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**Arc Flash Study**

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**Analysis of Arc Guard  
Technology**

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Becker Mining America

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## Introduction

An investigation has commenced to study the understanding of arc flash, compare technology available, and recommend a solution for project GBCSLPD01.

In the occurrence of an electrical arc condition the results are equipment damage, downtime costs, litigation costs, workman's compensation costs, and personnel injury from:

- Burns (non FR clothing can burn onto skin)
- Fire (could spread rapidly through area injuring personnel in not immediate area)
- Flying debris (molten metal)
- Blast pressure (2,000 lbs / sq. ft)
- Sound blast (140 db – as loud as a gun)
- Heat (upwards of 35,000°F)

## History – Understanding Arc Flash

An arc flash is a sudden release of heat and energy caused by an electric arc where a flashover of electric current leaves its intended path and travels through the air from one conductor to another, or to ground. The results are often violent and when a human is in close proximity to the arc flash, serious injury and even death can occur.

Arc flash can be caused by many things including:

- Dust
- Dropping tools
- Accidental touch
- Condensation
- Material Failure
- Corrosion
- Faulty installation

Three factors determine the severity of an arc flash injury:

- Proximity of the worker to the hazard
- Temperature
- Time for the circuit to break

Because of the violent nature of an arc flash exposure when an employee is injured, the injury is serious – even resulting in death. It's not uncommon for an injured employee to never regain their past quality of life. Extended medical care is often required, sometimes costing in excess of \$1,000,000 according to OSHA studies.

As much as 80% of all electrical injuries are burns resulting from an arc-flash and ignition of flammable clothing. Arc temperatures can reach 35,000°F, which is four times hotter than the surface of the sun – fatal burns can occur at distances over 10ft.

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## Health and Safety Concerns

Arc exposure energy basics:

- Exposure energy is expressed in cal/cm<sup>2</sup>
- 1 cal/cm<sup>2</sup> Equals the exposure on the tip of a finger by a cigarette lighter in one second
- An exposure energy of only one or two cal/cm<sup>2</sup> will cause a 2<sup>nd</sup> degree burn on human skin

Occurrences involving human exposure to Arc Conditions

1. Surface Phosphate Mine – A miner was injured while preparing to add a 1000 ft. cable to a junction box on a 7,200 volt power circuit. The victim opened the junction box and placed the static grounding clamp assembly across the corner of the open junction box. The grounding clamp assembly fell into the junction box making contact with the energized conductors. An arc flash occurred severely injuring the miner.
2. October 10, 2010 - Michael A. Solomon, contract apprentice electrician, age 42, and two co-workers were seriously injured when an arc flash occurred. They were performing maintenance work on an electrical circuit breaker. The circuit breaker was in the "OFF" position but remained energized on the input side. They were all hospitalized. Solomon died on October 12, 2010, as a result of his injuries.
3. March 23, 2003 – Energy Plus, Inc. Number 50 Mine. A section foreman was using 2-phases of the 480 volt, resistance grounded, 225 amp output, on the section power center to detonate explosives during construction of a boom hole. This resulted in an electrical arc flash that produced intense heat, resulting in serious burns to the victim's hands and face. The victim died on April 10, 2003 from complications due to these injuries.
4. October 12, 2006 – United Plant Mine. A 24-year old maintenance coordinator, with 1 year and 4 months mining experience, was fatally injured at an iron ore operation. The victim was troubleshooting an electrical fault in a high-voltage motor control center when a sustained arc blast occurred.
5. Burro Chiefe Copper Company – An electrical supervisor was fatally injured while testing a 480 volt electrical circuit breaker. An arc phase fault occurred at the breaker, resulting in an arc flash that injured the supervisor and two other miners. The supervisor died due to injuries sustained in the accident.
6. An electrical accident caused the death of one contract electrician and seriously injured two coworkers. They were installing ground fault indicator lights in a circuit breaker enclosure when an arc flash occurred. They were not aware the circuit breaker enclosure contained a bottom feed circuit breaker and had locked out the wrong disconnect.

These instances of human exposure provide useful evidence of the possible human health effects due to exposure to arc flash incidents.

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## Equipment and Arc-Resistant Standard

Switchgear sections with compartments containing power circuit breakers, bus, and cable are the primary means for managing an industrial facility's electrical distribution. In fact, switchgear is the heart of such facilities.

Switchgear is an engineered-to-order product, meaning it is custom-built by the manufacturer to the exact specifications that meet a given facility's needs. It's also built to handle the rigors of day-to-day power needs over multiple decades, and if well-maintained, it will operate optimally to clear any fault condition.

But while maintenance is critical and should be performed on a regular schedule, situations arise that can't be predicted, such as an arc fault that occurs within a switchgear section. (For recommendations on proper maintenance intervals, see the 2006 edition of the National Fire Protection Assn.'s NFPA 70B consensus standard "Recommended Practice for Electrical Equipment Maintenance.") The likelihood of that happening is rather remote—if one occurs, it's typically caused by an external source. Meaning personnel is located within the limited boundary area and most likely will be injured.

No matter the source, the heat and pressure generated by an internal arc fault can have devastating consequences for anyone in close proximity to the switchgear or the equipment itself, and ultimately the facility owner and his business. That's why many facilities have deployed Arc Guard® Technology to their operations, designed to direct heat and pressure of an arc fault away from nearby personnel. In this fashion, the chances increase that the personnel and switchgear section can be saved. In addition, the time and monetary costs to completely replace a destroyed section can be avoided.

## Arc Resistant Standard

When an arc fault occurs within a confined space, such as a circuit breaker compartment within a switchgear section, the arc energy is converted into heat, resulting in a rapid pressure increase than can cause an explosion that will heavily damage the switchgear and endanger nearby personnel. As defined in ANSI/IEEE C37.20.7-2007, the intention of arc-resistant switchgear is "to provide an additional degree of protection to the personnel performing normal operating duties in close proximity to the equipment while the equipment is operating under normal conditions." (See ANSI/IEEE C37.20.7, section 1.2.2)

According to the standard, normal operating conditions entail:

- Opening or closing switching devices
- Connecting and disconnecting withdrawable parts
- Reading of measuring instruments and monitoring equipment.
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This is a performance standard, not a construction standard. It does not specify how switchgear should be built to increase arc resistance, but rather what the results in a test laboratory must be in order for switchgear to be considered arc resistant.

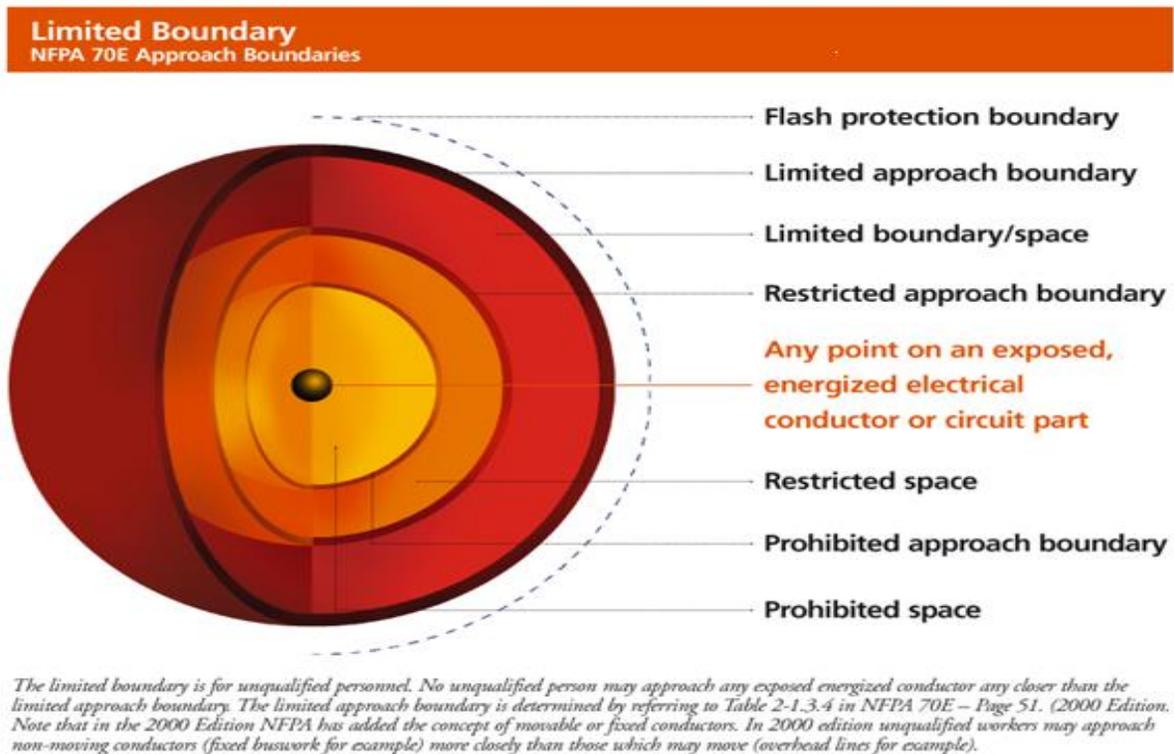
Becker Mining's Arc Guard® system is the only system which passes this performance standard above 1000 volts. It will protect personnel walking by or working in close proximity of the switchgear from the effect of an arc fault.

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## Remote Closing Solution

Given the nature that fatal burns can occur at distances over 10ft it is not recommended to use remote closing in place of arc resistant build equipment. This alternate choice can result in injury, death, equipment replacement costs, and accident litigation costs. Also, understanding his operation and personnel on arc flash training is imperative. The worker must understand boundary limitation each time operating on the equipment.

The National Fire Protection Association (NFPA) has developed specific approach boundaries designed to protect employees while working on or near energized equipment. These boundaries are:



## Electronic Relay Solution

These devices are designed to detect an arc flash and send a trip signal to a circuit breaker, which reduces the total clearing time and subsequent damage. This is accomplished by providing an output that directly activates an electrical system circuit breaker to cut off current flow to the arcing fault.

Unfortunately, this solution requires:

- Fiber to run throughout the equipment
- Light to be present to activate – arc condition happens
- Personnel are still exposed to the arc flash
- System maintenance in order to ensure the relay is functioning properly

Table 1 – Approach Boundaries

Nominal System Voltage Range	Limited Approach Boundary		Restricted Approach Boundary	Prohibited Approach Boundary
	Exposed Moveable Conductor	Exposed Fixed Circuit Part		
Phase-to-Phase			Includes Inadvertent Movement Adder	
0 - 50	Not specified	Not specified	Not specified	Not specified
51 - 300	10 ft. 0 in.	3 ft.6 in.	Avoid contact	Avoid contact
301 - 750	10 ft. 0 in.	3 ft.6 in.	1 ft. 0 in.	0 ft. 1 in.
751V - 15 kV	10 ft. 0 in.	5 ft.0 in.	2 ft. 2 in.	0 ft. 7 in.
15.1 – 36 kV	10 ft. 0 in.	6 ft.0 in.	2 ft. 7 in.	0 ft. 10 in.
36.1 – 46 kV	10 ft. 0 in.	8 ft.0 in.	2 ft. 10 in.	1 ft. 5 in.
46.1 – 72.5 kV	10 ft. 0 in.	8 ft.0 in.	3 ft. 3 in.	2 ft. 1 in.
72.6 – 121 kV	10 ft. 8 in.	8 ft.0 in.	3 ft. 3 in.	2 ft. 8 in.
138 – 145 kV	11 ft. 0 in.	10 ft.0 in.	3 ft. 7 in.	3 ft. 1 in.

## Arc Guard® Technology

Standard mining electrical equipment is designed to withstand the mechanical forces generated by bolted faults on the load terminals until a power circuit breaker or other protective device can interrupt the of fault current. However, this design is not capable of protecting against internal arcing faults. During an arcing fault, the voltage at the fault location is essentially the system voltage and the fault energy is focused within the equipment. As temperatures rise to or above 35,000°F the metal parts vaporize and create thousands of pounds of impact force. The expanding plasma creates severe mechanical and thermal stress in the equipment, which can blow off top covers, panel doors, and burn

through the enclosure. Personnel located in this area based on the NFPA boundary areas will be severely injured or worse, death will occur.

Becker Mining America offers Arc Guard® technology, an arc resistant open type mining electrical equipment designed to eliminate arc flash potential and provide an additional degree of protection for personnel performing normal operating duties in proximity to the energized equipment. Such duties include opening or closing breakers, changing relay settings, programming PLC's, reading instruments or other activities that do not require cover removal. The standard features of the Arc Guard® include:

- Protection to miners at the front, back, and sides of the equipment.
- Does not depend on light or electronics. It's a mechanical system that will not fail and does not have to be maintained.
- Performance tested to ANSI/IEEE C37.20-2007
- Reinforced enclosure to withstand pressure from internal arcing faults
- Internal venting system with pressure dams and pressure vents to channel the flow of arc fault gases and vent these gases out the top of the gear and away from personnel
- Reinforced sealed top covers and panels
- Reinforced bolted covers
- Ventilation inlet/outlet shrouds

## Conclusion

Based on this study, we recommend Becker Mining America's Arc Guard® technology which is patented under USPTO 8,648,274 and is the best option for arc resistant power distribution equipment. This eliminates the potential of arc flash injury, meets ANSI/IEEE C37.20.7-2007 allowing personnel the most protection possible.

What arc-resistant switchgear can provide is safety & cost management—an arc fault event that is averted due to the Becker Mining America's Arc Guard technology can prevent a major capital expenditure for new switchgear, or lost business due to processes that have to be halted because power simply isn't available. That also doesn't begin to cover the potential healthcare and litigation costs due to worker injury.

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