SHP Safety & Health Practitioner
THE OFFICIAL MAGAZINE OF IOSH

Electric arc – Spark of interest

30 March 2011

While legislation requires businesses to perform risk assessments for most work activities, electric-arc risk is often overlooked because many people are unsure how to assess and manage it effectively, say Mike Frain and Elaina Harvey.

On 1 February 2007, at an office building in Shoe Lane, central London, two technicians were installing a capacitor to help reduce energy consumption at the site. One of the workers was fitting cables in the back of the capacitor, which was positioned above a number of live conductors. The cables came into contact with one of the conductors and caused an electric-arc flashover. The worker suffered severe burns to his face and upper body – horrific injuries that have prevented him from returning to work.

In the ensuing prosecution, the health and safety manager who had overall responsibility for safety procedures at the site was found guilty of various breaches and fined £2500 and ordered to pay £5500 in costs. The company pleaded guilty to similar charges and was fined £25,000.[1]

Electrical flashover, or arc flash, is one of the most deadly and least understood hazards of electricity, and is prevalent in most industries. Each year, around a thousand electrical accidents at work are reported, and as many as 25 people die from their injuries.[2] It is widely recognised that the higher the voltage of an electrical power system, the greater the risk for people working on, or near energised conductors and equipment. However, the thermal energy from arc flash, which is more common at lower voltages, can actually be worse and can cause severe burn injury and even death.

What is an electric-arc flash?

An arc flash is usually caused by inadvertent contact between an energised conductor, such as a bus bar or wire, and another conductor, or an earthed surface. When this occurs, the resulting short-circuit current will melt the conductors, ionise the air and create a conducting plasma fireball, with temperatures in the core of the arc that can reach upwards of 20,000 degrees centigrade. Those working on the electrical equipment – and anyone located nearby – can be at risk of severe injury, or even death.

Arc-flash injury can include external burns to the skin, internal burns from inhaling hot gasses and vaporised metal, hearing damage, eye damage caused by the ultraviolet light of the flash, plus many other devastating injuries. Depending on the severity of the arc flash, an explosive force known as an arc blast may also occur, which can result in pressures of more than 100 kiloPascal (kPa), launching debris as shrapnel at speeds of up to 300 metres per second (m/s).

Where the risk is, and how to manage it

All industries have some level of risk but those that carry the highest risk include utilities, energy producers and providers, mining, manufacturing companies – particularly those in the food, pharmaceutical and chemical industries – hospitals, large commercial organisations, data centres, education establishments and large leisure facilities.
For low-voltage work, which is carried out at some point in most workplaces, activities that have the potential to initiate an arc – some of which have been shown to be common causes of electrical flashover – include:

Related Articles | Most Commented
1. Contractor had part of skull removed after suffering electric shock - In Court
2. Contractor wasn't provided safe system of work for crane repairs - In Court
3. Energy firm fined £130k for power-line fatality - In Court
4. Farm worker suffered severe electrical burns - In Court
5. Firm failed to locate underground cables before drilling job - In Court

- connecting cables into live equipment;
- testing – especially with substandard instruments and test methods;
- testing on damaged cables and equipment (there are several known cases of arc flash due to using voltage indicators on faulted cables);
- inspections, or any interactions that involve the exposure of live-voltage conductors;
- work on, or adjacent to live low-voltage conductors that are insulated but where the work may adversely affect the integrity of that insulation – examples are drilling into panels and drawing cables into cable management systems;
- custom and practice activities, such as installing or repairing equipment that is adjacent to exposed live low-voltage conductors;
- removal and replacement/insertion of components such as circuit-breakers into energised panel boards and large power bus-bar tap-off units;
- live underground cable jointing;
- switching and racking out poorly-maintained or legacy LV switchgear; and
- replacement of fuses and links – especially on to faults.

The arc-flash hazard needs to be determined by risk assessment, on the basis of which the decision to work live or dead, and the required precautions, will be made. In addition to the usual considerations of what could cause injury or harm, whether the hazard can be eliminated, and the preventative or protective measures that could control the risk, it is advisable to adopt a step-by-step 'Predict, Prevent, Protect and Publish' approach.[3]

Predict

The severity of the thermal effect of an arc flash is defined by the amount of 'incident energy' that a victim, standing at a given distance away from the arc, could receive to the surface of the skin. The 'incident energy' can be quantified in units of kiloJoule/metre2 (kj/m2), Joule/centimetre2 (J/cm2) and calories/centimetre2 (cal/cm2). One cal/cm2 is equal to [4].184 J/cm2 and 4.184 kJ/m2. The cal/cm2 unit is most commonly used, as it is specified for PPE garment labels according to IEC 61482-2.

As a frame of reference for incident energy, an exposure to heat flux of 1.2 cal/cm2 during one second – i.e. exposure to 1.2 cal/cm2 – can produce the onset of second-degree burn to the skin. This value is used by many standards as the benchmark that defines protection against the thermal effects of arc flash and the threshold of a zone that is commonly known as the arc-flash protection boundary. This is where the predicted incident energy falls to 1.2 cal/cm2.4

Prevent

Design out, eliminate, or remove the hazard at its source. This leads to the conclusion that the majority of electrical tasks must be carried out with the equipment made dead. To work dead, the electricity supply must be isolated in such a way that it cannot be reconnected, or inadvertently become live again, for the duration of the work. As a minimum, this will include the positive identification of all possible supply sources, the opening and locking of suitable isolation points by personal padlocks, and a method of 'proving dead' at the point of work.

Where the arc-flash hazard cannot be eliminated, then suitable risk controls should be in place (preventative or protective measures). The physical task to be carried out on, or near energised equipment is a hugely significant factor, as it is usually worker activities that initiate a damaging arc-flash event. Whether or not work should proceed where there is a significant arc-flash hazard is not a decision that can be taken in isolation, without considering such factors as the level of hazard and the availability and effectiveness of preventative or protective measures.

General principles of prevention – as outlined in Article 6(2) of European Council Directive 89/391/EEC EU, the workplace health and safety directive – should be considered against the following hierarchy of risk controls:

1 Elimination of the arc-flash hazard.
2 Minimisation/engineering controls.
3 Safe systems of work.
4 Information and training.
5 Personal protective equipment.

Protect

Where the risk cannot be controlled by prevention, or where there is a residual risk of injury, then it may be necessary to consider mitigation to prevent injury to workers. The requirement for and suitability of mitigation techniques are essential elements of any risk assessment. Protection arrangements can include remote operations, reduction in arcing time through arc detection and rapid disconnection, and training in operational techniques, such as body positioning when operating equipment.

As a last line of defence, it may be necessary to consider personal protective equipment

(PPE). Where protection against thermal effects becomes necessary it must be emphasised that PPE does not prevent the accident happening in the first place.

PPE used to protect against arc flash includes garments made from flame-resistant (FR) fabric. This fabric is designed to provide a thermal barrier and limit the incident-energy exposure at the skin surface to no greater than 1.2 cal/cm2. FR clothing is rated on its Arc Thermal Performance Value (ATPV) in cal/cm2, or Breakopen Threshold Energy (EBT) in cal/cm2 according to EN 61482-1-1, and/or on its Class 1 or 2 performance according to EN 61482-1-2, with the arc rating certified according to IEC 61482-2.

The ATPV is the limit of the incident energy up to which a material can be exposed, so that the curve of the energy transmitted through the material will remain below the Stoll curve,[5] and without causing breakopen. Or, more colloquially, the ATPV is the incident thermal energy that the clothing can support before the wearer suffers second-degree burns.

To properly protect a worker, the ATPV value – or the EBT value, if the ATPV cannot be determined – of the FR clothing must exceed the prospective incident energy available at a given location at a given distance from the electric-arc event. Non flame-resistant clothing may ignite, or melt at low incident-energy values and, once ignited, will continue to burn after the electric arc has been extinguished.

Publish

In workplaces, signs must be provided where hazards cannot be adequately reduced by techniques for collective protection, or by measures, methods or procedures used in the organisation of work. They must warn of any remaining significant risk, or instruct employees in the measures they must take in relation to these risks.
The arc-flash hazard is a serious electrical risk that needs to be managed in many industrial environments, and risk assessment for workers who operate in proximity to, or on energised electrical equipment and cables is essential to ensure safety and compliance with the law.

References

1 www.shponline.co.uk/incourt-content/ full/safety-manager-failed-to-identify-electricity-risk
2 HSE Electrical Safety at Work – www.hse.gov.uk/electricity/index.htm
3 This approach is explained in the DuPont™ Arc-Guide, which was developed in conjunction with independent experts to help companies better assess arc-flash hazards (with the use of simple calculators) and provide them with the knowledge on how to reduce both the severity and consequences of an arc flash
4 The calculation methods in the DuPont™ guide are taken from the IEEE 1584 Guide for Performing Arc-Flash Hazard Calculations 2002, and take into account distance to worker, arc confinement, conductor gap, voltage, prospective fault current, and disconnection time
5 A standard curve, based on heat and time, used to predict the onset of second-degree burn injury

Mike Frain is a consultant with Electrical Safety (UK) Ltd and Elaina Harvey is the Nomex® account manager with DuPont™.

Andy Chappell

An excellent article.
A mention of the use of insulating shrouds/blankets, to be held in place by plastic, insulated clips (like oversized clothes pegs), inside electrical equipment panels would have added a cost-effective, practical control measure to those already mentioned. This is particularly useful where live testing is required next to live circuits in a multi-purpose panel and total isolation is not practical or justified under Regulation 14 of EAW Regulations.
Widely available.

Posted on 31/03/11 10:55.

±0 (0 Votes) Sign in to vote. Post Reply Top

Massimo Verdi

A very informative and practical feature – my thanks to the authors

Posted on 04/04/11 14:20.

±0 (0 Votes) Sign in to vote. Post Reply Top

Showing 2 results.

Related Articles | Recently Added | Most Viewed | Most Commented

1. Contractor had part of skull removed after suffering electric shock - In Court
2. Contractor wasn't provided safe system of work for crane repairs - In Court
3. Energy firm fined £130k for power-line fatality - In Court
4. Farm worker suffered severe electrical burns - In Court
5. Firm failed to locate underground cables before drilling job - In Court