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HIGH-VOLTAGE ARC FLASH ASSESSMENT AND APPLICATIONS — PART 1



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ELECTRICAL SAFETY PROGRAM PRINCIPLES:

ARE THEY IN YOUR ELECTRICAL SAFETY PROGRAM?

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NFPA 70E Article 110.1 and CSA Z462 Clause 4.1.6 outline the requirements to implement a compliant electrical safety program as part of an employer's overall occupational health and safety management system (OHSMS).

ANSI Z10, *Occupational Health & Safety Management Systems* (for the US) and CSA Z1000, *Occupational health and safety management* (Canada) outline general requirements

and specific content for an overall OHSMS. In the US, OSHA also provides guidance in *Recommended Practices for Safety and Health Programs*, 2016.



Specifically, NFPA 70E and CSA Z462 advise that the electrical safety program shall include content related to inspection, condition of maintenance, awareness and self-discipline, electrical safety program principles, electrical safety program controls, electrical safety program procedures, risk assessment procedure, job safety planning and job briefing, incident investigations, and auditing.

This list is detailed, but may not be complete, and the employer should consult additional standards and industry best practices. The framework or table of contents of the employer's electrical safety program should be complete and should also address requirements for emergency response to electrical incidents and incident reporting; requirements to provide electrical specific PPE, tools, and equipment; training; contractor management; documentation management; and change management.

WHAT IS AN ELECTRICAL SAFETY PROGRAM?

NFPA 70E Article 100 Definitions and CSA Z462 Clause 3 Definitions define an electrical safety program as:

A documented system consisting of electrical safety principles, policies, procedures, and processes that direct activities appropriate for the risk associated with electrical hazards.

With respect to the ESP principles, a principle is a fundamental truth or proposition that serves as the foundation for a system or belief or behavior or for a chain of reasoning. In simple terms, the electrical safety program's principles are the Coles notes (Cliff notes in the US) key requirements that form the basis of the electrical safety program as a system.

Does your company's electrical safety program outline detailed principles? Let's start by reviewing a list of principles that an electrical safety program could include.

Principle #1 Elimination. As outlined in NFPA 70E Article 110.1(H)(3) and CSA Z462 Clause 4.1.6.8.4, elimination is the highest priority and most effective risk control method related to arc flash and shock hazards. Electrical work shall be performed on de-energized electrical conductors or circuit parts by establishing an electrically safe work condition unless de-energizing introduces additional hazards or increased risk or is infeasible due to equipment design or operational limitations or the voltage is less than 30V for Canada or 50V in the USA.

Principle #2 Safe Installations. Electrical equipment shall be installed and maintained to the minimum requirements of the jurisdiction having authority. The electrical equipment shall be approved or listed, or equivalently approved or listed by the jurisdiction having authority.

Principle #3 Operating Is Not Maintenance.

Operating energized electrical equipment for its intended use is NOT maintenance and, under normal operating conditions, doesn't require arc flash or shock PPE. A risk assessment procedure and process shall be used to validate normal operating conditions. Follow manufacturer's requirements for operating electrical equipment within specific parameters.

Principle #4 Portable Cord-and-Plug-Connected Electrical Equipment.

Portable cord-and-plug-connected electrical equipment and cord sets shall be approved for the usage and shall be visually inspected before use. Where required, a GFCI shall be used. When a GFCI is used, it shall be inspected and tested before use by pushing the Test and Reset buttons to confirm proper function.

Principle #5 Risk Assessment Procedure. For a job assigned to a qualified electrical worker, a risk assessment procedure shall be applied and documented to justified energized electrical work tasks to assess the potential severity of injury or damage to health and estimate the likelihood of occurrence. The hierarchy of risk control methods shall be applied in order to achieve a residual risk level that is as low as reasonably practicable (ALARP).

Principle #6 Arc Flash and Shock Risk Assessments. Before a qualified electrical worker works on energized electrical conductors or circuit parts and as a component of the job's overall risk assessment procedure, both shock and arc flash risk assessments shall be completed and documented to determine additional protective measures that must be applied to reduce risk. This includes work practices, approach boundaries, and the electrical specific PPE, tools, and equipment required when the electrical hazards are real and the qualified electrical worker is inside the approach boundaries.

Principle #7 Energized Electrical Work Permit (EEWP). Energized electrical work task(s) may require the use of an energized

electrical work permit (EEWP). In most cases, routine work tasks such as operating energized electrical equipment in a normal operating condition, voltage and current measurements, inspection, general housekeeping around electrical equipment, and reading meters or using HMI displays DO NOT require an EEWP. Other work tasks may also be exempted due to infeasibility due to equipment design or operational limitations such as:

- Racking power circuit breakers in or out
- Installing or removing temporary protective grounds
- Removing bolts on covers

Justified repair or alteration work tasks shall require an EEWP to be executed and issued.

Principle #8 Electrical Work Zone. An electrical work zone shall be established for energized electrical work tasks with red danger tape and tagged or otherwise barricaded at the arc flash boundary or limited approach boundary, whichever is farther away or at the doors into electrical rooms. Establishing an electrical work zone ensures that unqualified/unprotected workers are not exposed to arc flash and shock hazards and eliminates interruption of the execution of the work task by tourists, which could increase the likelihood of occurrence.

Principle #9 Overhead Power Lines, HV Substations, and Buried Power Cables. Work on high-voltage overhead power lines and other high-voltage outdoor substation electrical equipment with exposed conductors or circuit parts requires regulated limits of approach or minimum approach distances, and additional industry-accepted practices to be followed. When entering an outdoor, fenced-in, high-voltage substation, authorization-to-access policies and procedures shall be followed. If energized buried power cables are present, CALL BEFORE YOU DIG!

Principle #10 TEST-BEFORE-TOUCH. All electrical conductors and circuit parts shall

be considered energized (i.e., voltage present) until proven otherwise by testing for absence of voltage with an approved test instrument. **TEST BEFORE TOUCH!** Where required, temporary protective grounds shall be installed. Testing for absence of voltage is energized electrical work, and the process for establishing and verifying an electrically safe work condition shall be followed.

Principle #11 Qualified and Competent Workers. Workers shall be qualified, competent, and authorized for the energized electrical work task(s) they undertake, including the ability to identify the electrical hazards related to the work task(s) assigned to them.

Principle #12 Planning and Procedure Use. All energized electrical work shall be planned. If an electrical safe work procedure is required for the job and work task(s), it shall be documented and filed for record purposes and future use.

Principle #13 Job Safety Planning. Prior to beginning the work task(s), a job safety plan shall be documented by the qualified electrical worker. The plan will include a description of the work task(s); identification and analysis of the electrical hazards that apply to the work task(s); documentation of each work task's arc flash and shock risk assessments; and identification of appropriate work procedures, special precautions, and energy source controls.

Principle #14 Job Briefing. A job briefing for specific jobs and related energized electrical work tasks where multiple qualified electrical workers are involved shall be completed before the work task(s) are executed. The job safety plan and any additional requirements of the employer's OHSMS shall be reviewed.

Principle #15 Electrical Equipment Maintenance. Electrical equipment shall be maintained in good working order and electrical protective equipment (e.g., circuit

breakers, relays, etc.) shall be tested on a determined frequency to ensure it will perform as expected and designed. An employer shall document and implement a comprehensive electrical equipment maintenance program.

Principle #16 Electrical Safety and Technical Skills Training. Personnel shall receive appropriate workplace electrical safety training and technical skills training depending on their role. First aid and CPR training are required based on employer requirements.

Principle #17 Electrical Specific PPE, Tools, and Equipment. Appropriate electrical specific PPE, tools, and equipment shall be selected for a work task. It shall be readily available and properly cared for, maintained, and used. It shall be inspected prior to use. Budgeting shall be provided for maintaining and upgrading electrical specific PPE, tools, and equipment.

Principle #18 Mitigation, Substitution, and Prevention through Design (PtD). Arc flash and shock mitigation for existing electrical equipment shall be considered and incorporated into new facilities or upgrades. Where arc flash hazard incident energy analysis studies have been completed, technically and cost-feasible incident energy reduction design changes shall be considered.

Principle #19 Electrical Emergency Response. Emergency response requirements for electrical incidents and methods of release related to shock shall be reviewed with affected employees and contractors and training provided.

Principle #20 Electrical Incidents and Near Misses. Electrical incidents or near misses shall be reported by workers to their supervisors and fully investigated in compliance with the employer's incident management system. Root cause(s) shall be determined and corrective actions implemented. A continuous improvement model shall be followed.



Principle #21 Management of Change.

Management of change is required to ensure that changes to the power distribution system, electrical equipment, electrical protective devices, single line drawings, and the electrical safety program that can affect worker exposure to electrical hazards is controlled and approved.

Principle #22 Audit. The principles and the electrical safety program shall be audited. A continuous improvement model shall be followed. Measure performance and ensure sustainability. PLAN-DO-CHECK-ACT!

CONCLUSION

An employer's electrical safety program is an occupational health and safety management system that includes a comprehensive and detailed document with supporting appendices, forms, and flow charts. Electrical safety program principles provide a summary of the core and key requirements an electrical safety program must fulfill. These principles are extracted from industry standards such as NFPA 70E and CSA Z462, as well as recognized OHSMS standards such as ANSI Z10 for the US, CSA Z1000 for Canada, industry accepted practices, or to meet OH&S regulatory requirements.

REFERENCES

OSHA 3885, *Recommended Practices for Safety and Health Programs*, October 2016. Available at <https://www.osha.gov/shpguidelines/>.



Terry Becker, P.Eng, CESC, and IEEE Senior Member, is an independent electrical safety specialist and consultant at TW Becker Electrical Safety Consulting. As the previous owner and visionary of ESPS Electrical Safety Program Solutions Inc., he spent more than 10 years growing the company into an industry-leading total solutions provider for electrical safety consulting, licensed electrical safety programs, and training solutions, including the e-Learning Electrical Safety Training System (ESTS), Electrical Worker, and Non-Electrical Worker training programs. Terry brings more than 25 years of experience as an Electrical Engineer working in both engineering consulting and for large industrial oil and gas corporations. He is the first past Vice-Chair of the CSA Z462 Workplace electrical safety Standard Technical Committee and is currently a Voting Member and leader of the Annexes Working Group and Clause 4.1 Working Group. Terry is also a voting member of the IEEE 1584 Arc Flash Hazard Calculations Standard Committee and a voting member of the CSA Z463 Maintenance of electrical systems Standard Technical Committee. He attends all NFPA 70E technical meetings as a guest, is recognized as an electrical safety subject matter expert, and participates in NFPA 70E Working Groups. Terry is a Professional Engineer in the Provinces of Alberta, British Columbia, Saskatchewan, and Ontario, and has presented on CSA Z462, NFPA 70E, and electrical safety practices at industry conferences and workshops in Canada, the United States, Australia, and India.