Arc Fault Energy Reduction For Power Systems

AUTHORS
Al deLeon
Senior Project Engineer

INTRODUCTION

The electrical power industry has placed more focus on Arc Energy reduction to improve personnel safety during maintenance of energized equipment. Engineers and facility owners include mechanisms and equipment features to reduce the Arc Energy in the event of a system fault during maintenance procedures.

This paper will explain the concepts behind Arc Energy reduction techniques and considerations when selecting generator features.

DEFINITIONS: ARC FAULT, ARC FLASH AND ARC ENERGY

Arc Fault occurs when electrical current flows through an unintended path. This happens when a phase conductor is exposed to or makes a connection to another phase conductor.

There are two types of arc faults. A "Parallel Arc" happens between two different phases or neutral and ground conductors. While "Series Arc" happens along the same conductor phase. When this occurs, the discharged energy causes an Arc Flash, an intense heat capable of igniting surrounding materials and starting a fire. (See *Figure 1*).

The magnitude of this energy depends on the amount and the duration of the fault before any of the system's protective devices disconnects and clears the fault from the source. This Arc Energy is a form of thermal energy and is measured in calories per area (kcal/cm^2). It is a factor that determines the severity of damage to equipment and more importantly to personnel servicing the equipment.

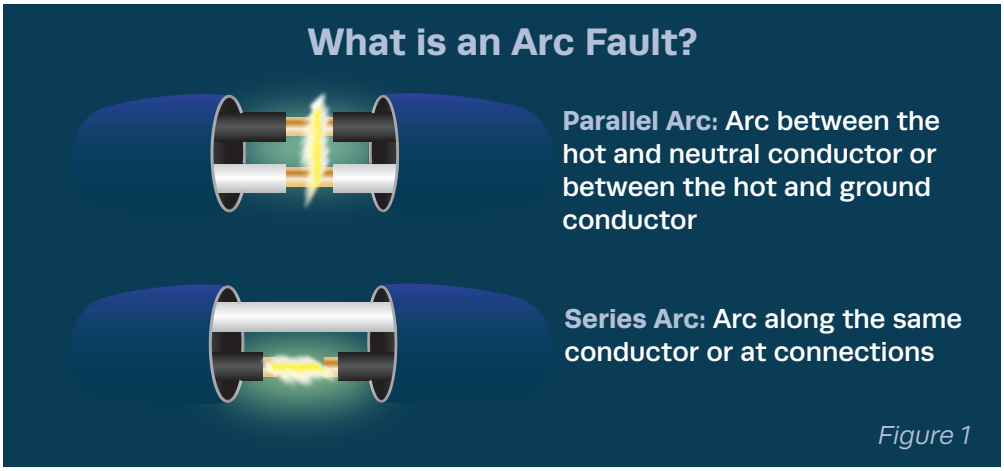


Figure 1

ELIMINATION OR REDUCTION OF Arc Energy

The safest way to work on energized electrical equipment is to eliminate the possibility of an Arc Flash. This is best achieved with operational procedures such as Lock-Out-Tag-Out (LOTO). By properly de-energizing the power source, the equipment can be serviced without risk of an Arc Flash. (See *Figure 2*).

However, it is recognized that sometimes equipment must be serviced or maintained while energized and there is a possibility of an Arc Flash. Therefore, devices such as a circuit breaker can be set to quickly open the circuit, reducing the time Arc Flash and thus reducing the Arc Energy.

Overall, the goal of Arc Energy reduction is achieved either by reducing the magnitude of the fault current or by reducing the duration of the event and thus reducing the Arc Energy that can cause harm to the personnel. This is achieved by many different methods and design philosophies. The National Electrical Code (NFPA 70 – NEC) provides requirements and definitions of acceptable Arc Energy reduction techniques.

Figure 2: Arc Flash

ARC ENERGY REDUCTION REQUIREMENTS

The National Electrical Code's history for Arc Energy requirements started in 2011, when NEC Section 240.87 was introduced to require acceptable methods of reducing Arc Energy on installations that used protective devices that have little or no instantaneous trip protection.

This was to provide requirements to improve existing installations that did not have adequate short circuit protection. The code also required new installations with requirements using modern equipment that can reduce downstream Arc Energy.

The code has since been expanded by enumerating what power systems require Arc Energy reduction. In 2014, it defined what power systems are required to have methods of Arc Energy reduction. Additional requirements and acceptable mitigation methods were also added to the list since then. (See *Figure 3*).

NEC 240.87 also requires accurate and updated record keeping and documentation of the power system. This includes the operator's record keeping of information detailing the system design, settings and maintenance records. Any major changes to the power system may affect the available fault current. Short circuit Arc Flash studies should be conducted before installation whenever major power system changes occur.

Figure 3

NEC Arc Energy Requirements

Revision Year	Revision Requirement	Acceptable Methods
2011	OCPD without adequate instantaneous short circuit protection	Zone Selective Interlocking Differential Relaying Energy Reducing Maintenance Switch
2014	OCPD 1200A and above	Arc Flash active mitigation Approved equivalent means
2017	Fused systems	Instantaneous Trip Setting and Override
2020		Upstream Current limiting fuses

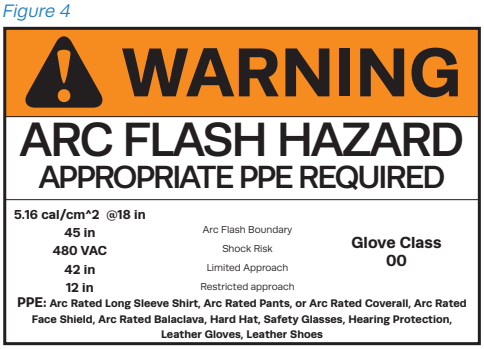
SHORT CIRCUIT STUDY AND ARC FLASH STUDY

Once equipment is selected and settings are determined, the facility conducts a short circuit study and Arc Flash study. The entire system is studied to determine the available fault current and the Arc Energy present at any single location or device in the system. The result of these power system studies is used to determine protection settings that will provide with the most adequate overcurrent.

Devices that are part of the study are provided with an Arc Flash label that indicates the calculated Arc Energy, safety and risk boundaries as well as the appropriate classification of PPE protection. (See *Figure 4*) This provides the necessary clothing requirement when working on the equipment.

Determining the best method for Arc Flash reduction depends on findings from this study and a thorough understanding of the power system.

Figure 4



PERSONAL PROTECTIVE EQUIPMENT

Perhaps the most important equipment in the personnel's toolkit is the PPE. The Personal Protective Equipment (PPE) is essential for safely working on electrically energized equipment. Wearing properly classified safety gear provides protection from shocks and burns caused by an Arc Flash.

PPE includes, but is not limited to clothing, gloves, helmet, face shields, eyeglasses and footwear. Best practices and regulation requirements dictate the use of classified PPE. (See *Figure 5*).

Figure 5: Technician suited up with Personal Protective Equipment

ARC ENERGY REDUCTION GENERATOR SYSTEMS

The best practice is servicing de-energized equipment through proper facility procedures using Lock-Out-Tag-Out (LOTO).

A properly followed LOTO procedure significantly reduces the risk of an Arc Flash. Working with de-energized equipment is a safer way to ensure personnel safety. Generators should not be operating during maintenance.

Generators are typically ordered with circuit breakers providing basic protection against short circuit conditions. These circuit breakers have instantaneous protection settings that will be used for the short circuit and Arc Flash study. Additionally, circuit breakers can be equipped with energy reduction systems.

Arc Energy Reduction Maintenance Switches (ERMS) can be turned on to reduce the circuit breaker's tripping time. (See *Figure 6*). This ERMS switch, when turned ON, sets the instantaneous pick up to a pre-programmed value, allowing it to override the normal mode trip settings. This setting allows the breaker to open as fast as possible, reducing the Arc Energy for downstream equipment.

Rehlko's APM603 on-board generator controller may also act as a means of reducing Arc Energy. It is a UL6200 listed on board paralleling controller, that has integral alternator thermal protection. It provides basic protection for overload condition. Additionally, it can be programmed to monitor short circuit current and send a trip signal to a circuit breaker.

This feature allows for short circuit protection below the circuit breaker's instantaneous trip, without temporarily adjusting the circuit breaker. This allows the breaker to be coordinated with downstream devices while providing a means of adjusting the instantaneous trip through the genset APM603 controller.

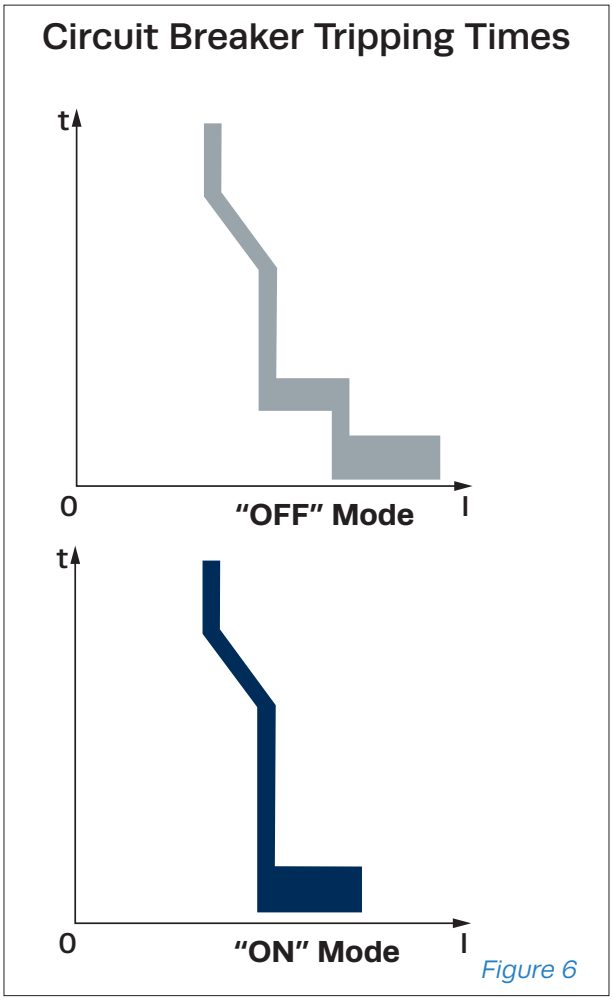


Figure 6

SUMMARY

To reduce the Arc Energy released from an Arc Flash event, mitigating designs and equipment selection should be considered. Rehlko industrial generator sets may be equipped with circuit breakers that have instantaneous protection. They can also be equipped with Energy Reduction Maintenance Switches (ERMS) to further increase its short circuit protection settings.

All aspects of personnel safety should be considered when maintaining or servicing electrical equipment. The most effective way is to ensure that electrical equipment is de-energized before any servicing and maintenance. Working on live equipment introduces the dangers and effects of an Arc Flash that can cause significant harm to the personnel.

Designers, specifiers, owners and operators must all be aware of these techniques to minimize potentially hazardous situations. Please contact your Rehlko representatives for additional insights and information.

ABOUT THE AUTHOR

Al deLeon is a Senior Project Engineer at Rehlko. He holds a Bachelor of Science in electrical engineering from Marquette University. Al joined Rehlko in 2022 with extensive experience in facility design as a consulting engineer for more than a decade. He has been part of engineering teams designing large industrial, commercial, and educational buildings with generator systems. He has also designed wind, hydroelectric and solar power plants.

ABOUT POWER SYSTEMS

Power Systems, Rehlko's largest division, delivers worldwide energy solutions designed to ensure resilience for mission-critical applications of all sizes. Building on more than a century of expertise and dedication, the company offers complete power systems, including industrial backup generators (HVO, diesel, gaseous), enclosures, hydrogen fuel cells systems, automatic transfer switches, switchgear, monitoring controls, genuine parts and end-to-end services. As a global company with service partners in every country, Power Systems provides reliable, cutting-edge technology to keep industries and businesses running.
www.powersystems.rehlko.com

ABOUT REHLKO

A global leader in energy resilience, Rehlko delivers innovative energy solutions critical to sustain and improve life across home energy, industrial energy systems, and powertrain technologies, by delivering control, resilience and innovation. Leveraging the strength of its portfolio of businesses – Power Systems, Home Energy, Uninterruptible Power, Clarke Energy, Heila Technologies, Curtis Instruments, and Engines, and more than a century of industry leadership, Rehlko builds resilience where and when the grid cannot, and goes beyond functional, individual recovery to create better lives and communities, and a more durable and reliable energy future.

REHLKO.com

rehlko