Electrical Arc Safety:
setting the standard

Version 1

Electrical shock was once thought to be the major risk associated with working "live". But experiences of those required to work on or near energized electrical equipment tell a different story.

Exposures associated with an electrical arc fault can be catastrophic and often fatal. Ontario's Ministry of Labour, Immigration, Training and Skills Development reports in the last 10 years 28 workers have been killed and another 255 seriously burned from arc flash incidents. Twenty-one per cent of all electrical-related fatalities involved workers in the electrical trades. However, 79 per cent of these deaths involved workers in other occupations.

What is an electrical arc?

An electric arc is a short circuit which jumps through the air from one live conductor to another conductor or to ground. The amount of energy released depends, in part, on the amount of energy in the circuit — the more energy, the more powerful the arc. Generally though, electrical arc incidents occur with equipment operating at levels between 480 and 600 volts. An arc incident can be initiated by a variety of causes including: dust, corrosion or other impurities on the surface of the conductor; equipment failure because of substandard parts, improper installation, or even normal wear and tear; proximity to high-amp sources with a conductive object; dropping or improperly using a tool so as to create a spark that ignites an arc; and accidental tool contact with live parts. Regardless, an arc results in both an arc flash and a blast.

Arc flash

Electrical arcs produce intense heat that manifest as a flash of light. Air can be heated to temperatures as high as 19,427 degrees Celsius — four times the surface temperature of the sun.

Arc blast

The intense heat from the arc causes the sudden expansion of air producing a dramatic pressure wave and sound blast with results similar to a chemical explosion. The pressure wave can generate sufficient energy to cause equipment to explode, parts to be ejected and supporting structures crushed.

What are the health effects?

The direct effects of an electrical arc are horrific. The most common injury is a burn from the initial flash or subsequent flame from ignition of clothing. At several feet, burns can be fatal and at 10 feet, serious burns are not uncommon. Heated air and molten metal from arcs can cause ordinary clothing to burst into flame, even if not directly in contact with the arc. Inhalation of vapourized metal can result in lung damage. A high density flash can also damage the eye, resulting in a distortion or complete loss of vision.

The blast from an arc can generate sound that exceeds 160 dBA, causing immediate hearing loss as it ruptures ear drums. Pressure on the chest can be as high as 2,000 pounds per square foot, collapsing the lungs. A worker may also be thrown up to several feet away, suffering shattered bones. Concussions are just as likely, as are shrapnel wounds from flying metal pieces.

What does the law say?

The only guaranteed way to prevent arc flash is to de-energize the system or equipment before beginning work — in other words, ***don't work live.*** Recognizing this, Construction, Industrial, Mining and Health Care Regulations under the *Occupational Health and Safety Act* require disconnection, locking out and tagging the power supply to electrical installations, equipment or conductors. Rule 2-304 (1) of Ontario's Electrical Safety Code (OESC) also stipulates no repairs or alterations shall be carried out on live equipment and that adequate precautions shall be taken, such as locks on circuit breakers and switches and warning signs. Further, the Canadian Standards Association have developed a complete standard on lockout and tagging (CSA Z460-20).

However, the law also recognizes there are some ***limited situations*** where it is not possible or practical to de-energize power sources. As an example: for construction workers limited situations for live work are set out in section 191 of the Construction Regulations. Criteria include: the equipment, installation or conductor is rated at 600 volts or less; disconnecting would create a greater hazard to a worker; and the work consists only of diagnostic testing.

Regardless, in these situations, ***employer general duties*** under the *Act* still apply. The Construction Regulations state specifically, "Every reasonable precaution shall be taken to prevent hazards to workers from energized electrical equipment, installations and conduction." Section 25(2)(h) of the Act requires employers to "take every precaution reasonable under the circumstances to protect workers".

Meantime, Section 25(2)(a) requires the employer to "provide information, instruction and supervision to a worker to protect the health or safety of the worker." This includes ensuring electrical systems and equipment are safe and that workers required to work on, or work in the vicinity of electricity, know how to protect their health and safety.

For guidance in determining ***reasonable precautions*** for live work the Ministry of Labour, Immigration, Training and Skills Development is using the CSA standard on workplace electrical safety (CSA Z462-21). A complement to the standard on lockout and tagging, CSA Z460-20, it is presently the most complete authority on electrical safety. This industry good practice is applicable in most workplaces.

What precautions safeguard workers?

The CSA standard on workplace electrical safety is designed to protect workers from both shock and arc flash exposures. But provisions related to arc flash have garnered the most attention, as they address a need previously unmet by other Canadian standards. The following include some of the standard's key provisions.

Live work criteria

The standard sets narrow criteria to allow live work. Going beyond the Ontario's Construction Regulations, it says one exception to the zero energy 'rule' is where de-energizing the system will create an additional or greater hazard, stating examples such as interruption of life support equipment, deactivation of emergency alarm systems or shutdown of local ventilation. Live work can also be performed if the employer can demonstrate the task cannot be completed in a de-energized state because of equipment design or operational limitations. This includes inspection or testing of live circuits and work on circuits that are integral to the process and where isolation would result in a complete shut-down of the line.

Energized electrical work permits

These are required for work on energized conductors or circuit parts not placed in an electrically safe work condition. The written permit must contain information outlined in Clause 4.3.1.2.2 of the CSA standard, including (but not limited to) a description of the work and a justification for why the work needs to be performed in an energized state.

WHSC WORKERS HEALTH & SAFETY CENTRE
Training for What Matters Most

Information Bulletins for health, safety and environmental representatives

Resource Lines

Hazard analysis

Prior to any work commencing on an energized system the potential for an arc incident must be assessed. (Exceptions to this requirement are as follows: the circuit is rated 240 volts or less, the circuit is supplied by one transformer, the transformer supplying the circuit is rated less than 125KVA.) The hazard analysis establishes three boundaries of approach, all with specific requirements to protect workers. These boundaries are based on voltage amounts, the available fault current, the time it takes for the upstream protective device to operate and clear the fault, and distance from a live part. The standard explains, "Observing a safe approach distance from exposed energized electrical conductors or circuit parts is an effective means of maintaining electrical safety. As the distance between a person and the exposed energized conductors or circuit parts decreases, the potential for electrical accident increases."

Limited approach boundary is the minimum distance from the energized item where unqualified workers may safely stand. No unqualified person may approach any closer unless continuously escorted by a qualified person. A qualified person must have appropriate personal protective equipment (PPE) and training to perform the required work in order to be permitted to cross the limited approach boundary.

Restricted approach boundary can only be crossed by a qualified worker who has completed training and wearing appropriate PPE as well. This worker must also have a written, approved plan for the work he/she will perform.

Prohibited approach boundary work is done under the same conditions as the restricted approach boundary, with the added consideration that crossing it would be the same as making contact with exposed energized conductors or circuit parts. Consequently, workers in the prohibited space must also have a documented plan justifying the need to work that close.

Training

In the above-mentioned situations a qualified person is defined as "one who has skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to recognized and avoid the hazards involved." This training must also include methods of first aid and emergency procedures. The CSA standard further states, "All those working on, *or near,* electrical systems where there is the potential for exposure must be trained." The standard also covers the need for retraining and employer documentation of training.

Hazard analysis labels

These are an essential tool for communicating the various aspects of an analysis. Annex Q of the CSA standard provides a useful sample label. Among other things, it includes an overall warning, approach boundary information, energy levels, required level of PPE, the name of the person and/or company that performed the analysis and the date of analysis.

PPE selection

When it is determined work will be performed within an arc flash protection boundary, selection of protective (arc-rated, flame-resistant) clothing and other PPE must be selected in one of two ways. In method one, selection is based on an incident energy analysis to be documented by the employer. Calculated in calories per square centimeter, the analysis predicts incident energy exposure levels based on the working distance of the worker's face and chest areas from a potential arc source. In method two, selection is based on work activity, the type and voltage of power systems and as assessed hazard/risk category ranging from zero to four. Once the hazard/risk category has been determined, the CSA standard advises what PPE, clothing and equipment will be necessary for controlling the hazards and risks of the work.

Finally, it is worth noting other important provisions of the standard include power system maintenance requirements and requirements for special electrical equipment such as electrolytic cells, batteries and lasers.

What other measures can be taken?

Engineering controls incorporated into the design and operation of an electrical system are an important means of minimizing the possibility of an arc incident. This typically involves the use of a range of safety devices such as current limiting fuses, voltage indicators and portable infrared scanners.

Safety devices employed to reduce the potential for an arc target one or more of the three factors contributing to incident energy — available current, fault clearing time (the time interval between the fault inception and the fault clearance with a fault being a defect in a circuit, component or line) and/or working distance from the fault.

One of the most frequently used devices is a current limiting fuse, designed to detect the increased current associated with a short circuit and clear the defect, thereby eliminating the current available for an arcing incident.

Voltage indicators, attached to equipment, are yet another mechanism used to reduce the potential of an arc. The danger of reliance on an automatic voltage indicator, however, is that while a lit device proves that voltage is present, an unlit one might indicate either the absence of voltage or a malfunction in the indicator itself, requiring a double check by workers using a hand held voltage meter.

The status of electrical equipment can also be assessed by portable infrared scanners. Ideally, infrared scanners are built into the electrical system and act to periodically "check" the status of certain critical electrical components or connections. Strategically located windows allow the viewing of potential problems at specific locations, without the need to touch "live" electrical parts.

Where the possibility of an incident cannot be controlled through engineering, work practices, PPE and clothing, proper maintenance and worker training become critical.

An arc incident is one of the most dangerous hazards facing those who work with electricity. A decision not to work "live" is by far the best means to prevent an incident. But where workers are required to work near, or on, energized systems or equipment, a combination of controls, safe work practices and training will help reduce the risk. By getting down to specifics, CSA Z462-20 has helped raise the bar on what these measures should look like.

NOTE: Space limitations prevent an exhaustive discussion of this issue. The Workers Health & Safety Centre offers training and other information related to electrical safety. To learn more contact a Training Services representative near you.

WHSC WORKERS HEALTH & SAFETY CENTRE
Training for What Matters Most

Resource Lines

Published by the
Workers Health & Safety Centre

675 Cochrane Drive, Suite 710
East Tower, Markham,
Ontario L3R 0B8

416-441-1939
Toll free: **1-888-869-7950**

whsc.on.ca

contactus@whsc.on.ca

Executive Director: **Andrew Mudge**

Director, Policy and Programs:
Loretta Michaud

Submissions are encouraged.