TECHNOLOGIES THAT REDUCE LIKELIHOOD OF INJURY FROM ELECTRICAL HAZARDS, INCLUDING SHOCK, ARC FLASH AND FIRE

The following are technologies that reduce the likelihood or limit the severity of electric shock, arc flash and electrical fires. These technologies provide opportunities for application beyond the minimum requirements of building codes and electrical design standards. Each technology may have some disadvantages along with its advantages. As with any design, an engineering analysis must be performed to determine the best type of equipment for the situation. This is a preliminary summary and may be expanded. They are not ranked in any order.

1. Coordination—Design and application of proper coordination of fuse selection and protective relay and circuit breaker settings is the easiest and simplest method to reduce arc flash hazards and provide the best protection to workers. Traditional application was limited to equipment protection. This technology has expanded to include worker protection. Impacts arc flash hazards

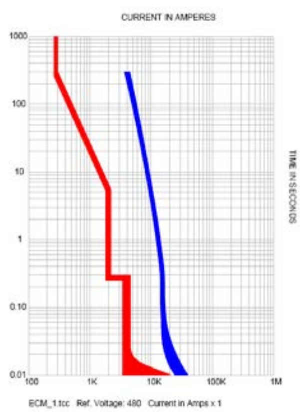
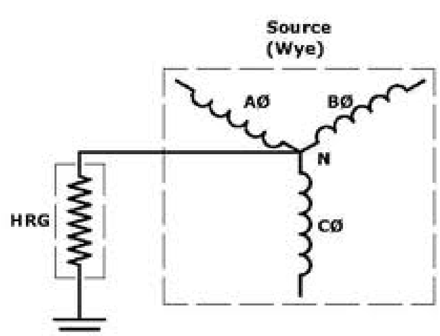


Figure 1. Illustrating coordination of two protective devices in an electric power system.

In this example, the tripping characteristics of a circuit breaker depicted on the left are selected to coordinate with the clearing characteristics of a fuse on the right. The selection of trip settings and fuse characteristic are design choices that impact arc flash energy exposures.

2. High resistance grounding (HRG)—HRG limits the amount of ground fault current during a phase-to-ground fault to a low value. This reduces the risk of occurrence of phase-to-phase and 3-phase faults. A control system is used to monitor an HRG system and sound an alarm when a phase-to-ground fault occurs; thus, the fault can be taken off-line before it becomes a multiphase fault. Impacts arc flash hazards. Typically applied to 480V power distribution systems, Impacts arc flash hazards

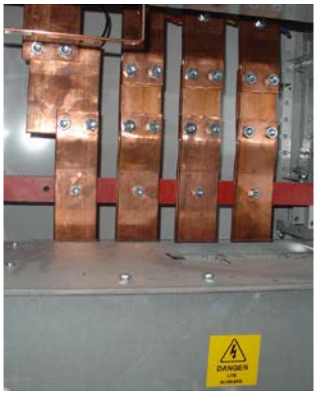


High resistance grounding is accomplished by installing a resistor in the transformer neutral connection to ground

An example of a neutral ground resistor (courtesy I-Gard)

Figure 2. Illustrating High Resistance Grounding

3. Covered or isolated bus—The energy associated with a single-phase fault is less than the energy associated with a multiphase fault. A covered or isolated bus keeps the single-phase fault from becoming a multiphase fault. Consequently, there will be less energy available at the fault location. In addition, the covered or isolated bus helps prevent a single-phase fault from occurring. Covered or isolated bus is not designed to protect personnel from the energized bus. Impacts arc flash hazards.



An example of bare exposed bus bars

An example of an insulated (covered) bus

Figure 3. Illustrating covered or isolated buss

4. Current-limiting fuses and current-limiting breakers—The greatest advantage of these devices is their ability to clear faults in one-half cycle or less, when they operate in their current-limiting range, thus reducing the amount of available energy. When acting in their current-limiting range, the devices also introduce additional impedance into the circuit, reducing the current, which reduces the amount of available energy. When they operate outside their current-limiting range, the amount of fault energy at the arc may be significantly higher (i.e., greater than 10 times) than when they operate in their current-limiting range. Impacts arc flash hazards

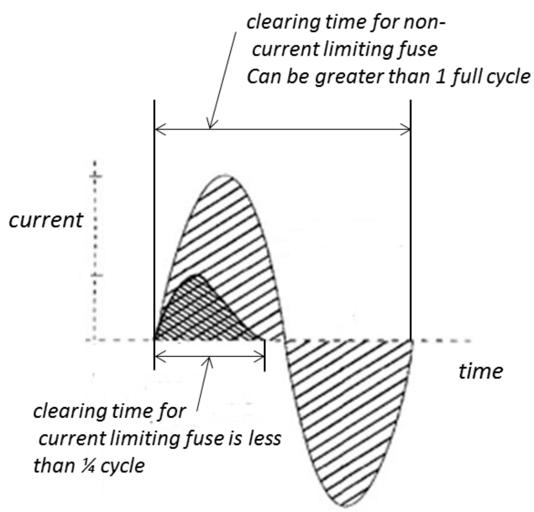


Figure 4. Illustrating the time-current characteristics of a current limiting fuse. The amount of thermal incident energy in an arc flash event is proportional to the area under the curves. Current limiting fuses and circuit breakers clear a fault within ¼ cycle. non-current limiting fuses and circuit breakers can take much longer. (adapted from *Arc Flash Hazard Analysis and Mitigation*, J.C. Das, p236)

5. Touch-proof equipment—Touch proof equipment prevents individuals from contacting energized terminals directly or with equipment they are using. The touch proof equipment reduces the likelihood of a person contacting an energized terminal and receiving an electric shock. This technology also limits the ability of an individual to cause an arc flash due to an accidental phase-to-ground and/or phase-to-phase contact. Specifying equipment meeting IEC 60529 IP2X ingress requirements is one method to ensure the equipment is touch proof. Impacts electric shock and arc flash hazards

An example of a touch safe fuse holder

An example of a non-touch safe fuse holder

Figure 5. The touch safe fuse holder on the left allows the fuse to be removed from an energized circuit without personnel exposure to bare energized conductors. The fuse holder on the right requires the use of insulated tools and voltage rated gloves to remove a fuse safely.

6. Remote operation of equipment—Operation of equipment from a remote location eliminates the possibility of a person's being exposed to an arc flash during equipment operation. Impacts arc flash hazards. Examples include the following:
   - – Remotely operating medium voltage switchgear
   - – Installing motor controls away from the motor terminal box and MCC
   - – Use of 'smart' MCCs to reduce exposures to energized equipment; the worker can troubleshoot remotely over the network

This remote switching device utilizes an actuator to operate the control handle, allowing operating personnel to stand outside the boundary of the arc flash hazard. Without the remote switching device, the person would be standing in close proximity to the switchgear.

This motor operated device allows the removal or insertion of a draw-our circuit breaker. The person can stand outside the boundary of the arc flash hazard. Without the remote operator, the person would be kneeling in front of the switchgear using a manual wrench.

Figure 6. Illustrating remote operating devices that move personnel outside the arc flash boundary

7. Arc-resistant enclosures—Arc-resistant enclosures (e.g., arc-resistant switchgear) help to contain the arc and the arc by-products (e.g., plasma and gas) and redirect them away from the worker. Impacts arc flash hazards

Non-arc resistant equipment designs do not control direction of thermal energy released in an arc flash event. In this illustration, the person is in the line of fire.

Arc resistant designs direct thermal energy away from where personnel would normally be positioned. In this example, the energy is directed out of the top of the switchgear.

Figure 7. Illustrating the benefits of arc-resistant switchgear

8. Arc detection and suppression systems—These systems use light detection and current sensing to detect an arc and initiate high-speed clearing of the circuit. Impacts arc flash hazards.

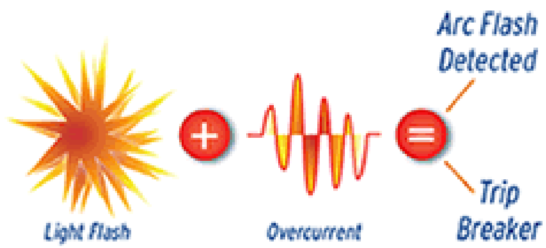


Figure 9. Overcurrent detection is the most common method to detect an arc flash event. This illustration shows how light detection can be used in addition to overcurrent detection. This can enable a much faster tripping of the circuit breaker to limit arc flash incident energy. (Illustration courtesy Schweitzer Engineering Laboratories)

9. Fully withdrawable MCC design—The fully withdrawable MCC design ensures physical access to the inside of the unit can only be gained by removing the unit from the power bus. The unit may be withdrawn or fully removed to accomplish this. Impacts electric shock and arc flash hazards.

Figure 10. A fully withdrawable motor control center design. The motor starter is shown in the withdrawn (disconnected) position.

10. Ground fault circuit interrupters —This technology was introduced in the late 1960s and has demonstrated significant results in preventing electrocution fatalities from defective tools and appliances and when using tools and appliances in damp environments. Recent advancements has expanded the application of this technology from 120V application to 600V. Impacts electric shock

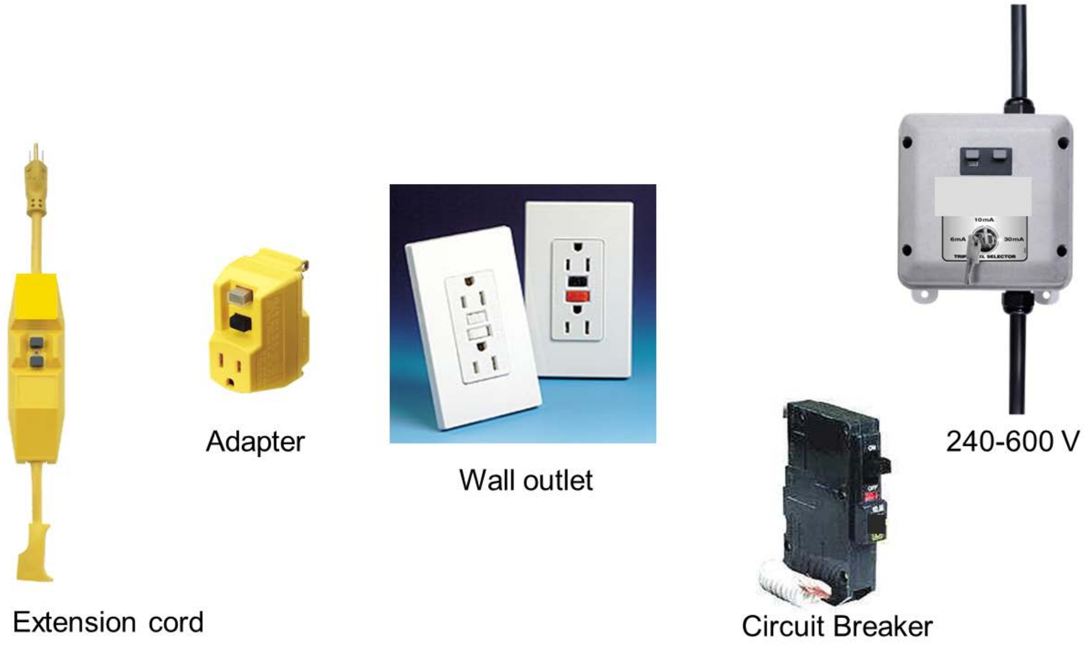


Figure 11. Illustrating options in GFCI devices

11. Arc fault circuit interrupters— This technology addresses fire hazards from defective wiring and appliances in residential and commercial buildings. Impacts fire prevention

Figure 12. Arc Fault Circuit Interrupter (AFCI) technology is available in outlets (left) and circuit breakers (right).

12. “Smart” motor control centers and substations— This is an evolving group of technologies that incorporates self diagnostic capability and data communications that enable remote trouble shooting, adjustments, and failure recovery remotely, reducing need for a worker to be exposed to hazardous energy. One example - The Coast Guard has recently installed technology that automatically performs diagnostic testing on large motors and generators. This reduces need for worker to perform these tests with potential exposure to lethal energy. Impacts electric shock and arc flash hazards

Figure 13. The motor control center on the left has “smart“ technology, including sensors and data highway that enables the technician to perform troubleshooting and adjust protective device settings without opening enclosure doors, avoiding exposure to unguarded energized components. The motor control center on the right does not have the “smart” technology. Troubleshooting must be done using chock and arc flash PPE to protect the workers from hazards from unguarded energized components.

13. Inspection viewports— These are devices that enable infrared and ultrasonic inspections of switchgear and other power distribution equipment without opening doors or removing covers that would expose workers to lethal energy. Impacts electric shock and arc flash hazards

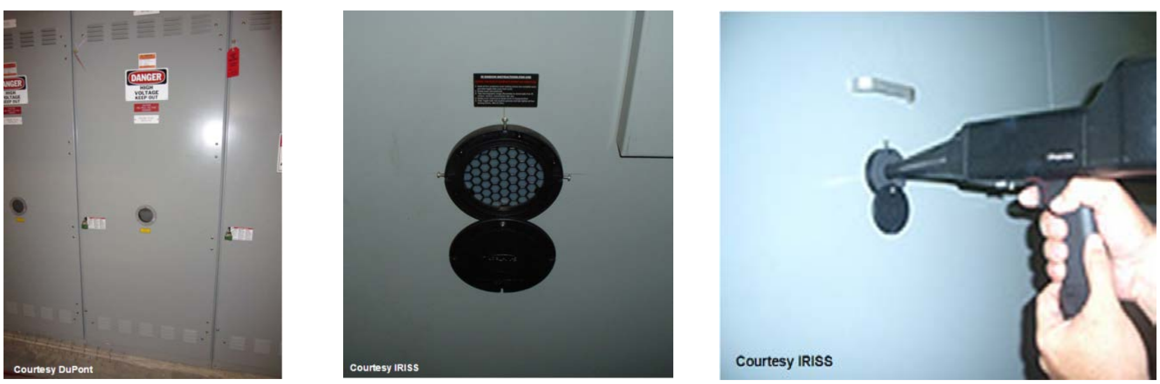


Figure 14. The left illustration shows infrared inspection viewports installed in industrial switchgear. The center illustration is a close-up of an infrared viewport. The right illustration shows an ultrasound testing port.

# # #