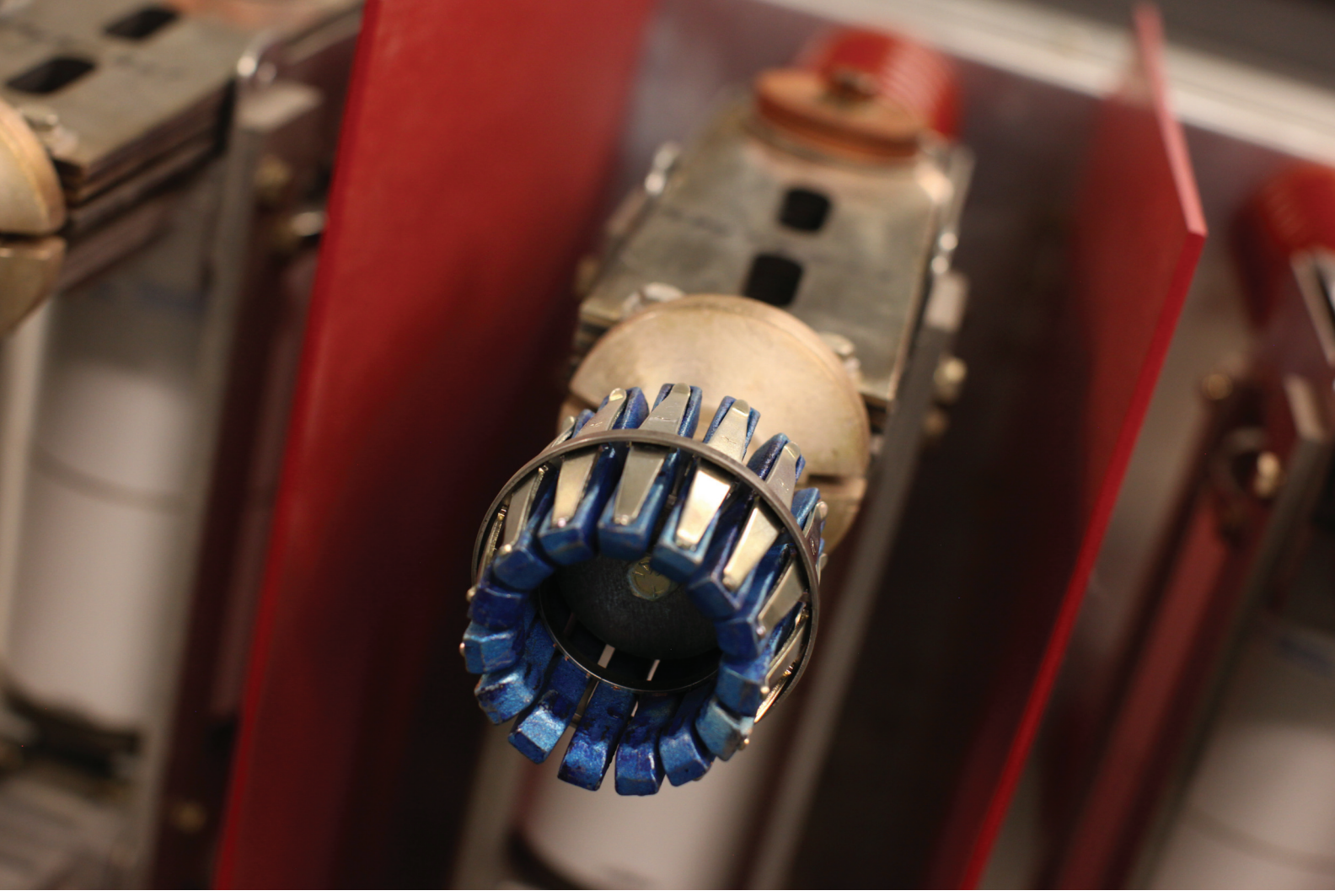

# Electrical Safety Measures

## Eliminating Abnormal Arcing Faults

**"Elimination is the first priority! Ensure a risk assessment is completed before energized work tasks are completed."**

**By Terry Becker, P.Eng., CESCP, IEEE Senior Member**

Eliminating exposure to any workplace hazard is the goal of the employer. With respect to the electrical hazards of electric shock and arc flash this would be the desired state, this is aligned with occupational health & safety regulations and the CSA Z462 Workplace electrical safety Standard (CSA Z462).

CSA Z462 Clause 4.15 Electrical safety policy states:

*"Employers shall create and document an electrical safety policy that affirms the organization's commitment to:*

*(a) Proactively identify and eliminate electrical hazards and assess and control the associated risks; and*

*(b) Create an electrically safe work condition in accordance with the requirements of this Standard.*

*The policy may be documented in the employer's occupational health and safety management system (OHSMS), where one exists, or in the employer's electrical safety program.*

If an electrical safe work condition cannot be established, energized work tasks performed must be justified and complete in compliance with the additional listed requirements of CSA Z462 Clause 4.1 General requirements for electrical-safety related work practices and procedures and Clause 4.3 Work involved electrical hazards.

With respect to CSA Z462, Clause 4.1.7.8, Risk assessment procedure, Clause 4.1.7.8.5 Hierarchy of risk control methods it advises "The risk assessment procedure shall require

**Table 1. Hierachy of Risk Control Methods – Shock and Arc Flash Hazards**

| Risk Control Method | Description | Comments |
|---|---|---|
| **Elimination, Isolation, Zero Energy State** | Occupational health & safety Regulations require hazardous energy sources to be identified and eliminated as a priority.<br><br>A zero-energy state should be established and verified before any work is completed without PPE. | Employer lockout program/policy/practices and related procedures implemented.<br><br>As a priority Establish an Electrically Safe Work condition before completing any repair or alteration work tasks as required by CSA Z462.<br><br>Testing for absence of voltage is energized electrical work. |
| **Substitution with Safer System, Processes, or Electrical Equipment** | Specify Arc Resistant Switchgear and arc free/arc resistant low voltage MCCs.<br><br>Specification of gas insulated switchgear (GIS).<br><br>Consider fuse-based protection vs molded case circuit breakers.<br><br>Specific high resistant grounding (e.g., NGR).<br><br>Installing smaller kVA transformer and higher impedances.<br><br>Change control voltages from 120VAC to 24VDC.<br><br>Specify "Bluetooth" enabled test instruments to be used for inserting into energized electrical equipment for taking voltage or current measurements for trending data. Lowers frequency of exposure. | |
| **Engineering "Safety by Design," Prevention Through Design (PtD)** | Proper specification of electrical equipment load break vs non-load break rated.<br><br>Finger Safe Components, Covers and Barriers.<br><br>Specify current-limiting devices.<br><br>Specify IR scanning windows and ultrasonic ports.<br><br>Specify disconnect switches with view window.<br><br>Design includes appropriate interlocks.<br><br>Following the completion of an incident energy analysis review the results and reduce incident energy levels >75, 100 or 140 cal/cm$^2$.<br><br>Installation of permanently installed supplemental absence of voltage Test Portals or Automatic Voltage Testers (AVTs).<br><br>Remote racking or on-board racking for low and high voltage switchgear.<br><br>Remote opening and closing of circuit breakers.<br><br>Real time electrical equipment temperature sensor or IR monitoring.<br><br>Increasing the working distance. Use "Extend-a-Rack".<br><br>For more complex power systems consider other protective device relaying schemes:<br>1. Zone-Selective Interlocking (ZSI).<br>2. Differential Relaying.<br>3. Consider lockable maintenance mode reduction switches to reduce incident energy when energized electrical work tasks are required to be completed.<br>4. Arc Flash Detection Relay.<br>5. Energy-reducing Active Arc Flash Mitigation System.<br>6. Blown Fuse Operation for Switches. | Eliminate exposure to shock.<br><br>Eliminate or reduce the likelihood of an abnormal arcing fault occurring.<br><br>Limit faults to single phase to ground.<br><br>No requirement to open hinged door or remove bolt on cover.<br><br>Target incident energy reduction for 75, 100 or 140 cal/cm$^2$. Where technically feasible attempt to achieve incident energy level as low as possible. |
| **Warning Signs and Barricading** | Install door signage on defined Electrical Room doors.<br><br>Install Arc Flash & Shock Warning Equipment Labels or provide "Arc Flash Hazard Results Tables" from the arc flash hazard incident energy calculation report.<br><br>Ensure an Electrical Work Zone is created with barricading (e.g. red "Danger" tape). | Reinforce policy and training of workers with signage.<br><br>Keep unprotected workers out of the work area and eliminate potential for interruption of work. |
| **Administrative** | Follow the policies, practices, and procedural requirements of the Electrical Safety Program.<br><br>Manage human performance to limit potential for human error.<br><br>Provide generic Arc Flash & Shock training to QEWs, TQWs & QIWs, including emergency release of a shocked worker.<br><br>Provide lockout program training to appropriate workers.<br><br>Provide Electrical Safety Program Orientation/Roll Out training to appropriate workers.<br><br>Provide Electrical Safety Awareness training to appropriate Non-Electrical Workers.<br><br>Use Electrical Safe Work Procedures.<br>Develop and implement of formal Electrical Equipment Maintenance Program. | Qualification training provides knowledge to be applied to electrical hazard identification and the required hierarchy of risk controls methods to be applied to reduce risk.<br><br>Training on policy and practice requirements ensures workers understand their responsibilities.<br><br>Where required the use of an Electrical Safe Work Procedure can reduce likelihood of occurrence.<br><br>Ensure electrical equipment maintenance requirements are defined, are approved, budgeted for, and implemented. |
| **Electrical Specific PPE, Tools, and Equipment** | Potential severity of injury or damage to health is managed with the application of appropriate PPE, tools, and equipment. Exposure to electrical hazards can be reduced to zero or to a recoverable injury. | Note: Need to ensure proper testing, pre-use checks, care, use and maintenance. |

that preventive and protective risk control methods be implemented in accordance with the following hierarchy:

(a) **Elimination**;
(b) Substitution;
(c) Engineering controls;
(d) Awareness;
(e) Administrative controls; and
(f) PPE.

With elimination as the priority it is recommended that a work task-based risk assessment procedure be completed. With respect to arc flash a specific arc flash risk assessment is required as outlined in CSA Z462, Clause 4.3.5 Arc flash risk assessment.

Within CSA Z462, Clause 4.3.5 it provides direction in Clause 4.3.5.2 that likelihood of occurrence of an abnormal arcing fault shall take into consideration electrical protective devices and related operating time and the electrical equipment operating condition and condition of maintenance. CSA Z462 Table 2 Estimate of the likelihood of occurrence of an arc flash incident for AC and DC systems provides guidance based on a work task description and equipment condition if the likelihood of occurrence of an abnormal arcing fault is YES or NO.

So where should the employer focus attention with respect to eliminating an abnormal arcing fault from occurring? Proactive review of existing power distribution electrical equipment and related to capital projects consideration must be given to the hierarchy or risk controls methods of "substitution" and "engineering safety by design." Other administrative control methods and even some available PPE and tools can also be used to eliminate abnormal arcing faults from occurring or reduce the likelihood.

What specific risk control method options are available that would contribute to eliminating the likelihood of occurrence of an abnormal arcing fault? What risk control method options are technically feasible? What risk control method options are not cost restrictive?

In Table 1 on page 22, Hierarchy or Risk Control Methods – Shock and Arc Flash Hazards, provides summary of available options is available. The list below also includes consideration of enhanced electrical equipment maintenance aligned with the focus of the CSA Z463 Maintenance of electrical systems Standard and as required to ensure equipment condition is unlikely to lead to an abnormal fault condition. The risk control methods listed will decrease the likelihood of occurrence of an abnormal arcing fault occurring:

1. Specify additional insulation, finger safe components and guarding.
2. Use insulated hand tools for all battery terminations.
3. Segregation with a suitable barrier between power and control compartments of electrical equipment when the electrical equipment includes both.
4. Specify gas insulated switchgear (GIS).
5. Specify arc resistant electrical equipment, this doesn't eliminate abnormal arcing faults from occurring, but eliminates arc flash exposure to the Qualified Person, under normal equipment conditions.
6. Ensure preventive maintenance includes an appropriate frequency of inspections.
7. Ensure any potential for electrical equipment contamination is eliminated.
8. Specify high resistance grounding (e.g. NGR).
9. Consider real time predictive maintenance and trending electrical equipment health, temperature, or IR scanning.
10. Increase electrical equipment maintenance frequency for specific tests.
11. Ensure electrical equipment is used in accordance with instructions included in the CE Code Part II and in accordance with manufacturer's instructions.
12. Ensure Qualified Persons are provided compliant arc flash & shock training.
13. Ensure Qualified Persons are qualified and competent to execute energized electrical work tasks.
14. Ensure Qualified Persons, human performance is managed, apply appropriate administrative controls to ensure pre-cursors are eliminated.
15. Ensure adequate lighting for work task execution and no blind reaching.
16. Specify the use of test instrument "probe extenders" that removes the Qualified Person's hands from the enclosed electrical equipment and increases visibility when an energized electrical work task is executed.
17. Specify "true color grey" lens technology for arc-rated face shields and arc flash suits hoods. This increases the visibility of the work tasks and eliminates wire colour discolouration.

Reasonable and realistic interpretation, evaluation, and implementation of any of the risk control methods listed above need to be considered.

To answer the question – yes an employer can eliminate abnormal arcing faults from occurring. A realistic and reasonable approach to applying the risk control methods listed above needs to be considered.

If you are interested in discussing the information presented in this article do not hesitate to contact me.

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