-to-primary voltage, is at least 1/3 the rating of the transformer primary overcurrent protective device, and
- Secondary conductors terminate in a single set of fuses or circuit breaker that limit the load current to not more than the conductor ampacity permitted by 310.15, and
- Secondary conductors are suitably protected from physical damage.
Figure 2 illustrates an example that meets the requirements of 240.21(C)(6).

Notice this requires the secondary tap conductors to be terminated in a single set of fuses or circuit breakers. Once again, we should analyze the secondary conductors for short circuit protection.

In this case the secondary conductor is a 6 AWG conductor. Per ICEA, the 6 AWG conductor can withstand 10,761 amps for 1 cycle. This would represent a current of 4,663 amps on the primary (10,761 X 208/480).

Thus, if a fault were to occur in the secondary conductor and generated more than 10,761 amps on the secondary (or more than 4,663 amps on the primary) and the primary overcurrent device took 1 cycle or longer, damage to the insulation of the secondary conductor could occur.

This fault current level may be more attainable, especially with a low impedance transformer. In this case a current-limiting overcurrent protective device may be needed. If the primary overcurrent protective device was a Bussmann LPS-RK LOW-PEAK® Fuse, it would reduce a fault current of 12,000 amps on the secondary (5,200 amps on the primary) to a value of 4,615 amps on the secondary (2,000 amps on the primary).

Conclusions
Transformer secondary conductors are often considered "tap conductors". Most often, transformer secondary conductors are protected in accordance with 240.21(C)(2) or 240.21(C)(6). Regardless of which requirement is met, short-circuit protection of transformer secondary conductors should be explored.

For more information on transformer tap conductor rules, see the Bussmann NE02 (p. 27-28) at:
http://www.bussmann.com/library/docs/NE02.pdf

Register for the Bussmann® Industrial & Commercial Power System Seminar on Overcurrent Protection
October 23-24. Seminar is in St Louis and includes demonstrations in our high power test lab. 1.6 CEUs will be offered for attending the seminar.
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