ARC FLASH RISKS AND THEIR COSTLY REALITIES

Electrical Safety White Paper

Honeywell
SALISBURY

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INTRODUCTION

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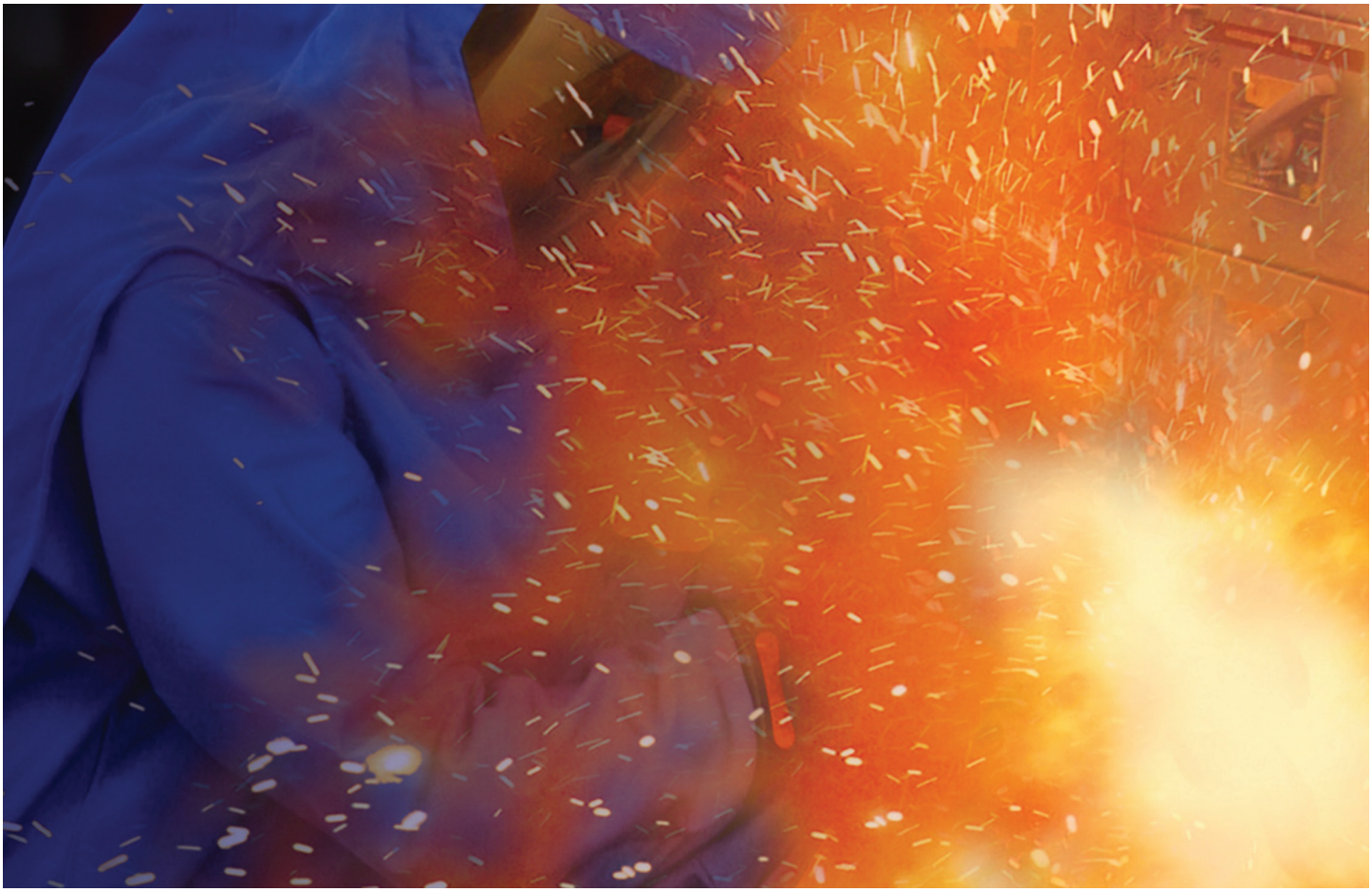
Every year, about 76,000 workers are disabled due to serious shock and burn injuries.[1] One of the most significant dangers to industrial workers are arc flashes. Learn the science behind arc flashes, their expensive toll on both human lives and businesses, and real-world preventative measures you can put in place against electrical hazards.



1. Surveys of Occupational Injuries and Illnesses
U.S. Bureau of Labor Statistics

YOUR MISSION: KEEP YOUR WORKERS SAFE

2

ARC FLASHES ARE ONE OF THE MOST DANGEROUS AND PERVASIVE ELECTRICAL SAFETY ISSUES

They occur when electrical current passes through air between two or more conducting surfaces or from conductors to ground. They are hard to predict, difficult to prevent and challenging to protect against.

Graeme Edwards, a unit controller with more than 30 years experience, was reinstalling a high-voltage circuit breaker at an Australian power station. Although the procedure was routine, it was obviously potentially hazardous. So, Edwards did his work during a planned outage.

Despite the outage, a phase-to-phase arc flash caused an explosion, and that explosion led to Edwards's death, reported EnergyAustralia.[2] Nobody is sure who or what was at fault – ethically or electrically.

Despite best intentions and the company trying to repair the damage, a trained professional passed away, leaving behind a grieving family and coworkers.

You wouldn't want to find yourself in the shoes of Edward's employer – and yet, can you be sure you won't?

As with all dangerous things, the first step in prevention is education. This guide helps you understand the full impact of arc flashes – also called arc blasts or electrical arcs[3] – from injury incidence to both human and financial costs.

That's especially important these days, because so much industrial and consumer equipment relies on power-hungry electrical devices.

For example, although electric car adoption is on the upswing, a vehicle's operating voltages, at different frequencies, may make it more difficult to protect against direct and indirect contacts.[4]

ARC FLASHES HAVE SEVERAL CAUSES.

They include:

- Gaps in insulation
- Corrosion
- Condensation
- Dust or other impurities on a conducting surface

2. Bryce Eishold. "Phase-to-phase arc flash" caused explosion: EnergyAustralia, Latrobe Valley Express, November 20, 2018
3. "What is Arc Flash?", E-Hazard
4. "Electrical Safety of Plug-In Electric Vehicles," IEEE Industry Applications Magazine, May/June 2018

A REMINDER OF ELECTRICAL HAZARDS

3

Electricity presents an impressive number of ways to get hurt including shock, burns and blasts

> Electrical hazards are an all-too-common source of injury. Electrical safety accidents perpetually rank in the top 10 of industrial fatalities.[5]

ARC FLASHES PRESENT A SIGNIFICANT DANGER AND REGULARLY CAUSE SERIOUS INJURIES

It's critical for workers to understand the importance and function of protective equipment and procedures. Let's put arc flashes into context, because they aren't the only form of electrical injury.

The main hazards are:

- Contact with live parts which causes shock and burns
- Faults, which could cause fires
- Fire or explosion where electricity could be the source of ignition in a potentially flammable or explosive atmosphere.[6]

THE INJURIES CAN BE COMPLEX

Electrical injuries can produce multisystem trauma and a range of complications, including cardiopulmonary arrest, cardiac arrhythmia, hypoxia, renal failure and sepsis, according to the Fire Protection Research Foundation.[7] "Exposure to electricity may also produce long-term neurological and psychosocial effects and significantly influence the quality of life," the report added.

Sadly, there is a lot of data to draw on.
Over the last 10 years, according to the Electrical Safety Foundation, more than 46,000 workers have been injured by on-the-job electrical hazards.[8] The foundation says a worker suffers a lost-time, electrically-induced injury every 30 minutes during the work day.[9]

Unsurprisingly, engineers, electricians and overhead line workers are the most exposed to electrical hazards because they are busy repairing, testing and installing equipment, according to *Safety Culture*.[10]
The BLS says most electrical injuries are caused by touching live conductors, such as a machine's wiring or transformers, but electrical injury can occur anyplace there is a power plug.

THE ARC FLASH RISK

A study of electrical injuries over a 20-year period at a Texas burn center found that 40 percent of burns were the result of arc flashes. While mortality was the lowest relative to other electrical burns in this group, the burn size was the largest and the mean length of hospital stay was 11.3 days.[11]

IN OTHER WORDS:

Arc flashes can cause traumatic and long-lasting effects.

5. Keith Bilger. "Electrical Safety Basics: Not Exactly Shocking," *Occupational Health & Safety* , October 1, 2013
6. "Electricity in the Workplace," Health and Safety Authority
7. Richard B. Campbell, ScD, NFPA; and David A. Dini, P.E., UL, LLC. "Occupational Injuries from Electrical Shock and Arc Flash Events" National Fire Protection Association, March 2015
8. Rex A. Ferry. "Zeroing in on Electrical Safety in the Workplace" *Electrical Contractor*, July 2009
9. Workplace Fatalities and Injuries 2003 – 2016, Electrical Safety Foundation International
10. "7 Common Electrical Hazards in the Workplace," *Safety Culture*
11. Arnoldo BD, Purdue GF, Kowalske K, Helm PA, Burris A, Hunt JL (2004). "Electrical Injuries: A 20-Year Review," *Journal of Burn Care Rehabilitation 2*, 2004

According to the Bureau of Labor Statistics (BLS), about 76,000 workers are disabled every year due to serious shock and burn injuries.

THE CONSEQUENCES ARE SEVERE

4

Arc flashes are the root cause of burns and other serious health and safety risks.

"The flash and heat happen so fast that you literally burn your throat and lungs inhaling in that split second," explained one colleague of an electrician who had died in such an incident.

ELECTRIC ARCING PRODUCES TEMPERATURES AS HIGH AS 35,000 DEGREES — HOTTER THAN THE SURFACE OF THE SUN

Even though the victim hasn't touched anything he or she may be fatally injured; fatal burns can occur over a distance of 10 feet.

Burns pose a significant danger. As much as 80 percent of electrical injuries are burns resulting from an arc flash and after effects such as ignition of flammable clothing. Arcs typically release five to 30 calories. Exposure to just one to two calories causes second-degree burns. In 0.1 seconds, a worker can get a third-degree burn. And the odds of someone surviving a burn decrease as age increases.

There are other debilitating effects. Hearing loss, eye injury, skin damage from blasts of molten metal, lung damage and blast injury can all occur from an arc blast.

These explosive blasts — with equipment and manufacturing substances airborne until they reach a human body—can be an additional safety factor. Personal protective equipment (PPE) can shield a worker from the radiation of an arc flash, but that same PPE may be ineffective against the flying objects, molten metal and violent concussion that the arc blast can also produce.

ARC FLASH: MORE PERVASIVE THAN YOU MIGHT THINK

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So what, exactly, is an arc flash? What causes one?

AN ARC FLASH IS A COMPLEX PHENOMENON FORMED BY IONIZED GASES WHEN ELECTRICITY TRAVELS THROUGH AIR

It occurs due to a breakdown of insulation from air or another insulator, which causes the air to ionize. The ionization has two effects: a blast and radiation release. The "flash" part — the blast — is the light and heat produced from the arc fault: thermal energy, acoustical energy, a pressure wave and debris. It's a loud, hot blast of electrical energy and you don't want to be anywhere nearby.

The size of the blast is a function of fault current, container size and other parameters, including magnetic forces. Among the variables that affect an arc flash's size and energy are amperage, voltage, closure time and the physical properties of the space (such as if it is a confined space and the distance between the arc and anything nearby).

Although the assumption is that low-voltage equipment is safe from arc flashes, that isn't necessarily so. It's possible to have arc flashes at low voltages, as a result of high fault currents.

In most cases, electrical injuries are caused by human error. Everyone has careless moments: touching the wrong surface, using the wrong tool or abandoning a proper work process. Education helps, at least in maintaining awareness (and electrical workers can benefit from a reminder of behavior-based safety precautions).

However, maintenance practices may also be at fault. Among the other common sources of arc flashes are obstructions in disconnect panels, improper preventative maintenance for circuit breakers and switches, and exposed live parts, loose connections or corrosion. Also, some dangerous situations are environmental; for example, static electricity or the exposure of electrical equipment to water or other liquids.

With so many factors in play, prevention is difficult and postmortems challenging. In the case of the power company employee who died in Australia, for instance, there were indications that a cable connecting the circuit breaker to the station control system may have found an "electrical source," which could have caused the explosion.[12]

12. Bryce Eishold. "Yallourn fatality update released" Latrobe Valley Express, December 6, 2018

CORPORATE COSTS

6

You want your people to go home safe at night, every night.

YOUR FIRST THOUGHT GOES OUT TO THE PEOPLE WHO WORK FOR YOU:

The electrician who ensures that the lights stay on, the construction worker who shows up early every day, and the reliable inspector who is conscientious about testing equipment thoroughly.

If you need statistics to prove that electrical injuries affect the company's bottom line, as well as its people, here are a few numbers to give the subject some scope.

- Prevention costs far less than taking your chances. The Wisconsin Safety Council estimated that for every dollar spent on training, three dollars are saved on injury costs.
- Inspections also work to decrease workplace injuries. Companies that received an OSHA inspection saw a decline of 9.4 percent in injuries, and the average company saved $350,000 over the five years after the inspection. That's a lot cheaper than medical expenses (and doesn't even take into account their effect on medical insurance premiums).
- The National Safety Council estimates that work-related injuries of all types can cost businesses well over $30 million in fines, medical bills, litigation, lost business and equipment costs. Moreover, the safety council says medical expenses for severe electrical burns can exceed $4 million per person.
- A Mission Critical study says the average electrical accident costs $750,000, with hospitalization expenses typically $200,000 to $750,000, many over $1 million. While a worker is in the hospital, he isn't on the job; you have to hire someone else to get the work done.
- Even when an injury is not fatal, it is often excruciatingly painful and may require a long time to recover. The average hospitalization is 19 days, according to the Workplace Safety Awareness Council,[13] at costs exceeding $18,000/day.
- Even if you are lucky enough to avoid injury, failure to implement protective measures can be expensive. Willful or repeat OSHA violations can bring penalties of $5,000 to $70,000 for each violation.
- OSHA's statistics say that 80 percent of electrically related accidents and fatalities involving "qualified workers" are caused by arc flash. Between 2007 and 2011, more than 2,880 fines were assessed for not meeting OSHA regulation 1910.132(d), which averages out to 1.5 fines a day.

13. Work Place Safety Awareness Council

The Wisconsin Safety Council estimates that for every dollar spent on training, three dollars are saved on injury costs.

Don't be one of the noncompliers.

TAKE STEPS TO PREVENT ELECTRICAL INJURIES 7

> As with any sort of behavioral safety process, the best way to cope with a danger is to avoid the situation and stay out of harm's way. If you can't do that, minimize the risk, and then ensure that the people who do put themselves in jeopardy are protected in every way possible.

In one survey of arc flash injury victims, 94 percent of respondents believed that the incident could have been prevented.[14]

The prevention method most often referred to was to simply,

"TURN THE POWER OFF."

TO PREVENT WORKPLACE ELECTROCUTIONS:

- Train workers in electrical safety
- Implement and follow safe work procedures
- Follow corresponding OSHA, NEC or NESC requirements
- Implement and follow Lockout and Tagout (LO/TO) procedures

Training is more than an occasional talk. Improve safety training and risk awareness across the organization — and not just because OSHA requires it. As a safety professional and a caring colleague, one of your responsibilities is to raise the employees' awareness of their actions and the possible results. Employees must understand the consequences of any missed protocol and understand why they should follow proper safety procedures at all times (even when nobody is looking).

Among the best guidelines to follow:

- Ensure your company has a written safety program that identifies risks, sets boundaries and establishes the PPE needed to protect workers from arc flashes and other electrical hazards.
- Document the electrical regulations and work processes. Provide the training and tools to ensure they are understood and consistently enforced.

14. Fire Protection Research Foundation: "Occupational Injuries from Electrical Shock and Arc Flash Events"

SAFE WORK PROCEDURES SHOULDN'T BE A CHECKLIST THAT SOMEONE SHOVES IN A DRAWER

Safe work procedures include:

- Establishing a ***preventative maintenance program*** for electrical materials.
- Ensuring that only ***fully trained personnel***, equipped with proper tools and PPE, are permitted to work on electrical systems.
- Making sure there is a ***prework job briefing for every task***, giving workers information about the specific job site or other unique issues.
- ***Knowing your territory.*** Use low-risk technology wherever you can.[15] Collect data about your facility's power distribution system, and conduct short-circuit and protective device coordination studies to identify arc flash hazard categories for electrical equipment, as well as how to reduce them. Adjust the settings for circuit breakers and energy distribution systems where needed, and replace high-risk electrical equipment with devices that reduce incident energy.
- ***Eliminating hazards as much as possible.***[16] Before you start any electrical task, de-energize the equipment and get people out of the way. Take extra care while testing to ensure equipment has been de-energized. Use remote tracking technology to operate circuit breakers from outside an arc flash boundary instead of allowing personnel to be put at risk of injury or death.

There are plenty of requirements documents and industry standards to guide you, including recommendations to use flash hazard labeling. There are experts who have figured out the processes; you don't need to start from scratch.

One of these processes is issuing work permits for hot work.
The Fire Protection Research Foundation[17] recommends that you require a written work permit every time a worker operates inside a restricted approach boundary where there's an increased danger of arc flash.

15. Arc Flash: What Is It, Why Does It Happen, and How Can You Avoid It?
16. Arc Flash: What Is It, Why Does It Happen, and How Can You Avoid It?
17. Occupational Injuries from Electrical Shock and Arc Flash Events

PPE HELPS YOU MANAGE RISK

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> No worker should get near electrical equipment without wearing the right PPE.

YOU MAY FOLLOW ALL THE SAFETY PROCEDURES AND COMPLY WITH ALL THE RULES

It's obvious that electrical hazards are unpredictable. A worker cannot know if the workspace had a water leak, or if the wind will whip the wires to a place where they shouldn't be. The consequences of a "minor" misjudgment are not minor when it comes to electrical power.

As a result, the final important step in protecting workers from electrical injury is PPE.
It is the last line of defense, after all the other steps have been taken in a safety plan; don't treat PPE as an invincibility shield. Electrical hazards are frighteningly powerful.

Everybody who gets near a power plug should wear the appropriate gear.
"Appropriate" is important; make sure you provide the exact PPE needed for every application.

Honeywell Salisbury's hard hats, footwear, helmets, eye protection and flame-resistant clothing all help to reduce risk and minimize injury for your employees working with electricity

CONCLUSION

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Turn to Honeywell Salisbury for assessment, training and PPE.

Hundreds of deaths and thousands of injuries occur each year due to electric shock, electrocution and arc flash. Almost all of these tragic events are preventable. A clear understanding of the dangers involved is vital to worker safely. So is a culture-driven adherence to well-vetted and correctly executed processes and procedures. **Personal protective equipment is the last line of defense and is crucial in the safety process.**

Developing a comprehensive safety plan takes know-how —and we have that expertise. In addition to providing a comprehensive line of PPE products optimized for electrical needs, Honeywell Salisbury has an assessment service to help you ask the right questions. We'll come to your company site to evaluate your safety process and its compliance, from sticker warnings to PPE. Engineers assess the site's infrastructure and recommend products in a single turnkey package.

Visit our site **www.honeywellsafety.com** or contact a Honeywell representative at Honeywell Salisbury to learn more about establishing a mature safety environment.

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