

# SEL Arc-Flash Solutions

Arc-Flash Protection at the Speed of Light



## Protect personnel and equipment

- Detect arc-flash events and send a trip signal in as little as 2 ms to enhance safety and minimize equipment damage.
- Reduce arc-flash incident energy levels by as much as 88 percent to lower the potential for injury.
- Detect arc flashes securely by using a combination of light-sensing technology and overcurrent detection.
- Install into new systems or retrofit into existing equipment for all application needs.





## Arc-Flash Overview

Personnel safety is paramount for utilities and industries, including oil/gas, water/wastewater, and metals and mining. According to the *National Fire Protection Association (NFPA) 70E: Standard for Electrical Safety in the Workplace*, an arc flash “is a dangerous condition associated with the release of energy caused by an electrical arc.”

The energy produced by an arc-flash event is proportional to the voltage, current, and duration of the event ( $V \cdot I \cdot t$ ). It is measured in terms of arc-flash incident energy (AFIE), calibrated in  $\text{cal}/\text{cm}^2$ , and in turn used to determine the level of personal protective equipment (PPE) required to protect personnel from injury during an arc-flash event. PPE is designed to protect workers from serious workplace injuries or illnesses resulting from contact with electrical or other workplace hazards.

### Causes of Arc Flashes

Arc flashes occur when the insulation or over-air isolation between energized components within an electrical circuit is compromised. Arc-flash events can be caused

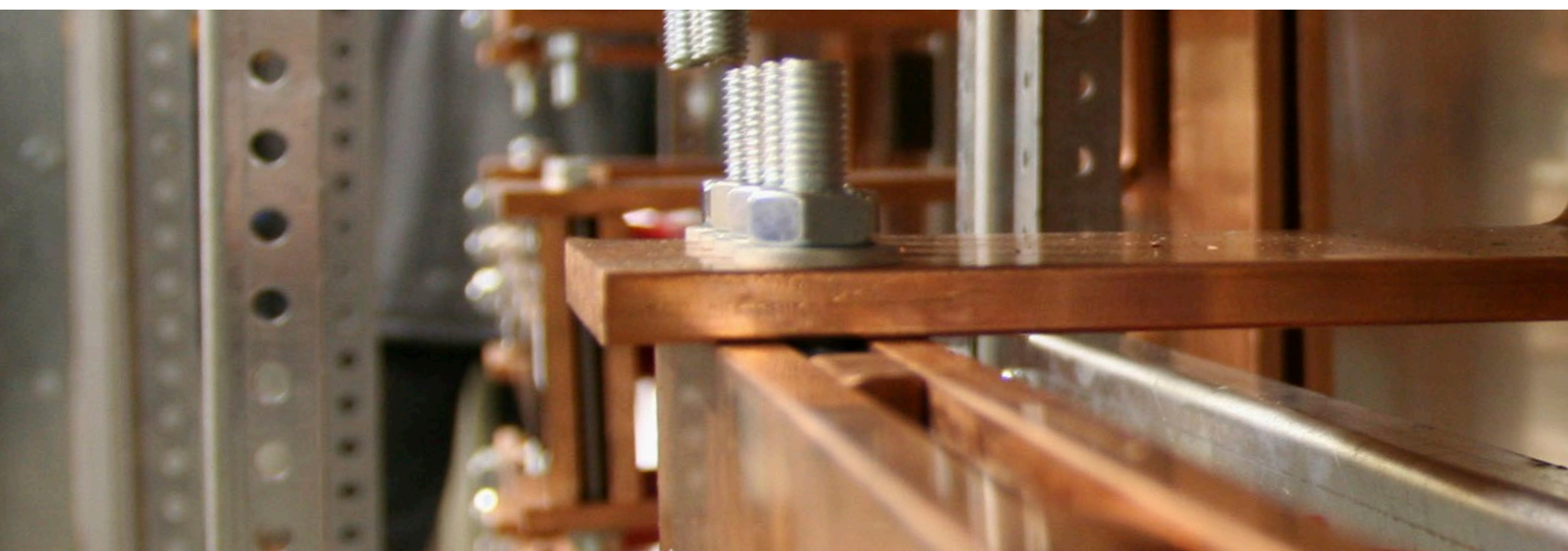
by numerous factors, such as the shorting of two phases, which creates a phase-to-phase fault. Common examples that cause phase-to-phase faults include dropped tools, accidental contact by maintenance personnel, the buildup of corrosion or conductive dust on conductors, and the presence of pests, like mice, rats, or snakes, that come in contact with energized conductors.

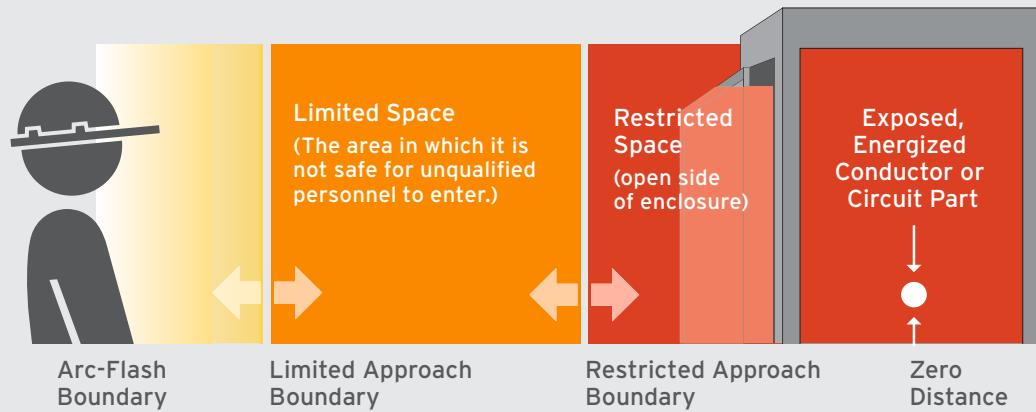
### Dangers of Arc Flashes

Arc-flash events can cause dangerous and potentially fatal levels of heat, ultraviolet radiation, blast pressure, flying shrapnel, and deafening sound waves.

### Arc-Flash Mitigation

Design engineers have a few options to reduce system voltage or fault currents, including grounding practices and the application of current-limiting fuses. However, the best and most direct way to reduce arc-flash hazards is to reduce fault-clearing times, thereby reducing the overall incident energy, or to eliminate the need for personnel to be in harm’s way by using remote operation.





## Arc-Flash Standards

NFPA 70E is the primary North American safety standard for working with electrical equipment. It provides guidance on implementing appropriate work practices that are required to safeguard workers from injury while working on or near exposed electrical circuits that could become energized.

### Arc-Flash Risk Analysis

Arc-flash risk analysis determines the amount of incident energy a worker may be subject to and defines the procedures to limit the damage of arc-flash events on personnel and equipment. It also defines the associated risk areas and determines the relevant level of PPE. The NFPA has developed specific approach boundaries designed to protect employees while they are working on or near energized equipment.

### Arc-Flash Boundary

If an arc flash occurred, this boundary is where an employee would be exposed to a curable second degree burn ( $1.2 \text{ cal/cm}^2$ ). The intense heat generated from a flash may result in severe burns and the ignition of clothing.

### Limited Approach

The Limited Approach Boundary is a distance from an exposed energized part where a shock hazard exists and should only be crossed by qualified personnel.

### Restricted Approach

The Restricted Approach Boundary is a distance from an exposed energized part where there is an increased likelihood of electric shock.



# Benefits of SEL Arc-Flash Protection

## High-Speed Tripping

SEL relays reduce arc-flash hazards by significantly reducing the total fault-clearing time.

## Incident Energy Reduction

The faster the extinction of the arc-flash event, the smaller the incident energy. SEL relays detect arc-flash hazards and send a trip signal to the breaker in as little as 2 ms.

## Improved Safety

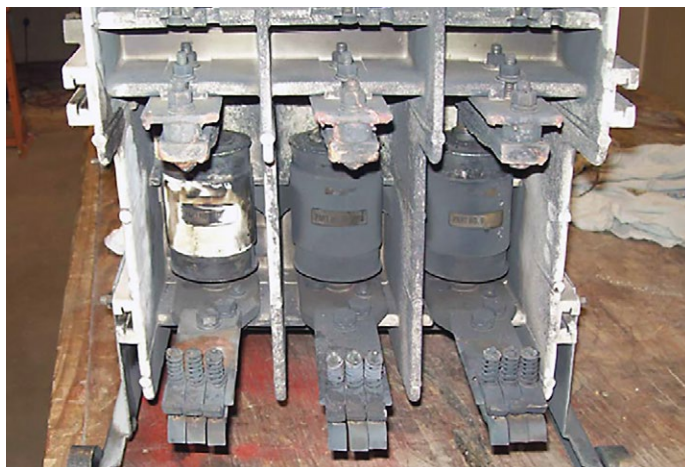
SEL arc-flash detection (AFD) decreases the fault-clearing time, which reduces arc-flash hazards, improves safety, and lowers PPE requirements. To validate the arc-flash protection performance, a series of tests were performed at a high-current laboratory. In these tests, arc-flash incident energy levels were reduced by 88 percent using SEL technology.

## Reduced Damage to Switchgear

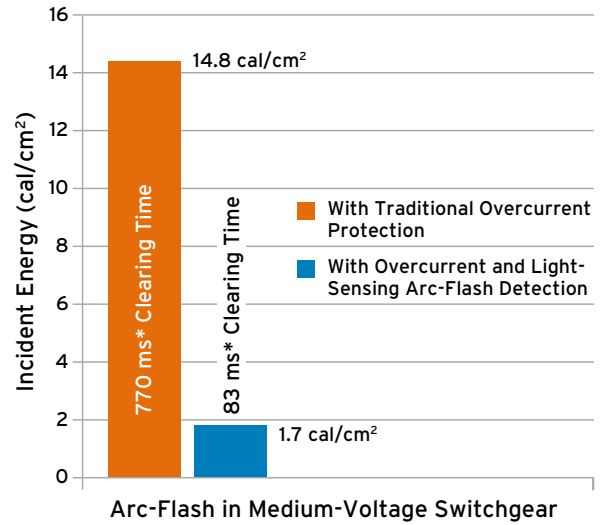
With arc-flash hazard protection, equipment damage is minimized during an arc-flash event, returning affected equipment to service faster and with less expense. In addition, power system availability is maximized.

## Maintain Selective Coordination

Arc-flash events trigger an immediate response, while coordination is maintained with downstream protection for external faults.



Above is a switchgear contactor after a 5 kV arc-flash event during which traditional overcurrent protection was applied. The damage required replacement of the contactor, fuse clips, copper bus, cable, control wiring, disconnect mechanism, and hardware.



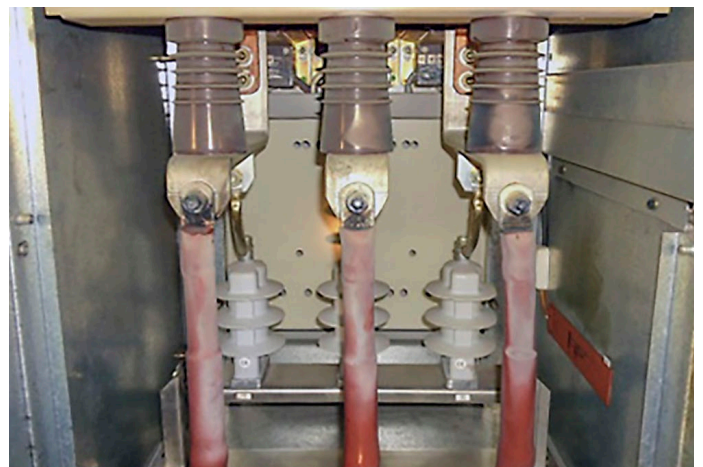
\*Assuming breaker fault-clearing time of 80 ms

## Simplify Procedures

AFD is always enabled. An operator or technician doesn't have to modify protective settings before and after performing live work to be protected from arc-flash events. Reduced potential arc-flash energy also simplifies PPE requirements, limiting the requirement of bulky "moon" suits and other movement-restricting PPE.

## Stay Outside the Danger Zone

Remain a safe distance away by remotely obtaining metering, event, and maintenance information from the relay with Ethernet or serial communications. Optional delayed breaker tripping or closing via pushbuttons allows personnel to move to a safe distance.



Shown here (before any cleanup) is the interior of switchgear that was protected by SEL light-sensing and overcurrent protection during a 6.6 kV arc-flash event. Damage was limited to arcing on the cable termination bolts.

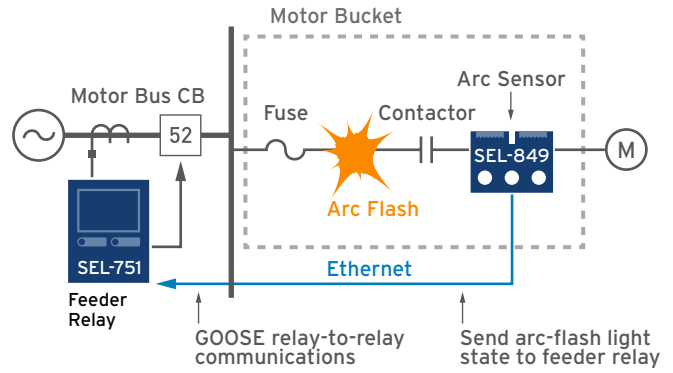
# SEL Arc-Flash Solutions

## Sensor-Based AFD

SEL AFD technology significantly decreases the time it takes a relay to trip in response to an arc fault, which reduces hazardous arc-flash incident energy. SEL combines light-sensing technology with fast overcurrent protection to provide secure high-speed AFD. Combining these technologies allows high-speed tripping during arc-flash events without overtripping for external faults.

### How It Works

Just after a fault current begins, the arc flash produces a very bright flash of light. The relay uses point sensors and/or bare-fiber sensors to detect the intense light. The overcurrent protection makes sure the relay does not trip for other sources of light, while the light sensors ensure the relay does not trip for an external fault.

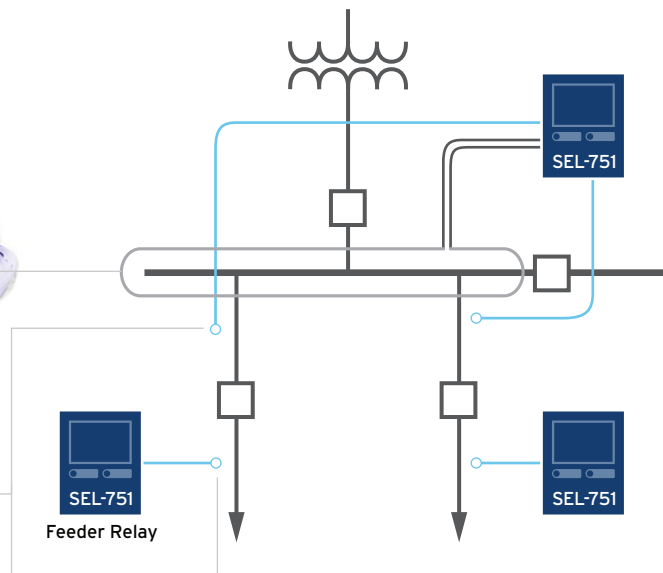


SEL AFD combines light-sensing technology with fast overcurrent protection.

Bare-fiber sensors detect light from the arc flash over the entire length of the fiber loop. This type of sensor is used for large areas, such as busbars.



Easily mounted point sensors detect light from the arc flash. This type of sensor is used for confined areas, such as breaker compartments.



## SEL Family of Sensor-Based AFD Products



**SEL-851**  
Feeder Protection Relay

**SEL-751**  
Feeder Protection Relay

**SEL-751A**  
Feeder Protection Relay

**SEL-710-5**  
Motor Protection Relay

**SEL-849**  
Motor Management Relay

# Arc-Flash Protection Using Bus Differential Relays

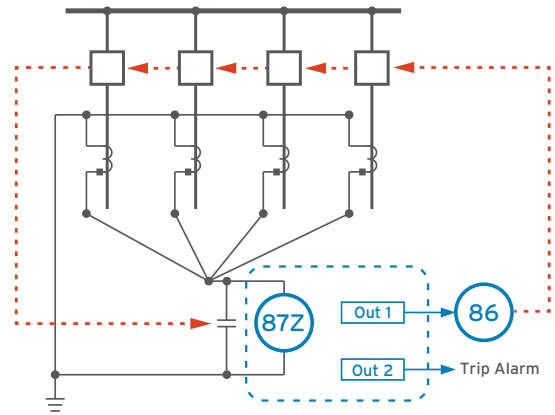
Bus differential protection is based on Kirchhoff's current law, which states that the sum of currents entering a node is zero. A bus or a protection zone is treated as a node, and current measurements are taken from all terminals connected to the bus/ protection zone. Under normal conditions or for an external fault outside of the protection zone, the currents sum to zero. During an internal fault condition, such as when an arc flash occurs within the protection zone, the currents do not sum to zero. Bus differential relays can be used to detect an internal arc-flash condition. The most common bus differential relays use either high-impedance or low-impedance differential elements.

## High-Impedance Bus Differential Relays

High-impedance bus differential relays are applied to the paralleled output of all CTs connected to a common bus. Any current difference is forced through the high impedance of the bus differential relay, causing a voltage drop across the relay. The high-impedance relay, which is calibrated and set to trip based on the voltage across the relay, provides sensitive and secure detection of an internal arc-flash condition. High-impedance bus differential relays require dedicated CTs that have the same ratio and proper polarity connection.



**SEL-587Z**  
High-Impedance Differential Relay



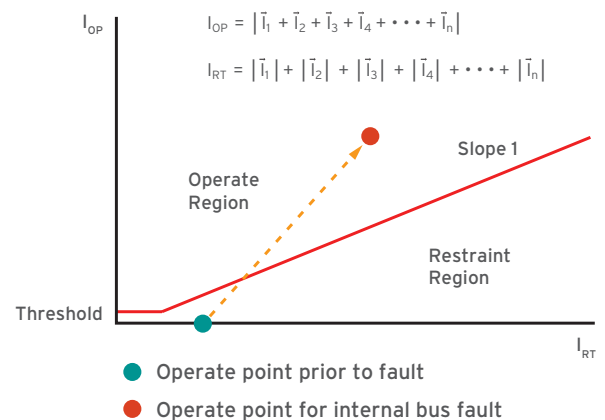
Paralleled CTs connected to a high-impedance bus differential relay.

## Low-Impedance Bus Differential Relays

Low-impedance bus differential relays do not require dedicated CTs and can share the CTs with other relays, transducers, etc. The low-impedance differential relay vectorially sums the normalized currents from all CT inputs to create the operate current,  $I_{OP}$ . The relay also arithmetically sums up the current magnitudes to create a restraint current,  $I_{RT}$ . The relay operates when  $I_{OP}$  exceeds a minimum threshold and a percentage of  $I_{RT}$ , defined by a slope setting. Advanced low-impedance bus differential relays operate in less than a cycle for internal faults and have built-in logic to remain secure for external faults even with CT saturation.



**SEL-487B**  
Bus Differential and Breaker Failure Relay



Percentage current differential characteristic of a low-impedance bus differential relay with and without an internal bus fault.

# SEL Arc-Flash Risk Assessment Services

SEL conducts flexible, customized arc-flash risk assessment services to mitigate arc-flash hazard risk, improve employee safety, and address OSHA regulations (29 CFR 1910.269), IEEE 1584b-2011, NFPA-70E-2015, NESC-2012, and CSA Z462-2015. SEL applies proven methods to create site-specific arc-flash protection and PPE requirements, among many other services for providing a complete, cost-effective arc-flash solution for your facility.

Customer benefits include:

- Protect employees and improve safety.
- Protect equipment.
- Comply with current regulations.
- Identify potential hazards.



## Power System Modeling

SEL creates a three-phase computer model of your power system in an electrical one-line format and enters facility-specific equipment and electrical data for all portions of the modeled system.

## Short-Circuit Study

Computerized electrical short-circuit studies determine fault-current levels at all electrical buses to as low as 208 volts for multiple operating configurations.

## Protective Device Coordination Study

SEL enters existing fuse, relay, and circuit breaker protective-device settings into the power system model to provide data for determining short-circuit clearing times. Graphical coordination curves can be created to prove selectivity with other protective devices.

## Arc-Flash Analysis Study

SEL calculates arcing fault currents, determines protective-device trip times, and reports incident energy, flash boundaries, and PPE categories. Arc-flash software computes incident energy levels based on 100 and 85 percent of calculated arcing currents and reports the worst case. SEL provides arc-flash analysis studies for both ac and dc systems to support a broad range of electrification environments.

## Arc-Flash Mitigation Study

For areas with unacceptably high incident energy levels, SEL investigates methods to reduce these levels by modeling current-limiting solutions, reducing protective-device clearing times, implementing differential relaying schemes, and other economical solutions.

## Arc-Flash Hazard Warning Plan

SEL provides customized arc-flash and shock-hazard warning and danger labels, detailing boundary distances, arc-flash energy levels, PPE classification levels, and other data.

PPE Level		Arc Flash Boundary
<b>#2</b>	0.1 cal/cm <sup>2</sup>	Incident Energy at 18 Inches
Failure to comply could result in INJURY or DEATH		
480 VAC	Shock Hazard when cover is removed	
3' - 6"	Limited Approach Boundary	
1' - 0"	Restricted Approach Boundary	
Equipment Name: AC-1_HV		(Date: October 2015)

## Arc-Flash Engineering Report

SEL compiles the results of each study into an engineering report, which includes the power system model for your facility.

## Field Survey

SEL assists in surveying your facility:

- Verify/obtain electrical equipment nameplate data.
- Record equipment nominal and short-circuit ratings.
- Note cable type, size, length, and insulation.
- Document electrical system topography.
- Record circuit breaker settings and relay settings.

## Detailed Engineering Study

If the ratings of existing equipment are inadequate, SEL can help by studying and evaluating alternatives. This study typically examines ways to redesign the existing electrical system to correct the deficiencies and provide a safer, more economical solution.

# Service and Support

## Ten-Year Worldwide Warranty

The SEL ten-year worldwide product warranty is proof of our confidence in the high-quality products we design, manufacture, sell, and support. This stated warranty and our track record for never charging a customer to replace or repair a defective product are the best substantiation of true quality and durability.

## Regional Technical Support

Worldwide SEL support teams provide our customers with local sales and technical service. Our commitment to quality extends through a product's installation and life as part of our customers' critical infrastructure. Application and integration engineers, customer service representatives, and sales managers truly understand the importance of local support. SEL provides personalized, regional technical support to our customers from more than 85 offices.



**SEL** SCHWEITZER ENGINEERING LABORATORIES

Making Electric Power Safer, More Reliable, and More Economical  
+1.509.332.1890 | info@selinc.com | selinc.com

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