Protecting Personnel From Arc Flash With Time-Delay Switching

by Glenn T. Keates, PE, and Justin S. Weinberg, EIT

National Fire Protection Association (NFPA) Standard 70E-2009 requires protection of electrical personnel against the hazards of arc flash. When applied to existing low-voltage installations, this standard can make areas previously considered safe "non-approachable." Louvers, grates, and other ventilation openings in the housings of certain switchgear commonly used in factories, office buildings, etc., tend to raise the risk level to the standard's Category 4 or higher.

This case study deals with such a problem at the Michigan headquarters of a major health-care insurer. Hired by the insurer to find a cost-effective solution, we conducted a study of this facility's short-circuit device coordination and arc flash/shock hazard and found its service-entrance equipment to be "non-approachable" with respect to the NFPA standard.

The Problem: "Non-Approachable" Circuit Breakers

Since the energy released by an arc flash can be high enough to vaporize metal, some such events have been known to spew molten metal and hot gases, ultimately destroying the equipment.

In general, arc flash hazard is abated by de-energizing the electrical equipment involved. The ideal solution is to design the equipment to reduce the risk from the outset.

Over the years, NFPA standards have required equipment warning labels as well as guidance for work practices, calculating danger zones, and other preventive measures in the ongoing quest to minimize the risk of arc-flash injury.

Circuit breakers are complex mechanical devices that can, without warning, come apart violently upon failure. Rodent infestation, contamination, and other such anomalies can lead to a breaker failure and produce an arc flash event. As defined in the literature, an arc flash event can occur when there are "exposed, live parts." In this case, the exposed parts are circuit breakers that are visible through expanded-metal ventilation louvers.

The equipment in question is a double-ended, 480Y/277-volt substation in a "main-tie-main" configuration, fed by a 2000kVA transformer. The available three-phase fault current was calculated to be 42,712 amperes sym. The main breaker is 4000 amperes with the long time setting of 1.00. As a point of reference, the breakers in question are General Electric models TC-4000 and 4040 Power Break with GE MicroVersaTrip™ RMS-9 trip units. Using the calculation method described in IEEE 1584-2002, we found that an energy level greater than 40.00 cal/cm2 could be experienced during an arc flash event. Under Table 130.7(C)(10) of NFPA 70E-2009, this made the equipment "non-approachable."

Proposed Solutions:

After reviewing the conclusions of our study, the healthcare insurer requested that this situation be mitigated to achieve an NFPA 70E Category 2 environment or better. Among the measures we considered were the following:

New switchgear: This would have cost considerably more than the healthcare insurer wished to spend.

The addition of an instantaneous element on the main breaker: This would have reduced the energy levels on the tie breaker and main bus, but not on the line sides of the main breakers. Nuisance tripping was also a concern, so the plan was discarded.

Differential protection: The use of overlapping bus differential protection was reviewed and found to be a viable solution, on the basis that an arc flash event would result in a differential operation. Differential relays would be installed to monitor the currents flowing into and out of the bus. Under normal conditions, the two currents would be equal, but if a fault occurred at the bus these relays would sense the imbalance and send a trip signal to the breaker. The cost of this option was prohibitive, however.

Arc flash/photo-optic relays: With this solution, photo-optic sensors coupled with a conventional instantaneous over-current element would detect an arc flash as it occurred and would trip the corresponding breakers. Once again, the cost to implement this solution was greater than the amount budgeted for the project.

Remote switching: This option involved the installation of a remote switching panel located outside the switchgear room. Due to the costs of running the control cables, connecting the fabrication, and securing the cabinet in what would have been a public space, the idea was rejected.

We then explored less expensive alternatives. These included the use of mechanical remote operators, placed over the handles of existing switches and operated by wire from a distance when an arc flash is anticipated. This idea was rejected for two reasons: 1) The concern that in the heat of the moment these switches would not be used; and 2) The fact that they were not easily adaptable to the existing switches.

A Unique, Cost-Effective Solution

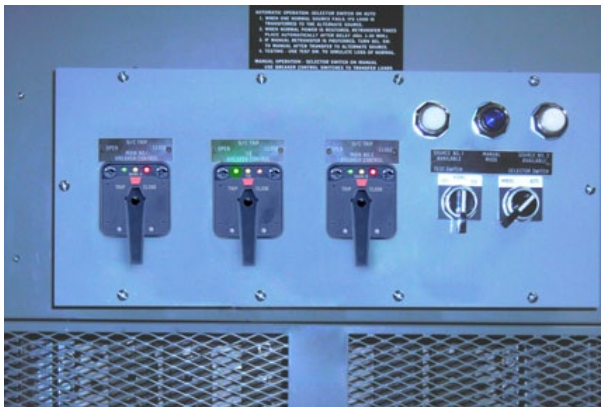
The idea of using a permanent time-delay switch was then raised. Although it would not lower the risk category as originally planned, it would render the safety issue moot, since it would allow the operator to be out of the room when the breaker actually closed or opened. Another advantage was that it would not be in the tripping (protective) portion of the circuit.

All agreed the unit should be a utility-grade product. The first relays we considered under these criteria were too large; they would have either taken up too much space in the switchgear or required a separate panel and associated conduit and control wires.

We then evaluated the Electroswitch Time Delay Control Switch Relay (Model TD-CSR) and found it to have the following advantages:

a) It is a utility-grade switch with built-in time delay;
b) It is suitable for permanent installation;
c) It allows a manually initiated time-delayed trip or close operation with a flashing LED that warns the operator to evacuate the arc flash area. The unit delays a trip or close operation for 10 seconds following initiation, with an option to easily cancel the pending operation. To prevent inadvertent operation, buttons must be depressed for 4 continuous seconds to activate the 10-second delay. (Other settings are available.)
d) Its intuitive pushbutton design simplifies personnel training;
e) No special wiring is required for installation;
f) Its reliable, self-cleaning, double-wiping contacts with silver or silver alloy surfaces provide very low contact resistance;
g) Its rugged, screw-type terminals are rated for 30A/600V continuous current;
h) It would replace some existing "low-end" switches with higher quality, more reliable switches.

Electroswitch TD-CSR Time Delay Control Switch Relay


Electroswitch TD-CSR Time Delay Control Switch Relay

With all these features in its favor, the TD-CSR was chosen as the solution by both management and the technical crew. Shortly thereafter, the new panel containing the Electroswitch TD-CSR was successfully tested in the Dymax Engineering shop in nearby Ann Arbor. During a scheduled downtime, it was installed and successfully tested on site in August of 2010. It has been in service since then.

Conclusion

When a "non-approachable" arc-flash situation was discovered at the headquarters of a major health insurer, the engineering firm hired to assess and remedy the problem recommended a unique application of a utility-grade device. The time-delay switch not only provided a cost-effective solution, but also required no change to the facility's existing relay protection.

Glenn T. Keates, PE, is Chief Engineer and Justin Weinberg, EIT, is an Electrical Engineer at Dymax Engineering in Ann Arbor, Michigan.

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For more information on the Electroswitch TD-CSR, visit: www.electroswitch.com/TD-CSR or e-mail: info@electroswitch.com.