

# ARC-FLASH CAN KILL OR MAIM KNOW THE FACTS

## WHAT ARE THE HAZARDS?

While it has been common practice to open equipment enclosures for examination, test, and/or repair, if opening the enclosure exposes anyone to energized components, a potential hazard exists. The heat energy and intense light at the point of an electrical arc is known as ARC-FLASH. Air surrounding the arc is instantly heated and conductors are vaporized causing a pressure wave termed ARC BLAST.

### *Arc-Flash*

Anything that produces electrical current has the potential to produce an arc, even a 12 volt battery. But what industry typically refers to as ARC-FLASH, is the SUDDEN release of large amounts of heat and light energy at the point of a fault. The results of such arcs are often devastating. Temperatures at the arc terminals can reach or exceed 35,000 degrees Fahrenheit (F) or four times the temperature of the sun's surface. Depending on the severity of the arc, temperatures over 400 degrees F have been recorded at distances of one foot and more from the arc.

Exposure to an arc flash frequently results in a variety of serious injuries and in some cases death. The injuries are mostly burn related and can include severe scarring and blindness. Workers have been burned even when ten feet or more from the arc center. Nearby flammable materials may be ignited resulting in secondary fires that can destroy entire facilities. Equipment can also be destroyed by fire, causing extensive downtime and requiring expensive replacement and repair.

### *Arc Blasts and Ejected Material*

An arc-flash not only includes intense heat and light but also loud sounds and blast pressures. Sound levels over 140 dB and pressures over 2,000 lbs per square foot have been recorded during tests. The arc blast often causes equipment to literally explode, ejecting parts, insulating materials, and supporting structures with life-threatening force.

As conductors are vaporized in the arc, they may project pea-sized molten particles. Three inches of vaporized #10 copper wire expands to approximately one cubic foot or 67,000 times its solid state. This violent expansion can cause tools, loose nuts and bolts, and similar items in the path of an arc blast to become projectiles. The effects are comparable to an explosive charge.

As Table 1 below illustrates, arcing events are classified in five Hazard Risk Categories. Categories are based on incident energy levels, with 0 being the least and 4 being the most hazardous.

Hazard Risk Category	Incident Energy Joules/cm <sup>2</sup>	Incident Energy calories/cm <sup>2</sup>
0	0 to 5.02	0 to 1.2
1	5.02 to 16.74	1.2 to 4
2	16.74 to 33.47	4 to 8
3	33.47 to 104.60	8 to 25
4	104.6 to 167.36	25 to 40

**Table 1.**

Category classification is determined by the calculated energy released by the arc, but does not account for the arc blast and effects of the material that could be ejected.

## POTENTIAL INJURIES

### *Direct and Secondary Burns*

At some distance from the arc, temperatures are often high enough to instantly destroy skin and tissue. Tissue damage is directly proportional to time and skin temperature. Studies show that skin temperatures above 205° F for 0.1 second result in irreversible tissue damage, defined as an incurable burn. Skin temperature is primarily determined by the intensity of the flash, the distance from the arc, and the exposure time. Table 2 shows effects for other temperatures and duration times.

Skin Temperature	Time Duration	Effect on Skin
110° F	6 hours	Cell breakdown begins
158° F	1 sec.	Complete cell destruction
176° F	0.1 sec.	Curable burn
205° F	0.1 sec.	Incurable burn

**Table 2.**

Heated air and molten materials from arc faults often cause ordinary clothing to burst into flame even if not directly in contact with the arc. Unless the clothing is flame retardant, it may continue to burn increasing the area of injury. Synthetic fibers such as nylon and polyester may melt, adhere to the skin, and continue to burn after the arc is extinguished, resulting in more severe secondary burns.

### *Vision and Hearing Injuries*

Even when regular safety goggles or glasses are worn, arc-flash may cause severe damage to vision or blindness. Intense ultraviolet (UV) light created by arc-flash can burn the eye's retina. Exposure to UV light can cause a feeling of grit in the eye, blurred vision, burning sensations, eye tearing, and even headaches. The pressure created by the arc blasts can also compress the eye severely damaging vision, possibly rupturing

the eyeball. If proper eye protection is not worn, ejected materials and flying particles can impact the eye and cause further damage.

Hearing can also be affected by the loud noises and extreme pressure changes created by arc blasts. Sound and noise levels are commonly measured in decibels (dB). OSHA defines the permissible exposure limit (PEL) at 90 dB and requires workers who are exposed to average levels of 85 dB or higher to use hearing protection. The average threshold of pain for hearing is 130 dB. A sound increase of 3 dB is equivalent to the sound level doubling. Published test data has shown arc blasts to exceed 140 dB, which is 8 times the pain threshold and the equivalent of a jet airplane taking off. Sudden pressure changes exceeding 720 lbs/ft<sup>2</sup> for 400 milliseconds can also rupture eardrums. Even at lesser pressures, serious or permanent damage to hearing may occur.

## KNOWING THE FACTS

While great strides in equipment design have reduced the number of electrical faults, the increased use of electricity has resulted in larger and larger electrical systems capable of releasing almost unlimited energy into faulted circuits. Numerous studies into the hazards of electrical faults and the accompanying arc-flash, pressure waves, and sound blasts indicate that workers should not work on energized equipment.

For more information on Arc-Flash, refer to Littelfuse Whitepaper *Understanding and Reducing Arc-Flash Hazards* at [www.littelfuse.com](http://www.littelfuse.com).