

Designing in safety by reducing the Arc Flash hazard in Low Voltage switchboards

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Abstract

You are the electrical engineer of record on a project. A call comes into your office. The electrician working on your latest job is hospitalized. An arc flash occurred while testing the low voltage switchboard. Could this tragedy have been avoided in your design? Could you have prevented this?

Let's take a look at arc flash, its causes and how to design a safer system.

What is an arc flash?

An arc flash is current flowing through air that flashes from one exposed live conductor to another conductor or to ground. When an arc flash happens, the temperature can reach up to 35,000 degrees Fahrenheit. This is 4 times the temperature on the surface of the sun.¹

What causes an arc flash?

An arc flash occurs when electrical clearances are reduced or compromised by deteriorating insulation or human error. The arc flash follows a conductive path between two hot (energized) wires or between a hot wire and ground.¹ Arc flash can be caused by an accidentally dropped tool or by getting too close to energized parts.

What is the risk?

The risk of Arc Flash is a growing concern within the electrical equipment community and among both designers and workers. Current research shows that up to 80% of reported electrical injuries are caused by an electrical arc². This fact has spawned new requirements and standards in governing documents, such as in NFPA 70E and the NEC. These documents address the safety of workers on and around energized electrical equipment. In response to safety needs and to fulfill these standards, several new technologies were developed to address the issue of arc flash, and help mitigate its risk.

Manufacturers strongly recommend that all systems be de-energized when personnel are working on electrical equipment. In some circumstances qualified professionals may need to access and work near energized equipment. Testing, troubleshooting, diagnostics and a continuous process segment require that power remain on to complete the task and de-energizing would introduce an increased hazard or is infeasible. This is where many accidents occur and the risks and effects of an arc flash are the greatest.

It is important to realize that there is no method that completely eliminates the hazard. Caution and good work practices must always be employed as well.

Can the risk be greater than NFPA70E Table 3-3.9.1?

Yes. The table is a guide. The levels can be higher or lower than the tables indicate. It cannot predict every scenario. In fact, with the recent addition and enforcement of Selective Coordination, the arc flash hazards often become worse in selectively coordinated gear. The problem is that selective coordination often requires higher instantaneous pickup settings in order to guarantee only one breaker trips. This creates a greater arc flash hazard often. Particular care should be used when working on emergency systems that are selectively coordinated. They can have elevated arc flash levels.

How do I design a safer electrical system if I do not know where the problems are?

Simply put, you cannot. You must know where the problems are in order to fix them. Performing an arc flash study is a must if you want to find and fix the problems. Arc flash software modules are available from the manufacturers of time current curve software. The designer or engineer should perform an arc flash study during the design phase prior to bidding. He or she should determine the dangerous points in the system. If problems are found, then alter the breaker settings or specify a protection method.



What Protection Methods are Available?

- Maintain Adequate Working Clearances
- Work De-energized
- Remote Operation and Racking
- Insulated Bus Bars
- Low Voltage Arc Resistant Gear
- Optical Systems
- High Impedance Transformers
- Adjustable Instantaneous Breakers

Maintain Adequate Working Clearances

The safest thing to do is not to get near the gear. If you are not a qualified electrician, stay away from exposed live parts. Obviously this is not practical for the qualified electrician, in this example. In many applications it is often not practical. Finally, maintaining adequate work clearances does not minimize the hazard.

Work De-energized

Working de-energized whenever possible is highly recommended. OSHA 1910.333(a)(1) states in that "Live parts to which an employee may be exposed shall be de-energized before the employee works on or near them, unless the employer can demonstrate that de-energizing introduces additional or increased hazards or is infeasible."

NFPA 70E further clarifies the preceding OSHA requirement. Examples of "additional or increased hazards" include the interruption of life support systems, emergency alarm systems, or hazardous location ventilation. Examples of "infeasible conditions" include startup testing, troubleshooting, diagnostics and a continuous process segment.

For the electrician injured in our original example, he was testing the switchboard. It was infeasible for him to be working de-energized.

Remote Operation and Racking

By operating the breakers remotely, you have increased safety. However, this idea is cost prohibitive in low voltage switchboards. To make every breaker electrically operated would add approximately \$1,000 per breaker to the switchboard plus the addition of a controller station.

Remote racking is a great idea for draw out switchgear. However, most switchboards do not have draw out components and thus this must be ruled out. Additionally, during testing this would not have helped in our example.

Insulated Bus Bars

Insulating the bus bars is a positive addition to any design. It adds protection from inadvertent live bus bar contact. It protects the qualified electrician from the unqualified and startled rodent, snake, bird or other animal that makes phase to phase contact inside the gear. Also it can protect the electrician from a flash due to metal parts left loose inside the gear or from a falling metal tool.

Hazard/Risk category	Clothing description	Required minimum arc rating of PPE [cal/cm ²]
0	Nonmelting, flammable materials (i.e., untreated cotton, wool, rayon, or silk, or blends of these materials) with a fabric weight at least 4.5 oz/yd ²	N/A
1	Arc-rated FR shirt and FR pants or FR coverall	4
2	Arc-rated FR shirt and FR pants or FR coverall	8
3	Arc-rated FR shirt and pants or FR coverall, and arc flash suit selected so that the system arc rating meets the required minimum	25
4	Arc-rated FR shirt and pants or FR coverall, and arc flash suit selected so that the system arc rating meets the required minimum	40

Table 1 – Protective Clothing Characteristics from Table 130.7(C)(11), NFPA 70E, 2009

On the down side it adds cost to the gear and it does not lower the level of arc flash incident energy or the level of Personal Protective Equipment (PPE) required.

Low Voltage Arc Resistant Gear

New equipment that can be used is low voltage arc resistant switchgear. This type of equipment utilizes chimneys and plenums to force the dangerous arc energy away from the gear and operator. While this is a useful safety method, it does not lessen the arc or arc flash boundaries and is not available in low voltage switchboard construction.

Optical Arc Flash Detection Systems

One of the latest developments in arc flash detection technology deploys the use of fiber optic cable and overcurrent transducers. These two devices transmit separate signals to improve accuracy of detection arc faults in switchboards. Dual feedback variables evaluate the arc flash event and determine if an arc flash event has occurred. If an arc flash event has occurred, an extremely fast quenching process is initiated, while tripping breakers within the arc flash zone to localize the arc flash fault. This is new technology. Not all switchboard manufacturers can provide this detection system. Long term performance could be an issue. Fiber optical cable is subject to harsh conditions inside the switchboard, which has not withstood the “test of time”. Reducing clearing time does lower arc flash incident energy, improving safety.

High Impedance Transformers

Increasing the impedance of the power transformer or padmount transformer lowers arc flash incident energy on the secondary side connected to the low voltage switchboard. This is another method to reduce arc flash incident energy through transformer design. This solution costs the owner money every day due to losses and inefficiency.

Adjustable Instantaneous Breakers

Switchboard or switchgear equipped with power breakers or Insulated case breakers using Siemens ETU776 trip unit, have adjustable instantaneous trip units can use a dual function setting.

The trip unit has two parameters (A and B), that allow the operator to switch back and forth from a normal operating mode to a maintenance mode, using a wall mount key lock, or remote switch. The maintenance mode (Parameter B) has a reduced instantaneous trip setting.

By reducing the instantaneous pick-up level, the trip timing of the system is accelerated. This reduction will cause the breaker to trip in the instantaneous range on a lower amount of current and thus reduce the arc flash energy in the danger zone, known as the arc flash boundary (AFB). Dual parameter trip settings have the advantage of being completely internal to the breaker. Care must be taken in design to ensure that the settings are such that the expected arc flash current level, derived from an arc flash study, will exceed the reduced instantaneous settings.

Conclusion

Designing an electrical system is difficult. The problems in design are compounded by safety regulations and local interpretations. Throw in selective coordination and your design has an additional dilemma. While you try to minimize the arc flash hazard, selective coordination attempts to push the time current curves out, creating a greater arc flash hazard. Particular care should be used in emergency systems that are selectively coordinated as they can have elevated arc flash levels.

In conclusion there are many methods to design in safety by reducing the arc flash in low voltage switchboards. When you factor in cost, repeatability, animals, falling metal parts and reducing the severity of the arc flash one method appears to be superior. This method is adjustable instantaneousness breakers.

References

¹ “Arc Flash Hazards – Protect your employees from fire and injury”, © 2010 Siemens Energy and Automation

² National Technology Transfer, Inc NFPA 70E/ Arc Flash: Electrical Safety. Edition 3.1

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