ELECTRICAL Safety Measures

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

Electrical Hazard Classification And Risk Assessment

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

I have attended the IEEE Electrical Safety Workshop (ESW) since 2006 when I started my electrical safety journey. This is the premiere conference for sharing knowledge and learning about arc flash & shock hazards, interpretation of CSA Z462/NFPA 70E, the evolution of IEEE 1584, low voltage work tasks, high voltage work tasks, arc flash & shock PPE, case studies, electrical incident statistics, what a compliant Electrical Safety Program is, and so much more.

The IEEE ESW was held in person in Jacksonville, Florida, March 8-11, 2022 and I decided I needed to attend in person, it is important that we all move back to a new normal and we need to interact directly in person on many fronts and for sharing knowledge and learning it is important we still meet in person.

At the conference besides technical papers and poster sessions, there are tutorials offered, again an opportunity to learn.

I attended a tutorial that I have attended in the past with presenters from the USA DOE with respect to their work and study of electrical hazards relative to their ongoing research projects.

Their work involves the use and application of electricity, and different electrical equipment. Since 2015 they proceeded to classify electrical hazards and evolved to complete risk assessments to ensure adequate hierarchy of risk control methods are implemented to eliminate exposure or reduce risk to as low as reasonably possible for their employees. I felt it was important to get more information out in Canada about their work and highlight some of the information they presented in the tutorial. I also referenced the CSA Z462 Workplace electrical safety Standard, NFPA 70E Standard for Electrical Safety in the Workplace, additional IEEE Electrical Safety Workshop papers, IEEE Industrial Application Society papers, and USA DOE EFCOG Work Practices.

Electrical Hazard Classification

The USA DOE has developed and implemented an Electrical Safety Program. In reviewing the Electrical Hazards related to their work and work tasks performed by their employees they created a comprehensive electrical hazard classification system and then applied this against work tasks and developed and implemented a comprehensive qualitative risk assessment process that included a related risk matrix. In Table 1 I have provided a simple summary of the electrical hazard classifications the USA DOE initially created and evolved over the years. Some of the information is also extracted from other information sources as noted above.

Table 1: Summary of Electrical Hazard Classification[1]

Electrical Hazard Classification Voltage or Electrical Equipment	Potential Severity of Injury or Damage to Health
50/60hz ac Electrical Equipment. Abnormal arcing fault, no arc flash. Shock hazard. • ≤30VAC, CSA Z462. No shock. • <50VAC, NFPA 70E. No shock. • 120VAC single phase. • 240VAC single phase. • 277VAC single phase. • 347VAC single phase.	**Abnormal Arcing Fault:** Resulting in potential thermal exposure burn injury to the Qualified Person's hands, noise, ejected molten metal, and bright light. **Electric Shock Effects:** • ≥30VAC, CSA Z462. • ≥50VAC, NFPA 70E. • Current flow into body, survivable injury. • Electrocution. • Electric shock sequela.
50/60hz ac Electrical Equipment. Abnormal arcing fault resulting in an arc flash. Shock hazard. • ≥208VAC three phase, 2000A available fault current. • 480VAC/600VAC three phase. • >1000VAC three phase.	**Abnormal Arcing Fault and Arc Flash Multiple Potential Effects:** • Thermal burn injury. • Expansion of air resulting in arc blast pressure. • Molten metal/shrapnel. • UV/IR light. • Toxic smoke/vapour. • Noise **Electric Shock Effects:** • Current flow into body, survivable injury. • Electrocution. • Electric Shock Sequela.
Batteries: • ≤60VDC, CSA Z462. No shock. • <50VDC, NFPA 70E. No shock. • ≥125VDC power e.g. UPS battery rack or other DC power source.	**Abnormal arcing fault and arc flash multiple potential effects:** • Thermal burn injury. • Expansion of air resulting in arc blast pressure. • Molten metal/shrapnel. • UV/IR light. • Toxic smoke/vapour. • Noise. **Electric Shock Effects:** • Current flow into body, survivable injury. • Electrocution. • Electric Shock Sequela.
Capacitors Hazard Thresholds (NFPA 70E, Article 360.3: • <100V and >100J stored energy. • ≥100V and >1.0 J of stored energy. • ≥400V and >0.25 J of stored energy.	**Abnormal Arcing Fault:** • >120kJ, >1.2 cal/cm². • Thermal hazard if >100J of stored energy. • Acoustical shock wave, hearing protection >100J of stored energy. **Electric Shock Effects:** • Function of energy, risetime, pulse length and body impedance. • Impulse shock. • ≥100V threshold. • **Energy delivered, 1 to 10ms:** ◦ Slight sensation, 0.05 to 1mJ. ◦ Disagreeable, 5 to 100mJ. ◦ Painful, 0.1 to 0.5J. ◦ Injury likely, 1 to 50J. ◦ Fibrillation likely, 50 to 1000J. **Other:** • Lung protection boundary, >122kJ. • Fire hazard, dielectric fluids. Toxic vapours.
RF • >3kHz to 100MHz.	**Shock/Burn Threshold:** • **0.003 to 0.1 MHz:** ◦ ≤1000f mA. No injury, no controls ◦ >1000f mA. Injury or fatality. • **0.1 to 100 MHz:** ◦ ≤100mA. No injury, no controls. ◦ >100mA. Injury or fatality.
Sub-RF • 1Hz to 3kHz.	**Thermal Threshold:** • **≤50V:** ◦ ≤1000 W. No injury, no controls. ◦ ≥1000 W. Injury or fatality. • **50-250V:** ◦ ≤5 mA. No injury, no controls. ◦ >5 mA. Injury or fatality. • **>250V:** Shock threshold: ◦ ≤5 mA. No injury, no controls. ◦ 5-75 mA. Injury or fatality. Arc Flash Threshold: ◦ 75 mA to 500A. Injury or fatality. ◦ >500A. Very serious, avoid work.

Note: This is a summary table only and may not be a complete reference.

[1] Information presented is derived from CSA Z462 Workplace electrical safety Standard, 2021 Edition, NFPA 70E Standard for Electrical Safety in the Workplace, IEEE 1584 Guide for Performing Arc-Flash Hazard Calculations, IEEE IAS Published Papers, IEEE Electrical Safety Workshop Papers and Tutorial information presented by the USA Department of Energy, and DOE EFCOG Work Practices.

Risk Assessment Procedure & Process

CSA Z462 and NFPA 70E have evolved since the 2015 Editions, they require an employer's Electrical Safety Program to include a mandatory "Risk Assessment Procedure." This would be completed by the employer for "Jobs" assigned to Qualified Persons and against anticipated energized electrical work tasks that would be completed under the "Job." This risk assessment procedure can be qualitative or quantitative. It is recommended that a qualitative risk assessment be used.

What does this mean? Your Electrical Safety Program shall identify energized electrical work tasks that would be completed at your workplace by Qualified Persons. Create an inventory. CSA Z462 provides a starting point in Clause 4.3.5 Arc Flash Risk Assessment, Table 2 Estimate of the Likelihood of Occurrence of an arc flash incident for ac and dc systems. You can use the work tasks listed and create a work task risk register table for your workplace and use this as

the basis of the qualitative energized electrical hazard risk assessment procedure you complete.

The outcome of the documented risk assessment procedure included in your Electrical Safety Program and reviewed with and agreed to by your Electrical Safety Committee provides validation of the expected hierarchy or risk control methods that will be documented by the Qualified Person in the field as applied to achieve the documented residual risk level.

In the tutorial offered by the USA DOE their risk assessment procedure utilized the electrical hazard classifications that would be identified against work tasks and included a review and validation of

the potential severity of injury or damage to health and expected likelihood of occurrence of worker exposure. The implemented risk assessment procedure and related electrical hazard risk matrix may be different from employer to employer, but the results achieved will be the same "residual risk reduced to as low as reasonably practicable."

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

Terry Becker, P.Eng, CESCP, IEEE Senior Member is the first past Vice-Chair of the CSA Z462 Workplace electrical safety Standard Technical Committee and currently a Voting Member and Working Group Leader for Clause 4.1 and the Annexes. Terry is also a Voting Member on the CSA Z463 Maintenance of electrical systems Standard and a Voting Member of the IEEE 1584 Guide for Performing Arc-Flash Hazard Calculations. Terry has presented at Conferences and Workshops on electrical safety in Canada, the USA, India and Australia. Terry is a Professional Engineer in the Provinces of BC, AB, SK, MB and ON. Terry is an Electrical Safety Specialist, Management Consultant, and can be reached at 587.433.3777 or by email **terry.becker@twbesc.ca**.