ELECTRICAL SAFETY AND ARC FAULT HAZARDS

The development and implementation of arc fault safety controls in Australia is beginning to gain traction, however it is still far from widespread. There are obviously exceptions, however it is unfortunate that business and organisations have generally only made moves to include arc fault safety into their safety programs after they or someone close to them has experienced an arc fault incident.

By Brett Cleaves, Engineering Safety

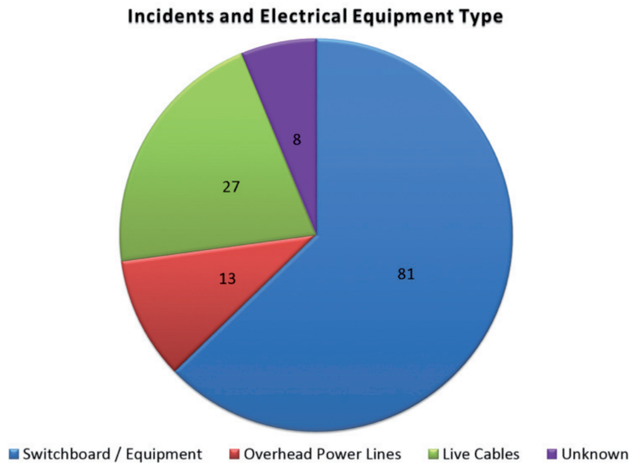
To put it in perspective, Australian Standard AS4836 Safe Work on Low Voltage Electrical Installations 2001 specified that electrical workers working on or near exposed energised conductors shall wear flame retardant clothing covering the full body. Engineering tools to assist with the development of controls have been available since 2002. AS 3000, the local wiring rules included changes to help protect people and equipment in Australia in 2007. In that year, I also first presented work on the BlueScope Steel arc fault analysis results and controls. In 2011, AS4836 was revised to include task and equipment based recommendations for the use of arc rated face shields, arc rated suits and hoods. Aside from the great work by Ausgrid, the NENS 09 committee and a number of revisions of overseas standards the resistance to act on or recognise the risk locally has continued. Many companies seem to be waiting for the next revision of the standards in the hope that they will better describe the process needed to control the risks. It is unfortunate, as the incident statistics included in this article show that people continue to be burned interacting with low and high voltage apparatus. It is also important to note that legislation is already in place requiring risk assessment and control of all electrical hazards including arc faults. The next revision of the key US IEE1584 standard has been under development for years and may take many more years to be ratified for use in Australia.

ARC FAULT INCIDENTS IN AUSTRALIA

With respect to burns from arc faults we generally get quoted United States figures by their manufacturers of arc fault equipment. This can incorrectly result in the belief that the problem is unique to the US and mostly due to their standards and work practices. In Australia, we typically only ever hear of the extreme incidents such as the tragic Morley Galleria incident in February 2015 and many of the lesser injuries go unnoticed by all but those closest to the people involved. The following statistics are from burn data supplied by the NSW Health Agency for Clinical Innovation Statewide Burn Injury Service from June 2003 to March 2016. The data only included burn patients treated at the NSW major burns units where the major contributing thermal source was electricity.

Of the 433 incidents reviewed Engineering Safety concluded that 129 of the injuries were due to arcing faults from people working on or near electrical apparatus. The remainder were due to contact burns, criminal activity such as copper theft, extra low voltage battery systems, or suicide attempts. 11% of the patients experienced superficial burns only, leaving 89% suffering the equivalent of second or third degree burns to at least 1 part of their body. The superficial only burns typically included burns to the hands and or face. There would have been many more superficial and possibly worse burns during this time treated at other hospitals and medical centres and not referred to the specialist burns units.

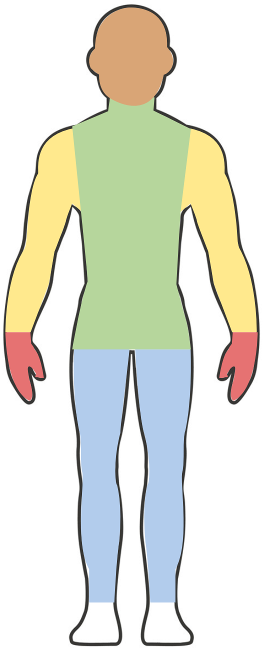
Statistically in NSW, the best year was 2004 with no incidents; the worst was in 2007 with 21. From 2005 to 2015 there were on Average 11.6 people burned working on or near electrical apparatus each year from arc faults. The average percentage body burn for the incidents was approximately 6.4%. To put that in perspective your whole hand is approximately 2.5% of your body. Only 2 of the 129 patients were female and the average patient age was 37 years. 78 of the 129 injured required admission into one of the specialist burns units for treatment with the rest treated as outpatients. The following chart outlines the electrical equipment involved.



Contact with overhead power lines generally did not involve electrical workers and included the only fatality in 2006 where the patient suffered burns to 75% of their body. Burns from live cables resulted primarily from cutting, drilling or digging activities. Incidents involving work on switchboards or electrical equipment accounted for almost 63% of all incidents. The data collected did not record the voltage level or if there was an associated electric shock. The incident description was used to ascertain the type of equipment. The majority of the descriptions that included a voltage for Switchboard and equipment incidents listed low voltage.

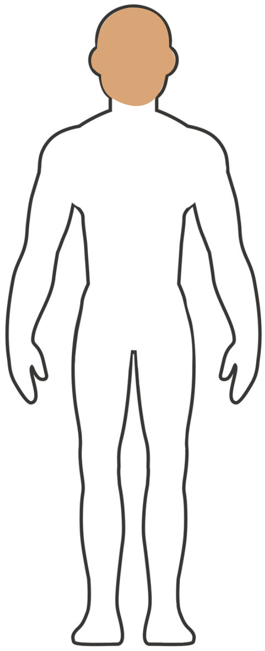
LOCATIONS OF BURNS

66%	Hands
57%	Head/Face
55%	Arms
54%	Face
16%	Torso
15%	Legs



SEVERITY OF FACE BURNS

Superficial Dermal	48.5%
Mid Dermal / Superficial	20%
Mid Dermal	28.5%
Deep / Mid Dermal	3%
Deep Dermal / Full Thickness	0%

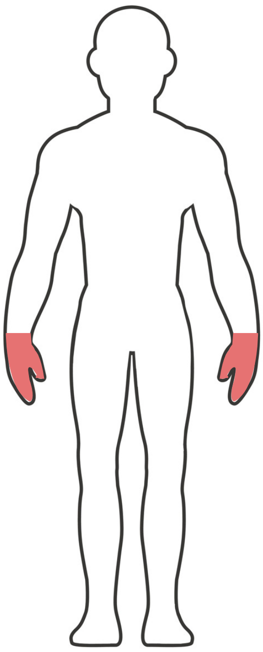


It is no surprise that the hands were involved in 66% of cases, as they are closest part of the body to any task related incidents. Burns to the head/face were the next most common, just eclipsing the arms. The head/face area was involved in 57% of injuries. Aside from safety glasses, traditional PPE leaves much of the head/face exposed, which likely accounts for the high incidence of injury. The face on its own received burns in 54% of incidents indicating that the patient was facing the source of the fault. More than half of the patients received burns to the arms. The majority of patients received burns to multiple parts of their body.

SEVERITY OF HAND BURNS

The table includes the newer clinical classification of burns. Translating into old school terms, first degree is equivalent to Superficial Dermal, third degree burns are Deep Dermal/ Full Thickness, and second degree burns cover the middle three dermal bands. 40% of patients with hand burns experienced burns to both of their hands.

Superficial Dermal	22%
Mid Dermal / Superficial	13%
Mid Dermal	37%
Deep / Mid Dermal	10%
Deep Dermal / Full Thickness	18%



Thankfully, the severity of burns to the face is typically less than that of the hands, however over 50% of the patients with facial burns were classified as second degree. The data indicated that over 91% of patients with facial burns included mostly more severe burns to other parts of the body.

AUSTRALIAN STATUTORY REQUIREMENTS

Under current federal work place health and safety laws, businesses are required to identify and control hazards so far as is reasonably practicable as per the hierarchy of controls. State based codes of practice provide supporting detail under the act to help describe the requirements for a number of hazardous areas including electrical. The electrical codes of practice are standard across all states excluding Victoria, which has similar requirements in its Electrical Safety Act and regulations. The codes of practice outline that a person conducting a business has the primary duty under the act to ensure that workers and other persons are not exposed to electrical risks arising from the business.

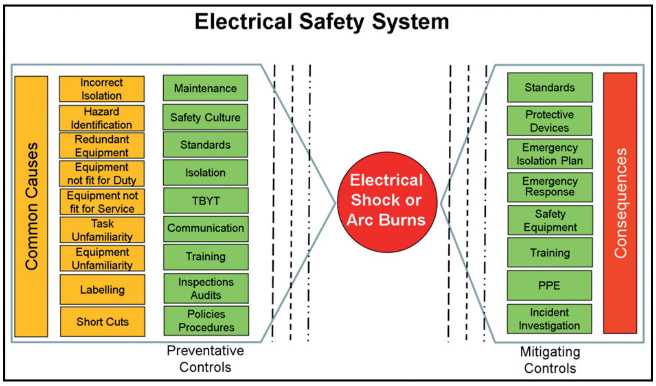
The codes of practice list the following as electrical risks and include direct references to arc faults:

- Electric shock causing injury or death.
- Arcing, explosion or fire causing burns. The injuries are often suffered because arcing or explosion or both occur when high fault currents are present.
- Electric shock from 'step and touch' potentials.
- Toxic gases causing injury or death.
- Fire resulting from an electrical fault.

The codes of practice include guidance on the process for identifying and controlling electrical risk in the workplace and are available for free download from your relevant safety regulator such as Workcover NSW.

CONTROLLING ARC FAULT HAZARDS

In controlling the hazards associated with exposure to the risks above, businesses require a robust electrical safety system with a suite of controls centred on the key risks. The bow tie diagram on the following page illustrates the various elements of an electrical safety system.



In the diagram, the controls in green are required to eliminate or reduce the likelihood or severity of an electrical incident. The yellow elements depict the common causes of electrical incidents. Failings in any of the controls will increase the likelihood of an incident.

As per the hierarchy of controls, elimination is the best option with arc fault hazards. If you sufficiently isolate the sources of supply, you eliminate the hazard. Again, it is important to remember that the process to establish and verify the required isolations exposes you to Arc Fault Hazards.

Work involving tasks such as those listed below should only be performed under full (remote end) isolation:

- The removal of busbar covers
- Any work on the incoming side busbar system or anything directly connected to it
- The removal or insertion of bolts or screws that enter blind holes in back plates, equipment mounting plates, etc.
- All drilling except on an open door where both sides can be seen
- Metal work modifications where both sides of the panel cannot be seen
- Pulling- in and termination of cables in compartments with exposed conductors or terminals
- Disconnecting and re-terminating of cables in compartments with exposed conductors or terminals
- Blowing out any of this equipment
- Any activity (except operating work) on any isolating device where the incoming side is still live
- Working on top of or above switchgear

Consideration should also be given to operating tasks, such as racking of breakers and the provision of low fault level testing points for isolation verification.

The potential energy as seen by a worker in an arc fault is a function of the arc current, arc duration and distance from the arc. Arc currents in low voltage installations are typically 50% or less than the available bolted fault current. By modelling your system, high incident energy equipment can be identified and strategies such as changing circuit breaker settings or fuse sizes can be developed to reduce the potential magnitude of the hazard. Reducing the trip setting of a circuit breaker to below the prospective predicted arcing fault level has a dramatic effect on reducing incident energy. Likewise certain tasks on high incident energy equipment can be reviewed to identify a safe work method.

WORKING LIVE

There is no doubt that working on or near live electrical equipment increases the likelihood for an electrical incident. Live electrical work is generally prohibited unless one or more of the exceptions under work place health and safety regulations apply. Testing and fault finding is electrical work, and most standards and codes provide exceptions to allow testing and fault finding on live equipment.

The high incidence of single and double hand injuries coupled with face burns indicates that work is being undertaken on or near live electrical equipment without sufficient arc hazard controls.

Working de-energised requires three general phases, creating a safe working situation, performing the work and restoration. The first and last phases are generally considered operational work. Likewise, for testing and fault finding, the tasks required for isolation, earthing, and isolation verification as well as the reverse all have associated arc fault hazards that need to be assessed and controlled as does the important step of Test Before You Touch (TBYT).

PERSONAL PROTECTIVE EQUIPMENT (PPE)

PPE is the least preferred method of hazard control. Despite all the controls, testing and fault finding, isolation verification, and especially TBYT place workers in close proximity to electrical apparatus that is live or possibly live. The end result is that while incident energies can be reduced, the need for arc rated PPE cannot be eliminated.

After reviewing the standards and information available, NSW Sydney metropolitan utility Ausgrid completed extensive arc fault testing at its own test facility. The results confirmed that incident energies as low as 1.2 cal/cm2 can ignite traditional cotton drill PPE.

Cotton PPE is not flame retardant, nor is it arc rated.

The results of the Ausgrid testing formed the backbone of the 2014 ENA NENS 09 standard. NENS09 specifies a minimum arc rating of 4 cal/cm2 for all work on or near electrical apparatus.

IN CONCLUSION

Electrical workers are being burned because of arc faults in NSW and across Australia. Existing standards and the Law requires businesses to assess and control electrical hazards including those for arc faults. Modifications to work practices and equipment can eliminate or reduce exposures, however it is rare that arc rated PPE can be engineered out.

For factory, building and plant owners the best and most complete results for understanding and controlling arc fault hazards are via a detailed arc fault hazard assessment.

For contractors however, it is rarely practicable to complete a detailed assessment and calculations for each of your client sites. In this case, NENS 09 PPE recommendations combined with voltage rated gloves with leather outers and an arc rated face shield with chin return will protect you from large percentage body burns over a range of operating and testing scenarios until a safe work situation can be established and verified.

It is the belief of the author, that had the 129 arc fault burn sufferers over the last 12 years and many of the workers with contact burns from electric shocks adopted basic level PPE as a last line of defence, then the majority of the incidents and harm could have been avoided.

For assistance with arc fault safety or any other electrical safety or design matters please contact us via our website at www.engineeringsafety.com.au.

Note this is an update on the previous article published in IE January March 2016. The NSW Health agency for Clinical Innovation Statewide Burn Injury Service supplied increased detailed data allowing further analysis of the recorded work related burns injuries.

ABOUT THE AUTHOR

Brett Cleaves is the founding director of Engineering Safety and has over 20 years engineering experience in heavy industry and electrical utilities including 9 years in Arc Flash hazard analysis and controls.

For contact information refer to www.engineeringsafety.com.au