Application Paper
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FP-4000 and FP-5000 control applied to arc flash hazard risk reduction

Introduction

Research on arc flash phenomena and the resultant risk on workers of energized electrical equipment are on the rise. The use of certain features of protective devices can help in the quest to protect our workers.

The National Fire Protection Association (NFPA®) and the Institute of Electrical and Electronics Engineers, Inc. (IEEE®) agreed on September 13, 2004 to join forces on an initiative to support research on arc flash phenomena. On October 8, 2004, Weyerhaeuser (one of the largest forest products companies) and Eaton Corporation (diversified industrial manufacturer) agreed to have Eaton Corporation perform arc flash surveys at a number of the Weyerhaeuser facilities. These are just two examples of recent articles found from a simple Web search on the topic of arc flash. There are many more articles, papers, and seminars available, as the hazard is so potentially harmful to not only an individual or the electrical equipment being worked on, but also the companies involved.

This paper seeks to explain the potential hazards involved, some of the industry standards written, and an application of a protective device and a control scheme to reduce the arc flash hazard.

Background information

What is arc flash? According to the NFPA, the developer of the NFPA70E, the standard for Electrical Safety in the Workplace, 2004 Edition, an arc flash can be defined as "an electric current that passes through air when insulation or isolation between electrified conductors is no longer sufficient to withstand the applied voltage. The flash is immediate, but the results of these incidents can cause severe injury including burns."

How is this different from a bolted fault? Bolted fault current results from phase conductors becoming solidly connected together, causing large amounts of short-circuit current to flow through two or more phase conductors. Arc fault current results from phase conductors making less than solid contact, causing a necessary arc to sustain the current flow through the loose connection. Usually, the air is the conductor during an arc fault. Depending on the arc impedance, the arc current may be as low as several amperes or as high as 20–40 percent of a three-phase, bolted short-circuit current. Because typical arc fault currents are less than the currents involved in a bolted fault, the conventionally configured overcurrent protective functions for a bolted fault may not be effective for an arc fault.

Although the cause of the short-circuit current normally burns away, the resultant arc fault is sustained and conducts as much energy as is available depending on the impedance of the arc. As a result, a delay or failure to clear an arc fault could result in damage to personnel or equipment. Reported resultant damage ranges from structural building damage to personnel eardrum rupture, blindness, or even death. It is these results that have caused the heightened awareness of arc fault.

Protection standards

How do we protect our personnel and equipment? The only true safe way would be to de-energize equipment before approaching it for opening or for maintenance. Because this is typically not practical, companies must find other ways. Using some standards created and new technology in protective devices there are ways to help reduce the risk of the arc flash hazard via the use of protective devices and a selector switch.

Following the guidelines of the IEEE 1584, a company should perform a short-circuit analysis, as would typically be done to properly set protective relays. In addition to calculating the bolted fault current, the potential arc fault current should be calculated (using the established IEEE 1584 formula for calculating [estimating] the arc fault current). Taking these values, relay coordination studies can then be performed.

Risk reduction via a protective relay

Today's protective relay devices, such as Eaton's FP-4000 and FP-5000, are equipped with four independent protection setting groups. This allows a user to configure each group of protection settings for a different application. Additionally, the FP-4000 and FP-5000 are equipped with eight optically isolated inputs that may be configured for custom logic applications. Connecting the source voltage to the appropriate terminal on the terminal block activates these contact inputs. Using these two features together, a simple control system can be created to change the active setting group (from standard to arc fault) when personnel are planning on working with energized switchboards, panelboards, or motor control centers. The use of a keyed selector switch and other accessories will be required for this application.

The following is an example scenario: Company A has just finished performing their short-circuit analysis. They use this information in preparation for setting their protective devices (in this case, the FP-4000 and FP-5000) for fault coordination of feeder and main breakers. Using the IEEE 1584 spreadsheets, they also determine the minimum and maximum potential arc fault currents. Once all calculations are made and protective settings are selected based on the calculated bolted fault and arc fault currents, the logic is then ready to be selected.

Setting group 2 (arc fault settings/maintenance mode) to contact input 7 (as an example). See **Table 1** below.

Table 1. Logic Settings for FP-4000 or FP-5000 Contact Inputs 7 and 8

Description	Contact Input 7	Contact Input 8
Setting	Setting group 2 (arc fault setting/maintenance mode) active	Setting group 1 (standard settings/normal mode) active
Selector switch position	Position "1"	Position "12"

Externally wire contact Input 7 to position "1" of a keyed selector switch labeled arc fault settings/maintenance mode. See **Table 2**, **Table 3** and **Figure 1**.

Table 2. Three-Position Selector Switch (Position "11"; Spring Return to Position "12")

Contact	Contact Block	Position "11" Test Light	Position "12" Normal	Position "1" Maintenance
1–2	Bottom block upper contact	X	0	0
3–4	Bottom block lower contact	0	0	X
5–6	Top block upper contact	X	0	0
7–8	Top block lower contact	0	0	X

Table 3. Bill of Material

Description	Part Number
Three-position selector switch, spring return from the left	**10250T1333** (Quantity 1)
Padlock hasp or flip-up guard	**10250TA38** (Quantity 1)
2NO contact block	**12250T2E** (Quantity 2)
120 Vac full voltage blue LED ①	**10250T197LLP2A** (Quantity 1)

① Change light to appropriate control power, 120 Vac shown.

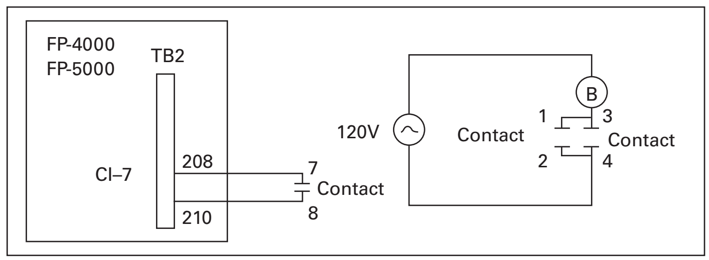

Figure 1. Selector Switch Wiring to Contact Input 7 of the FP-4000 or FP-5000 and Blue Light Indicating Maintenance Mode

Therefore, when the selector switch is in position "12," Standard Settings will be in place. When the selector switch is in position "1," Arc Fault Settings will be in place. Thus, when personnel approach the switchgear for maintenance, they will (with authorization, of course) switch the selector switch to Maintenance Mode, enabling the more sensitive settings based on arc fault.

Conclusion

In summary, there is a growing concern for arc flash hazards and numerous industry standards developed to address these hazards and to help protect unsuspecting personnel. Not only are the standards committees involved, but many manufacturers of electrical equipment are also doing their part to protect the unsuspecting personnel. This paper explained one method to enhance your protective relay system coordination and maintenance procedures to protect personnel when performing maintenance on energized switchboards, panelboards, and/or motor control centers.

Additional information

FP-5000—Please see **TD02602003E** and **IL17569C**.

FP-4000—Please see **TD02602007E** and **IL02602003E**.

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