Critical Incident Energy Reduction through Arc Flash Hazard Mitigation

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Incident Energy Reduction

Incident energy is directly proportional to the total arcing time. Because of this, most strategies for arc flash hazard mitigation focus on faster detection and clearing of the arc flash. The two main components of this time are the protection relay and the circuit breaker interrupting times. The total arcing time is the sum of the relay operating time and the breaker interrupting time. It is very important to keep the arcing time as short as possible.

Faster Circuit Breakers

ANSI Standard C37.06-2000, titled "AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis-Preferred Ratings and Related Required Capabilities", lists the preferred interrupting times for indoor circuit breakers as 83 ms (5 cycles). However, new switchgear breakers may actually be significantly faster than this. Circuit breakers using magnetic actuators have typical operating times of 3 cycles or less.

Circuit breakers employing the newest magnetic actuator technology also have far fewer moving parts than traditional spring mechanisms, typically less than 10 percent of their conventional spring mechanism counterparts. Some are also rated for 10 times the mechanical switching requirements of ANSI Standards. Not only are these breakers faster, their maintenance intervals can be extended and their interrupting times are less likely to degrade over time.

Older air magnetic circuit breakers typically have a rated interrupting time of 8 cycles but that may have been achievable only when they were in new, pristine condition. Over time, their interrupting time has likely degraded depending on the level and frequency of maintenance that has been performed.

Replacing or retrofitting older switchgear with new technology breakers can usually reduce the circuit breaker operating times by 40 percent or more.

Faster Protective Relaying

Installing faster relaying is another way to reduce the arcing time. It is generally a much more cost-effective approach to reducing arc flash hazards than replacing costly circuit breakers. The most commonly used protective relays today are bus differential (ANSI device 87), instantaneous overcurrent (ANSI device 50) and time-overcurrent (ANSI device 51) relays.

Bus differential protection is fairly fast with a typical operating time of 1-2 cycles but the cost of implementation is expensive because dedicated current transformers must be installed on every circuit connected to the bus. Bus differential protection also does not protect against arc flashes in the feeder cable compartments because faults in these areas are outside the bus differential zone. Another concern is the close-in external feeder fault. In this scenario, the total fault current flows through one CT, significantly increasing the chances of severe CT saturation and possible mis-operation due to false differential current.

Instantaneous overcurrent protection operates with no intentional time delay. Although not actually instantaneous, it is fairly fast with a typical operating time of 1-2 cycles. In microprocessor relays, this time consists of the processing time (sampling, filtering, calculation of RMS values etc.) plus the time required to close the physical tripping contacts. Interestingly, instantaneous overcurrent relays based on older solid-state or electromechanical technology may actually be slightly faster than ones using newer microprocessor technology.

Instantaneous overcurrent protection is also relatively inexpensive. However, it is usually impossible to set instantaneous elements low enough to provide meaningful arc flash protection without compromising coordination with downstream relays. One solution to this dilemma is to install a zone interlock scheme as described previously. More commonly used in low voltage switchgear, the zone interlock scheme uses a communication network to block bus protection relays from tripping when any of the downstream feeder protection relays sense a fault.

Time-overcurrent protection is also inexpensive but very slow since it intentionally adds time delay to coordinate with downstream feeder protection. Operating times can range from a few cycles to more than a second depending on system coordination requirements. Where time-overcurrent protection is being used for primary bus protection, incident energies can be extremely high and very dangerous hazard levels are likely to be present.

The fastest arc flash detection system currently available is one based on optical arc flash detection. The optical arc flash detection relay has a typical operating time of 2.5 milliseconds (0.15 cycle), making it far faster than any of the conventional current-based schemes described above. Moreover, its operating time is largely independent of the fault current magnitude since the low-level fault detector elements are only used to supervise the optical system. With optical arc flash protection installed, the relay operating time is essentially negligible compared to the circuit breaker operating time. Cost is fairly low since current transformers are only needed on the main breaker(s). Moreover, the feeder cable compartments can also be protected, providing complete coverage of all switchgear compartments.