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Reducing Arc Flash Risk with Protective Relay

The exposure to an increasingly higher arc flash incident energy fault to technicians operating on low and medium voltage switching equipment is a daily hazard in the workplace. While Personal Protective Equipment (PPE) protects for first and second degrees burns, it does not provide sufficient protection for the impact and forces that a high incident energy arcing fault produces and the associated gases released. Therefore, reduction of the incident energy of the arcing fault is required to improve worker safety.

NFPA 70E defines flash hazard as a dangerous condition associated with the release of energy caused by an electric arc, which occurs due to a short circuit where the fault current is traveling through ionized air. As ionized air provides high resistance path to the conduction of electricity, current flow could be as low as 43% of the bolted three-phase short circuit fault on 480 V buses. Due to long clearing of arcing fault, the resultant intense heat, flying debris or shrapnel, projected molten cooper and gases released from an arcing fault produces a great amount of arc flash byproduct. Faster clearing of an arcing fault reduces caloric energy that is produced, consequently, the less molten material, shrapnel, and gases released.

Applying a modern protection relay protection system with adjustable settings, multiple levels of protection, control, and communication function of the relays can substantially reduce arc flash (AF) incidence. The protection engineer must perform a systemic review of the electrical system to identify normal operation and switching operation, so that arc flash energy and protection level can be identified for each modes of operation. In a typical plant, the power system is normally operated with the tie circuit breakers open, except during switching operations. As a result, arch flash level is higher during the switching operation and AF labels need to be designed to indicate these different operating conditions.

The most important factor that can be controlled is the time-current characteristics of the system protective devices through selecting different curves and settings to reduce the time to clear the arcing fault. Relay adjustment settings are as follows:

a) Pickup: the minimum current at which a device actuates. Lower pickup provides arc fault protection for a greater range of fault currents.
b) Time delay setting: Shorter time delay reduces time to trip and lowers I^2t.
c) Instantaneous pickup: Operating time is typically the minimum possible for the circuit being protected. Lower instantaneous pickup settings reduce arc flash hazard.
d) Coordination Time Intervals: Tightening up coordination time intervals is a direct and simple way of reducing tripping times and thus reducing t for any given current.

Most engineers and many software programs use a 0.3-s minimum coordination time interval between tripping characteristics of series-overcurrent devices; this time interval can be safely reduced to 0.25 sec [1] when using digital protective devices if very specific testing and analysis are performed.

Adjustment of protection settings require that a protection engineer perform short circuit study, coordination study, and modify the settings to achieve lowest AF energy level possible without compromising selectivity. When designed properly, microprocessor based protective relays provide the means to accelerate the extinction of the arc produced by short circuits where the air is the conducting medium.

Appropriate PPE and increasing the distance of personnel from the electrical switchgear are the first line of defense to protect the people from hazardous risks; however, a well maintained electrical system, proper coordination studies and modern protective relays are the perfect companion for a safe working environment.

[1] Leoni, A.R. and Bowen, J., “Improving Safety and Reliability Via Cost-Effective Upgrades of Existing Systems”. IEEE Transactions on Industry Applications, Vol. 43, No.1 Jan/Feb 2007.

[2] IEEE 1584-2002, IEEE Guide for performing Arc-Flash hazard calculations.

[3] Standard for Electrical Safety in the Workplace, NFPA 70E, National Fire Protection Association, 2004.