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TechTopics No. 94

Circuit breaker interlocking and operating requirements

When manufacturers and specifiers discuss circuit breaker operational and interlocking requirements, several terms are used repeatedly. Despite the common use of these terms, it seems clear that many persons do not understand what these terms imply or require. This issue of TechTopics is intended to discuss several of the frequently used but often misunderstood terms.

First, the terms that apply to all medium-voltage circuit breakers will be discussed, whether stationary mounted (as in outdoor distribution type circuit breakers) or drawout mounted (as in metal-clad switchgear).

Trip-free

IEEE C37.04 for medium-voltage circuit breakers requires that they be trip-free, which is a condition in which the mechanism is designed such that the tripping or opening function takes precedence over the closing function. The requirements as elaborated in the standard are:

- If a closing operation is in progress, and a tripping signal (either mechanical or electrical) is received, the circuit breaker shall react as follows:
    - If the closing signal and the tripping signal are initiated simultaneously, the circuit breaker contacts are permitted to close or touch momentarily before opening.
    - If the closing signal is initiated before the tripping signal is initiated, the circuit breaker contacts are permitted to close or touch momentarily before opening.
    - If the trip circuit uses circuit breaker auxiliary switch contacts (52a contacts, closed when the circuit breaker is closed) or other equivalent contacts, the trip coil of the circuit breaker cannot be energized until these contacts in the trip circuit are made. Therefore, the circuit breaker main contacts are permitted to close or touch momentarily before opening.
    - If the tripping command is initiated mechanically (manually) and held in the actuated position before a closing signal (whether electrical or mechanical) is applied, the circuit breaker main contacts are not permitted to close, even momentarily. If the mechanism design requires, the circuit breaker may discharge stored energy but the main contacts are not permitted to move more that 10 percent of the open gap distance. The dielectric withstand capability of the open gap shall not be reduced, and the main contacts shall assume the fully open position.

Trip-free is a requirement of all medium-voltage circuit breakers, whether stationary mounted or drawout mounted.

Trip-free is an important safety feature, as it assures that the decision to open a circuit breaker dominates over the command to close. Further, and probably most important, if there were no trip-free functional requirement, it would not be possible to lock a circuit breaker open (fundamental to lockout-tagout procedures) when performing maintenance.

Anti-pump

IEEE C37.11 for circuit breaker control circuits requires the anti-pump function. This requires that when an electrical closing command is issued, only a single closing operation results. This is normally accomplished by incorporating an anti-pump relay in the close circuit. The anti-pump relay is energized at the same time that the close signal is applied. The anti-pump relay is connected so that it seals in as long as the close signal is maintained. The anti-pump relay, when sealed in, opens a contact in the close circuit.

Thus, the circuit breaker closes, but if the close signal is maintained, the close circuit has an open contact in the circuit, preventing further close operations as long as the close signal is maintained.

The anti-pump function is a very important feature of control circuits. Without the anti-pump function, if the user connected a maintained contact in the close circuit, and the circuit breaker were closed into a fault current, the protective relays would cause an immediate trip action, but the maintained contact in the close circuit would initiate closing (again) into the fault. This process is called "pumping", and would lead to ultimate catastrophic failure of some element in the system, perhaps the conductors leading to the fault, perhaps the circuit breaker, or elsewhere in the system. Therefore, anti-pump is one of the fundamental requirements for every medium-voltage circuit breaker.

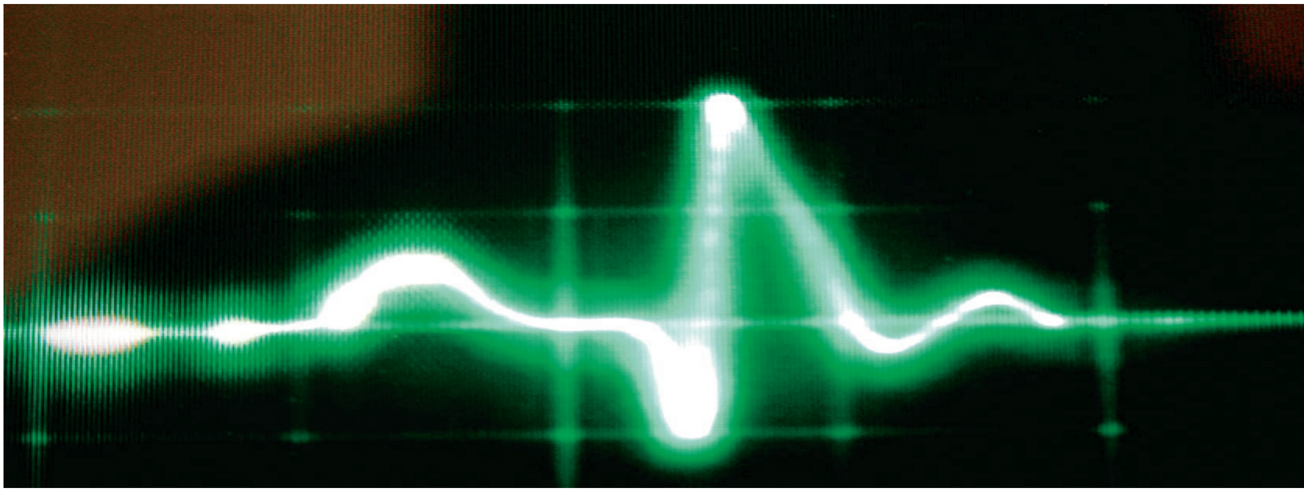
Note that the anti-pump function is reset if the control power supply is removed for some reason. When this happens, the anti-pump relay contact in the close circuit closes to complete the close circuit. Then, if a maintained contact in the user's control circuit is closed, and the control power is restored, the circuit breaker will close. However, after this initial close operation, the anti-pump relay will be sealed in, and further closing operations will be prevented until the maintained contact is opened or the control power supply is interrupted.

This illustrates that a maintained contact should never be used in a close circuit.

Drawout circuit breaker interlocks

Drawout circuit breakers must have interlocks for the following:

- To prevent moving the circuit breaker between the TEST position and the CONNECTED position while the circuit breaker is closed.
- To prevent closing of the circuit breaker while the circuit breaker is at a position between the TEST position and the CONNECTED position.
- To positively secure the circuit breaker in the TEST position and in the CONNECTED position, as well as in the DISCONNECTED position. While this requirement applies to the three defined positions, most modern designs positively secure the circuit breaker both in these three positions, and also between these positions.
- The mechanism must prevent closing of the circuit breaker unless the mechanism has full energy (stored energy) to complete the closing operation. This applies whether the energy stored is in a spring system, or is in a magnetic actuator type of operating mechanism.
- The mechanism shall provide protection against accidental discharge of stored energy during maintenance activities. This may be accomplished in any of several ways:
  - The mechanism may be designed to prevent withdrawal of the circuit breaker from the circuit breaker compartment with the stored-energy (spring) mechanism charged. Typically, with a design of this type, the user must initiate a closing operation manually in the DISCONNECT position in the circuit breaker cell (as control power is not connected in the disconnect position), followed by a manual trip operation to open the circuit breaker. This discharges the closing energy prior to withdrawing the circuit breaker from the circuit breaker compartment.
  - The mechanism may be designed such that closing cannot be performed when the circuit breaker is removed from the circuit breaker compartment. This is usually described as a "blocked closing" condition.
  - The mechanism may be designed such that, before the circuit breaker is removed from the compartment, the closing energy is automatically discharged from the stored-energy mechanism.



This latter item is most commonly referred to as the “spring dump” function. Of the three allowable methods of preventing accidental discharge of stored-energy (prevent withdrawal, block closing, and spring dump), only the last (spring dump) is automatic. The others require that the operator either perform actions in a particular sequence (for the prevent withdrawal type), or apply special tools or procedures when performing maintenance (for the block closing type).

The other interlocks required for drawout type circuit breakers are relatively simple to understand, so are not discussed in detail.

We hope this discussion of the interlocks required for circuit breakers is useful. For those wishing further knowledge, the reader should consult the relevant standards, including:

- IEEE C37.04-1999, Standard Rating Structure for AC High-Voltage Circuit Breakers (clause 6.9).
- IEEE C37.11-1997, Standard Requirements for Electrical Control for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (clause 3).
- IEEE C37.20.2-1999, Standard for Metal-Clad Switchgear (clause 7.10).

It should be noted that all three of these standards are in the process of revision, and the next edition of C37.11 is expected to be approved by the IEEE-SA Standards Board in 2013. Thus, the reader should always consult the latest approved revision of any standard.

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