

Arc Flash Energy Reduction – Part 2 – *A Short Trip Time is Your Friend!*

This is part 2 of a two-part article on how to reduce arc flash energy. IEEE Guide 1584-2002 and NFPA 70E have equations that you can use to calculate the arc flash energy and boundary. The arc flash energy calculations are based upon several variables which are listed in order of importance:

1. **Working Distance** (Distance from the Arc to the Torso)
2. **Bolted Arc Three Phase Fault Current** (Typically 80 to 100% if three phase bolted fault current)
3. Upstream Protective Device **Opening (tripping) Time**.
4. **Voltage**
5. **Bus Bar Spacing** (Gap)

The two items that significantly impact the arc flash energy calculations are *Working Distance* and *Protective Device Opening Times*. These also happen to be the things that you can easily control. The fault current cannot easily be reduced or controlled in a distribution system. The fault current is based upon the utility or owner step down transformer size and impedance, utility primary fault current, and sizes/lengths of the conductors.

Protective Device Opening Times

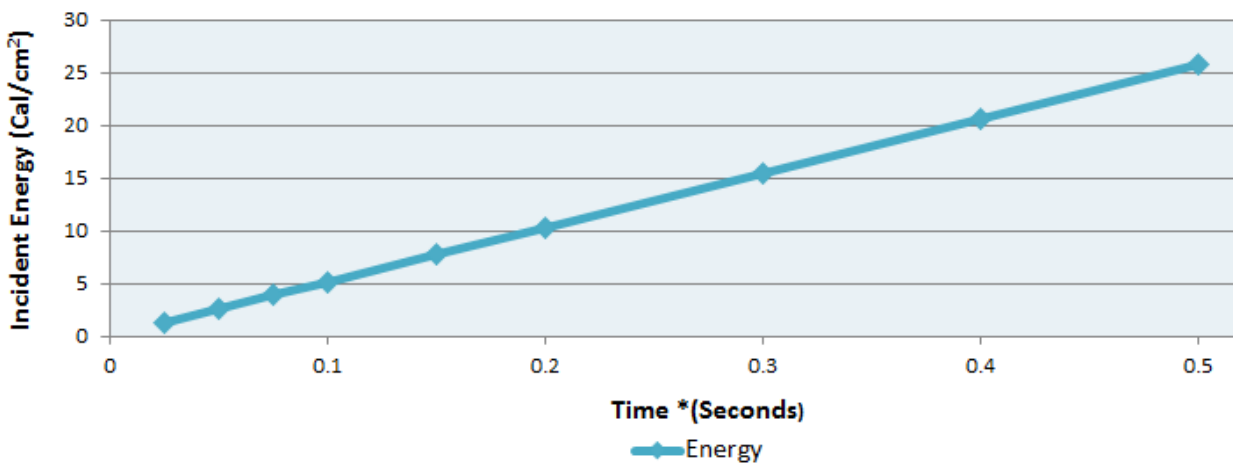
The upstream protective device operating/trip time has a large impact on the arc flash energy. Just a few tenths of a second delay can greatly increase the arc flash energy. The graph below shows the arc flash energy level versus protective device tripping time at 480 Volts. The available fault current is fixed at 30,000 Amperes and the working time is fixed at 18 inches. It can be seen from the graph that when the breaker is tripping instantaneously, then the arc flash energy is less than one Cal/cm². However, if the tripping time is increased to 0.1 seconds, the energy jumps to 5 Cal/cm². It can be seen from the graph, small increases in trip time has a large impact on the arc flash energy.

The relay or breaker tripping time can be decreased by changing the trip unit settings. Another method of reducing the trip times is by installing equipment that will detect faults and arc flashes quickly and send a trip signal to the upstream breaker. Below are some methods to reduce the tripping times.

- Temporarily reduce the breaker instantaneous setting of thermal/magnetic and solid state breakers that have no ARM feature.
- Specify that new breakers must have an Arc Flash Reduction Mode (ARM) switch
- On existing power circuit breakers, retrofit the breaker and install a new trip unit with an ARM switch.

- Specify that new switchboards and switchgear have breakers with zone interlock trip unit systems.
- Where possible, install differential relaying on low and medium voltage switchgear, which will quickly detect a fault within a zone and send a trip signal to the upstream breaker.
- Install arc flash optic detection relays.
- Install Medium Voltage Controllable Fuses with arc flash optic detection relays.
- Retrofit or Specify Medium Voltage Electronic Relays with Group Setting Feature.

Time vs. Incident Energy (Fault Current Constant @ 30 kA)



Reducing Breaker Settings without ARM Function

Arc Flash energy can be reduced by reducing the trip time. The upstream protective device trip units can be temporarily reduced. When energized work or trouble shooting will be performed downstream from the breaker, you can temporarily reduce the instantaneous settings. Many larger molded case thermal magnetic circuit breakers have adjustable instantaneous settings. If the instantaneous setting dial is visible, then this could be an option. Newer breakers with solid state instantaneous trip units may also have adjustments that allow the user to turn down the setting.

When the instantaneous setting is changed to the minimum setting, the pickup trip level is reduced. Usually this reduces instantaneous pickup to 3.0 to 5.0 times the phase trip setting. This is usually below the expected arcing fault current that will occur for the equipment downstream. If the arcing fault current is greater than the lowest instantaneous trip setting, then the breaker will trip instantaneously and the arc flash energy will be greatly reduced.

It should be noted that blindly reducing trip settings without engineering review could cause the circuit breaker to trip and thus cause an outage. The engineering review may find that the lowest instantaneous pickup still may not be low enough to allow the breaker to trip instantaneously.

Once the work is finished downstream, it is very important to change the instantaneous setting back to the original settings. Failure to do so could result in a mis-trip and reduced distribution reliability. Another recommendation is to put a label on the breaker that shows what the normal setting should be. The downstream equipment should have a label showing the Arc Flash energy when the upstream breaker's instantaneous setting is set to the lowest position.



Molded Case Circuit Breaker with Adjustable Instantaneous Trip Units

Breaker with an ARM Function and Switch

Many newer breakers with solid state trip units can be specified and purchased with the Arc Flash Reduction Mode feature. This feature usually comes with a door mounted switch that makes it very convenient to turn off the normal phase selective trip settings and turn on the ARM settings. When this switch is operated, either a strobe or light behind the switch is energized that gives a visual indication that the breaker is in the ARM mode.

The ARM feature acts like an instantaneous trip-only breaker. If the arc fault current is above the ARM pickup setting, then the breaker will trip instantaneously, thus reducing the arc flash energy for the equipment downstream. Older style Power Circuit Breakers can be retrofitted with this new style of trip unit, which will increase the breaker reliability and personal safety. Most of the major circuit breaker manufacturers and some specialty companies make retrofit kits for a wide variety of breakers. Just like the option above, an engineering review needs to

be conducted and the energy level downstream calculated. Then a label should be created and installed on the downstream equipment showing the arc flash level under normal conditions and the ARM conditions.



Door Mount ARM Switch



Breaker with Retrofitted Trip Unit and ARM Unit



ARM Trip Unit

Zone Selective Interlock System

A Zone Selective Interlock System is a method which allows two or more ground fault breakers to communicate with each other so that a short circuit or ground fault will be cleared by the breaker closest to the fault in the minimum time. For Switchgear and Switchboards, this feature can reduce the Arc Flash Energy at the gear. The main and feeder breakers have a communication system that allows the breakers to communicate. When a fault occurs downstream from the feeder breakers, the feeder breaker will send a signal to the main breaker and tell it to delay tripping and use its normal phase or ground fault settings. However, if a fault occurs on the Switchboard or Switchgear bus, the feeder breakers will not send a restraining signal and the main breaker will trip instantaneously.

Now this type of function and system is being deployed further down into the distribution. Multiple levels of breakers can be connected to the breaker communication system which will decrease the arc flash energy in multiple locations and equipment.

Electronic Fuses and Arc Flash Detection Relays

One of the most dangerous locations to work is between the secondary side of a transformer and the line side of the first downstream protective device. For larger transformers 225 kVA and above, the arc flash energy can be 30 Cal/cm² or more. In many locations, the arc flash energy is over 40 Cal/cm². This is due to the fact that the transformer primary device is usually the device that is protecting this area. When an arc flash event occurs on the secondary side of the transformer, the fault current is reduced due to the transformer impedance and transformer ratio. The result is that primary protective device sees the fault as an overload condition, not as a high current short circuit. Therefore it can take 10 seconds or more for the device to operate. This large time delay causes the arc flash energy to be very high. There are a couple of methods to reduce the arc flash energy in these locations and they are discussed below.

Transformer Differential Relays

When a transformer is protected by a primary circuit breaker, one method to reduce the secondary arc flash energy is to install transformer differential relays. The differential zone of protection would be from the line side of the transformer primary device to the load side of the transformer secondary device (this is sometimes called the main service protective device). The differential relay is set so that a fault within the zone will send a trip signal to the transformer primary device with very little delay. This small trip time greatly reduces the arc flash energy. These types of relays have been used in medium voltage distribution systems for many years. However, with a greater emphasis on reducing arc flash hazards, they are now being installed on some low voltage systems.

Electronic Fuses and Arc Flash Detection Relays

For locations where medium voltage fuses are protecting the transformer, the equipment can be retrofitted by installing electronic fuses, arc flash optic sensors and relays. The electronic fuse is a new type of fuse that can be forced to “blow” (interrupt) by a contact closure. The arc flash optic sensors and relays can detect when an arc flash occurs by the rise in current and increase in light intensity.

Should a fault occur in the switchboard or switchgear, the Arc Flash Detection relay will detect the rise in current and light intensity, and close the trip contact. This will then cause a fuse to interrupt the fault current faster than if a normal fuse was installed. Thus, the arc flash energy is greatly reduced.



Medium Voltage Controllable Fuse (MVCF)

Remember, Distance and short time delays are your friends when it comes to the electrical arc flash hazards. Increasing the working distance or decreasing the tripping times lowers the arc flash energy exposure. There are many ways to reduce the tripping times of protective devices. The solutions are very equipment specific and just one solution can not be applied everywhere in a distribution system. Sound engineering analysis and design is needed to determine the best and most cost effective method to reduce the arc flash energy. Before you operate that electrical equipment, stop and think about ways to operate it remotely and/or decrease the upstream operating trip times. This could save your life!