Arc flash – not just an

IT IS WIDELY RECOGNISED THE HIGHER THE VOLTAGE OF AN ELECTRICAL POWER SYSTEM, THE GREATER THE RISK FOR PEOPLE WORKING ON OR NEAR ENERGISED CONDUCTORS AND EQUIPMENT. ALTHOUGH THE ELECTRIC SHOCK HAZARD INCREASES WITH VOLTAGE, ANOTHER HAZARD KNOWN AS ELECTRICAL FLASHOVER OR ARC FLASH, CAN ACTUALLY BE MUCH WORSE AT LOWER VOLTAGES. ELECTROCUTION IS THE FIRST THING THAT USUALLY COMES TO MIND WHEN SOMEONE IS KILLED OR INJURED BY ELECTRICITY; HOWEVER, THIS IS NOT THE ONLY HAZARD THAT EXISTS. AN ELECTRICAL ARC FLASH CAN BE DEVASTATING CAUSING SEVERE BURN INJURY AND EVEN DEATH. IN THIS, THE FIRST OF A TWO PART ARTICLE, MIKE FRAIN AND JIM PHILLIPS EXPLAIN WHAT CAN BE LEARNT FROM AMERICAN CALCULATION METHODS OF CALCULATING RISK MANAGEMENT FOR LIVE PROXIMITY WORKING

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An arc flash, is usually caused by inadvertent contact between an energised conductor such as a bus bar or wire with another conductor or an earthed surface. When this occurs, the resulting short circuit current can melt the conductors and produce strong magnetic fields that blow the conducting objects apart. The resultant fault current ionises the air and creates a conducting plasma fireball with arc temperatures that can reach upwards of 35,000 degrees Fahrenheit. Severe injury and even death can not only occur to persons working on the electrical equipment but also to people located nearby.

Arc flash injury can include external burns to the skin, internal burns from inhaling hot gasses and vaporised metal, hearing damage, eye damage and blindness from the ultraviolet light of the flash as well as 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 a pressure of hundreds and even thousands of pounds of force, launching debris as shrapnel at hundreds of miles per hour.

The severity of the thermal effect of an arc flash is defined as incident energy and is measured in terms of calories/centimetre2 (cal/cm2) that a victim could receive to the skin surface. An arc flash can range from nothing more than minor uneventful sparks to a massive and deadly electrical explosion.

PROTECTION FROM ARC FLASH

As a frame of reference for incident energy, an exposure of 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 adequate protection against the thermal effects of arc flash. Limiting the incident energy exposure at the skin surface to no more than 1.2 cal/cm2 means you can still receive some burn injury, however the primary objective of arc flash protection is to minimise the injury and probability of death.

In general, if the prospective incident energy exposure at a given location is below 1.2 cal / cm2, no additional thermal protection is required for the worker. However, if the incident energy exceeds this value, protection against the thermal effects may become necessary but it must be emphasised that PPE does not prevent the accident happening in the first place.

Personal Protective Equipment (PPE) used for arc flash protection includes garments made from Flame Retardant (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. Although FR fabric will burn when exposed to a flame, it is designed to stop

ELECTROCUTION hazard part 1

burning when the flame is removed. It also must not break or burn open and expose the skin directly to the flame.

FR clothing is rated based on its Arc Thermal Performance Value (ATPV) in cal/cm2. To properly protect a worker, the ATPV rating of the FR clothing must exceed the prospective incident energy available at a given location.

UNITED KINGDOM ELECTRICAL SAFETY PRACTICES

A fundamental safety principle, which is embodied in U.K. legislation, is to design out, eliminate or remove the electrical hazard at its source. The Electricity at Work Regulations 1989 (EAWR 1989) 13 and 14 lead to the conclusion that the majority of tasks must be carried out with the equipment made dead or placed in an "electrically safe condition" as they say in the US. To work dead, the electricity supply must be removed in such a way that it cannot be reconnected or inadvertently become live again for the duration of the work. The Memorandum of Guidance HSR 25 on the Electricity at Work Regulations identifies the main features of an isolation system of work: 1. Isolate all sources of supply 2. Secure each point of isolation 3. Apply earthing to dead circuit conductors where appropriate (HV and some LV systems) 4. Prove dead at each point of work 5. Identify the safe zone of work 6. Insulate and safeguard adjacent live conductors 7. Issue a safety document for work to commence; confirming recipient understands the task and the location of the safe area.

Live working is defined as "work on or near conductors that are accessible and live or charged". This is anywhere that a worker is exposed to energised conductors, terminals, bus bars or contacts and that often includes the removal of fuses and links. In industrial & commercial environments this usually means live diagnostic testing, faultfinding, non-invasive inspections such as thermal imaging and some tests in accordance with BS7671 Wiring Regulations. Even if it is intended to carry out work on dead conductors, an assumption should be made that they are still live until proven dead.

Whilst live connection work is routinely undertaken by Utility Distribution Network Operators (DNOs), any work that requires the connection and disconnection of live conductors and components in most industrial and commercial premises would be extremely difficult to justify.

Live working should never be accepted as the norm and Regulation 14 of EAWR 1989 makes clear that three conditions must be met for live work to be permitted. These conditions are:

Examples of a fire-resistant shirt (5-6cal/sq cm) and gloves worn by a person burned in a secondary fault, while hooking up some 120/208V leads to a pad mounted transformer. The man came out of the accident with just second degree burns to his arm

1. It is unreasonable in all the circumstances for the conductor to be dead; and
2. It is reasonable in all the circumstances for that person to be at work on or near that conductor while it is live; and
3. Suitable precautions (including where necessary, the provision of personal protective equipment) have been taken to prevent injury.

If live working can be justified through the rigorous tests of reasonableness in conditions one and two, judgements must be made about suitable precautions against electric shock and the effects of electrical flashover to satisfy the requirements of condition three.

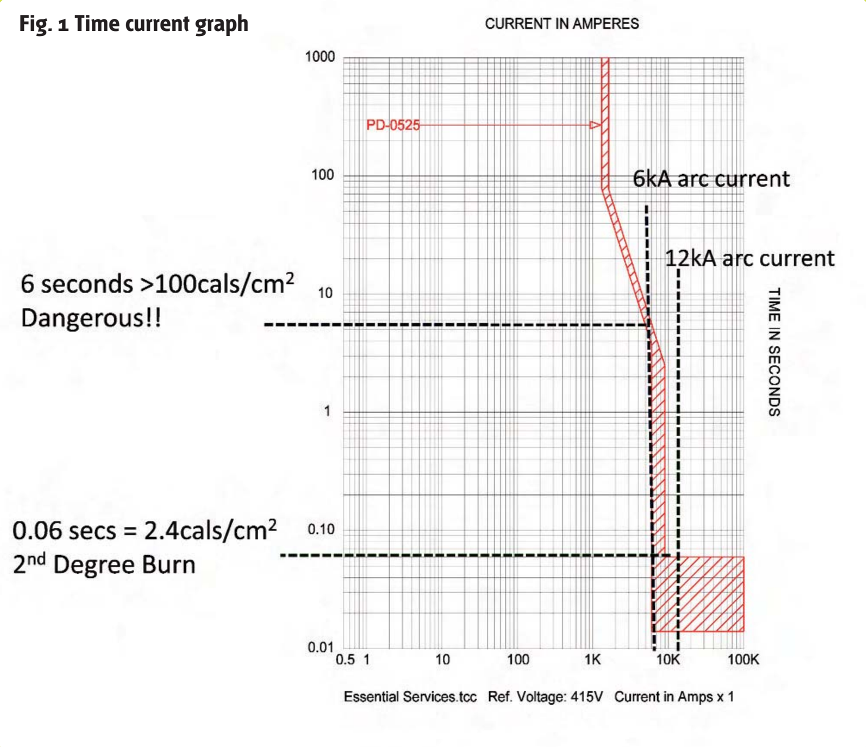

Fig. 1 Time current graph

UNITED STATES ELECTRICAL SAFETY PRACTICES

In the United States, several codes, standards and regulations exist regarding arc flash and electrical safety. Although the Occupational Safety and Health Administration (OSHA) creates, administers and enforces safety regulations at the federal level, these regulations often only provide general direction with the details left up to other standards. The most frequently cited standard for electrical safety is the National Fire Protection Association's NFPA 70E - Standard for Electrical Safety in the Workplace. This standard defines the requirements for safe work practices such as the selection of appropriate Personal Protective Equipment (PPE) and the use of Flame Retardant (FR) clothing. The basic concept of PPE selection for arc flash protection is simple. The magnitude of incident energy that could be available during an arc flash is calculated in cal/cm2 and PPE is selected that has an ATPV rating greater than this value.

Electrical utility company transmission, distribution and generation facilities are exempt from the requirements of NFPA 70E. However, they must conform to the requirements of the National Electrical Safety Code (NESC). As of 1 January 2009, the NESC required utility companies must have an arc flash assessment in place. It must be based either on calculations or data listed in several tables found in the NESC that are derived from arc flash calculations.

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ARC FLASH CALCULATION STUDY

If PPE including FR clothing must have an ATPV rating greater than the prospective incident energy, how is the incident energy determined? The Institute of Electrical and Electronics Engineers, (IEEE) has published IEEE 1584 - IEEE Guide for Performing Arc Flash Calculations. This guide defines the most commonly used methods for calculating the prospective incident energy when performing an Arc Flash Calculation Study (AFCS). The equations and methods of this document are based on extensive test data and research and was originally published in 2002 with a minor revision in 2004. Although the calculations may appear to be quite complex, they are actually based on the results of a short circuit study and protective device study and also uses much of the same data. Additional data required for the arc flash calculations include the gap distance between conductors where the arc flash could occur, enclosure type, distance that a person could be standing from the source of the arc known as the working distance, and whether the system is effectively earthed or grounded as they say in America.

An arc flash study will tell you the incident energy due to the flashover and in simple terms this means – how big is the bang? Most importantly there will be an evaluation which will highlight those cases of low risk, those which will need other protective measures and those areas where there is great danger to workers who engage in live working activities.

The study will evaluate the severity of injury at a given distance from the arc and the flash protection boundary at which distance there will be the onset of 2nd degree burns. This gives designers and facilities managers a scientific basis for the evaluation of the working space in front and around switchgear. It will also give warning label requirements to state the arc flash hazards, boundaries and PPE requirements.

By carrying out an arc flash study to IEEE1584 you will also know the fault levels throughout the facility and therefore assess the capability of equipment to withstand short circuit currents. You will also have a one line diagram of the electrical distribution system and protection coordination information. In fact it is an explicit requirement of the HSE guidance documents that duty holders should have this information in place anyway. The additional requirement for data collection in order to carry out an arc flash study is estimated at only 10% of the total to undertake the above fault level and protection studies.

From all of this data, the magnitude of incident energy in cal/cm2 at the working distance is calculated and used to select the appropriate PPE to wear if live work is performed. In addition to the incident energy calculations, the Arc Flash Protection Boundary (AFPB) can also be calculated. This Boundary is defined by NFPA 70E as "When the arc flash hazard exists, an approach limit at a distance from a prospective arc source within which a person could receive a second degree burn if an electrical arc flash were to occur." The ability to calculate Flash Protection Boundaries will enable UK managers to arrive at better-informed judgements before allowing live proximity work to proceed in the first place and provide an ability to apply quantitative techniques to risk control.

Part two of this article can be found in the September issue of Electrical Review or by visiting www.electricalreview.co.uk.