6.6.5.3 Personnel protection

Safety-related work practices shall be used to safeguard workers from injury while they are exposed to electrical hazards from exposed electrical conductors or circuit parts that are or can become energized. The specific safety-related work practices shall be consistent with the electrical hazard(s) and the associated risk. For calibration and adjustment of equipment as it pertains to sensors, motor controllers, control hardware, and other devices that need to be installed inside equipment or control cabinet, surrounded by electrical hazards, the electrical safety authority shall define the required PPE based on the risk and exposure.

Electrical insulating blankets, covers, or barriers may be used to prevent inadvertent contact to exposed terminals and conductors. Insulated/nonconductive adjustment and alignment tools shall be used where feasible.

6.6.6 Approval

The equipment or systems used in an R & D area or laboratory shall be approved or field evaluated before use.

Note: Laboratory and R & D equipment or systems can pose unique electrical hazards requiring mitigation. Such hazards can include ac and dc discharges; low voltage and high amperage current; high voltage and low amperage current; large electromagnetic fields; induced voltages; pulsed power; multiple frequencies; and similar exposures.

6.6.7 Custom built, non-approved research equipment, 1000 V or less, ac or dc

6.6.7.1 Equipment marking

Marking of equipment shall be required for, but not limited to, equipment fabricated, designed, or developed for research testing and evaluation of electrical systems. Marking shall sufficiently list all voltages entering and leaving control cabinets, enclosures, and equipment.

Caution, warning, or danger labels shall be affixed to the exterior describing specific hazards and safety concerns.

Note: See ANSI/NEMA Z535 for more information on precautionary marking of electrical systems or equipment.

6.6.7.2 Documentation

Sufficient documentation shall be provided and readily available to personnel that install, operate, and maintain equipment that describes operation, shutdown, safety concerns, and nonstandard installations. Schematics, drawings, and bill of materials describing power feeds, voltages, currents, and parts used for construction, maintenance, and operation of the equipment shall be provided.

6.6.7.3 Shutdown procedures

Safety requirements and emergency shutdown procedures of equipment, to include lock-out requirements. If equipment-specific lock-out is required, then documentation outlining this procedure and PPE requirements shall be made readily available.

6.6.7.4 Specific hazards

Specific hazards, other than electrical, associated with research equipment shall be documented and readily available.

6.6.7.5 Approvals

Drawings, standard operational procedures, and equipment shall be approved by the electrical safety authority on site before initial startup. Assembly of equipment shall comply with applicable standards unless research application requires exceptions. Equipment that does not meet the applicable standards shall be required to be approved by the electrical safety authority. Proper safety shutdown procedures and PPE requirements shall be considered in the absence of grounding and/or bonding.

6.6.7.6 Tools, training, and maintenance

Documentation shall be provided if special tools, unusual PPE, or other equipment is necessary for proper maintenance and operation of equipment. The electrical safety authority shall make the determination of appropriate training and qualifications required to perform specific tasks.

6.6.8 Custom built, unlisted research equipment, greater than 1000 V, ac or dc

Installations shall comply with all requirements of Clause <u>6.6.7</u>. In the event that research equipment requires PPE beyond what is commercially available, the electrical safety authority shall determine safe work practices and PPE to be used.

6.6.9 Energy thresholds

Energy exposure levels shall not exceed those identified in the following list unless appropriate controls are implemented as approved by the electrical safety authority:

- a) ac: 50 V and 5 mA;
- b) dc: 100 V and 40 mA; and
- c) capacitive systems:
 - i) less than 100 V and greater than 100 J of stored energy;
 - ii) greater than or equal to 100 V and greater than 1.0 J of stored energy;
 - iii) greater than or equal to 400 V and greater than 0.25 J of stored energy.

Note: This information is extracted from DOE-HDBK-1092.

6.6.10 Establishing an electrically safe work condition

Energized electrical conductors and circuit parts shall be put into an electrically safe work condition before a worker performs work.

At the discretion of the electrical safety authority, alternative methods of ensuring worker safety may be employed for the following conditions:

- a) minor tool changes and adjustments, and other normal production operations that are routine, repetitive, or sequential and integral to the use of the equipment for production;
- b) minor changes to the unit under test and other minor servicing activities, to include the activities listed under Item a), that take place during research and development; and
- c) work on cord-and-plug-connected equipment for which exposure to the hazards of unexpected energization or start up is controlled by
 - i) unplugging the equipment from the energy source; and
 - ii) the worker performing the work maintains exclusive control of the plug.

Annex A (informative) Aligning implementation of this Standard with CSA Z45001

Note: This Annex is not a mandatory part of this Standard.

A.1 General

Injuries from electrical energy are a leading cause of fatalities in the workplace in Canada, generally ranking as the fifth- or sixth-highest cause of occupational deaths. This Standard specifies requirements unique to the hazards of electrical energy. By itself, however, this Standard does not constitute a comprehensive and effective electrical safety program. The most effective application of the requirements of this Standard can be achieved within the framework of a recognized occupational health and safety management system standard.

An occupational health and safety management system standard applies proven methods of quality management to health and safety risks, including a systematic approach for continuous improvement in minimizing health and safety risks. It provides a businesslike approach to health and safety by providing for goal setting, planning, and measuring performance. Effective application of an occupational health and safety management system includes the following elements:

- a safety policy;
- a process for setting improvement goals and for measuring progress toward these goals;
- a process for identifying hazards and for evaluating and managing associated risks on an ongoing basis;
- a process for managing risks holistically, rather than having multiple, competing efforts;
- a process for ensuring personnel are trained and competent to perform their jobs;
- a process for reporting and investigating hazards, incidents and injuries for corrective action to prevent recurrence; and
- a process for conducting periodic reviews or audits of the occupational health and safety management system.

CSA Z45001 provides comprehensive guidance on the elements of an effective health and safety management system, and is one recognized Standard. CSA Z45001 is harmonized with other internationally recognized Standards, including ISO 9001 and ISO 14001. Some companies and other organizations have proprietary health and safety management systems that are aligned with the key elements of CSA Z45001.

Included in occupational health and safety management standards, such as CSA Z45001, is the requirement to consider a hierarchical approach to the implementation of reasonable and practical preventive and protective control measures. The control measures should be considered according to the following priority:

- eliminate the hazard;
- substitute with other materials, processes, or equipment;
- use engineering controls;
- use safer work systems that increase awareness of potential hazards (e.g., lights, signage, beepers, etc.);
- provide administrative controls, such as training and procedures; and
- provide PPE, including measures to ensure its appropriate use and maintenance.

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This list is consistent with content included in Annex \underline{F} with respect to the steps to be taken and the decisions to be considered when performing an electrical work risk assessment.

The most effective design and implementation of an electrical safety program can be achieved through a joint effort involving electrical subject matter experts and safety professionals knowledgeable about safety management systems. Such collaboration can help ensure that proven safety management principles and practices applicable to any hazard in the workplace are appropriately incorporated into the electrical safety program.

This Annex provides guidance on implementing this Standard within the framework of CSA Z45001 and other recognized or proprietary comprehensive occupational health and safety management system standards. Table <u>A.1</u> summarizes the harmonization of the key elements of CSA Z45001 and the corresponding requirements of this Standard.

Table A.1 Correspondences between this Standard and CSA Z45001 (See Clause A.1.)

CSA Z45001 Table of contents	OHSMS intent or objective*	CSA Z462 correspondence
1 Scope		1 Scope
2 Normative references		2 Reference publications
3 Terms and definitions		3 Definitions
 4 Context of the organization 4.1 Understanding the organization and its context 4.2 Understanding the needs and expectations of workers and other interested parties 4.3 Determining the scope of the OH&S management system 4.4 OH&S management system 	The organization (employer) is required to establish, implement, maintain and continually improve an OHSMS. The OHSMS must have a defined and documented scope that is applicable to the internal and external context in which the organization operates. Scope and context will be used to guide planning (Clause 6).	4.1.7.1 General The employer's electrical safety program must be implemented as part of the employer's OHSMS, when one exists.
5 Leadership and worker participation 5.1 Leadership and commitment 5.3 Organizational roles, responsibilities and authorities 5.4 Consultation and participation of workers	 To be effective, the OHSMS must have active leadership from top management that includes defining roles and responsibilities for the implementation of the OHSMS; and establishing a process for worker consultation and participation. 	 4.1.3.1 Employer responsibility The employer has the responsibility to establish, document, and implement the safety-related work practices and procedures required by CSA Z462; and provide workers with training in those work practices and procedures.
5.2 OH&S policy	The organization must establish, document and communicate an OH&S policy that reflects the organization's commitment to provide safe and healthy working	4.1.5 Electrical safety policy The employer must create and document a policy that affirms their commitment to eliminate

(See Clause <u>A.1</u>.)

(Continued)

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CSA Z45001 Table of contents	OHSMS intent or objective*	CSA Z462 correspondence
	conditions for the prevention of work-related illness and injury. The policy will be used to guide Planning (Clause 6).	hazards, control risk, and de- energize when feasible.
6 Planning 6.1 Actions to address risks and opportunities 6.1.1 General 6.1.2 Hazard identification and assessment of risks and opportunities 6.1.3 Determination of legal requirements and other requirements 6.1.4 Planning action 6.2 OH&S objectives and planning to achieve them	 This is not task planning, rather, it is the "Plan" activity in the management system iterative "PDCA" cycle when the organization formulates a plan to implement an OHSMS. Planning includes addressing the scope and context identified in Clause 4; establishing OH&S objectives and the method(s) to achieve them; establishing an ongoing risk assessment process to identify hazards and control risk; gathering and documenting information such as: hazards and risk legal and other requirements benchmarking best practices (such as CSA Z462) incident investigations. The OH&S objectives must be measured, monitored, and communicated. 	 4.1.7.1 General The employer's electrical safety program must direct activity appropriate to the risk associated with electrical hazards. 4.1.7.8 Risk assessment procedure The electrical safety program must include a risk assessment procedure that will be used before work is started to address worker exposure to electrical hazards. The procedure must include hazard identification; risk assessment; and risk control selected from the hierarchy of risk control methods. 4.1.7.6 Electrical safety program controls The electrical safety program must identify the controls by which it is measured and monitored.
 7 Support 7.1 Resources 7.2 Competence 7.3 Awareness 7.4 Communication 7.4.1 General 7.4.2 Internal communication 7.4.3 External communication 7.5 Documented information 7.5.1 General 7.5.2 Creating and updating 7.5.3 Control of documented information 	Upper management of the organization must commit ongoing financial, human and other resources to maintain a functioning OHSMS. Worker competence must be defined and action taken to attain and maintain such competence. Actions can include worker training, education and experience. Actions must be documented.	 4.1.7 Electrical safety program Employers must implement and document an electrical safety program. 4.3.1 Working while exposed to electrical hazards Only qualified persons are permitted to work on electrical conductors or circuit parts that have not been put into an electrically safe work condition. 3 Qualified person (worker) A qualified worker requires skills and knowledge and must be training in risk assessment and control.

Table A.1 (Continued)

(Continued)

CSA Z45001 Table of contents	OHSMS intent or objective*	CSA Z462 correspondence
		 4.1.8.1.2 Training of qualified persons This Clause lists detailed prescriptive training requirements to enable qualified workers to attain a specific level of competency. 4.1.8.1.4 Retraining Periodic retraining is mandated to maintain worker competence. 4.1.8.1.6 Electrical safety training documentation All electrical safety training and retraining must be documented.
8 Operation 8.1 Operational planning and control 8.1.1 General	This is the "Do" activity in the management system iterative "PDCA" cycle when the organization puts into operation the Plan developed in accordance with Clause 6.	
8.1.2 Eliminating hazards and reducing OH&S risks	 Risk assessments are performed to identify hazards and estimate and evaluate risk. Those hazards that can be eliminated are. The risk associated with hazards that cannot be eliminated is controlled. Risk is controlled via the following hierarchy: a) eliminate the hazard; b) substitute with less hazardous processes, operations, materials, or equipment; c) use engineering controls and reorganization of work; d) use administrative controls, including training; e) use adequate personal protective equipment. 	 4.1.7.8 Risk assessment procedure The electrical safety program must contain a risk assessment procedure to address worker exposure to electrical hazards. 4.1.7.9 Job safety planning and briefing Before work involving electrical hazards, a qualified worker must complete and document a job safety plan that includes a description of the job, the individual tasks and identification of the electrical hazards associated with each task; and a shock risk assessment and an arc flash risk assessment. 4.3.4 Shock risk assessment and 4.3.5 Arc flash risk assessment The risk assessment procedure developed per Clause 4.1.7.8 is implemented by workers to identify shock and arc flash hazards, determine if additional protective measures are required, and if so, select the appropriate risk control method or methods from the hierarchy of risk control.

Table A.1 (Continued)

(Continued)

CSA Z45001 Table of contents	OHSMS intent or objective*	CSA Z462 correspondence
		 4.1.7.8.5 Hierarchy of risk control methods: a) elimination; b) substitution; c) engineering controls; d) awareness; e) administrative controls; and f) PPE.
8.1.3 Management of change	 A process(es) for the implementation and control of planned temporary and permanent changes that impact worker safety such as a change in workplace locations and surroundings; working conditions; and legal requirements and other requirements. 	 4.1.7.9 Job safety planning and briefing Before starting each job that involves exposure electrical hazards a qualified worker must complete and document a job safety plan. 4.1.7.9.4 Change in scope Additional job briefings must be held if significant changes that might affect the safety of workers occur during the course of the work. 4.1.7.12.1 Electrical safety program audit The electrical safety program must be audited to verify that the program principles and procedures are in compliance with the requirements of the standard. Program audits must be done at a frequency not to exceed 3 years.
8.1.4 Procurement	A process(es) must be established and maintained to control the procurement of products and services in order to ensure their conformity to the OHSMS.	 4.3.7.3.14 Personal protective equipment Standards PPE must comply with the applicable Standard listed in Table 5 (e.g., ASTM D120 rubber insulating gloves). 4.3.7.4 Other protective equipment The other protective equipment specified in Clause 4.3.7.4 must meet the requirements of the Standards specified in Table 7 (e.g., CSA Z11, on ladders).
8.2 Emergency preparedness and response	Processes needed to prepare for and respond to potential emergency situations must be established, implemented, and maintained.	 4.1.8.3 Emergency procedure training 4.1.8.3.1 Contact release 4.1.8.3.2 First aid, emergency response, and resuscitation These Clauses establish emergency preparedness response training

Table A.1 (Continued)

(Continued)

CSA Z45001 Table of contents	OHSMS intent or objective*	CSA Z462 correspondence
		requirements, the frequency of such training, and the training verification interval.
 9 Performance evaluation 9.1 Monitoring, measurement, analysis and performance evaluation 9.1.1 General 9.1.2 Evaluation of compliance 9.2 Internal audit 9.2.1 General 9.2.2 Internal audit programme 9.3 Management review 	This is the "Check" activity in the management system iterative "PDCA" cycle when the organization monitors, measures, analyzes, and evaluates the performance of the OHSMS. The analysis and evaluation are done against the OHSMS objectives established per Clause 6 to identify opportunities for improvement.	 4.1.7.10 Incident investigations The electrical safety program must include a requirement to investigate electrical incidents. 4.1.7.12.1 Electrical safety program audit The electrical safety program must be audited to verify that the program principles and procedures are in compliance with the requirements of the standard. Program audits must be done at a frequency not to exceed 3 years. 4.1.7.12.2 Field work audit Field work must be audited to verify that the electrical safety program procedures are being followed. Field work audits must be done at a frequency not to exceed 1 year. 4.1.7.12.4 Documentation All audits must be documented.
10 Improvement 10.1 General 10.2 Incident, nonconformity and corrective action 10.3 Continual improvement	This is the "Act" activity in the management system iterative "PDCA" cycle when the organization determines opportunities for improvement (identified per Clause 9) and implements necessary actions to achieve the intended outcomes of its OHSMS. These actions will result in revisions to the OHSMS Plan (Clause 6) and possibly to the OH&S Policy (Clause 5.2).	 4.1.7.12 Auditing Audit results are used to revise the program, training or procedures to ensure: compliance with the Standard; and adherence to the electrical safety program principles and procedures.
Annex A (informative) Guidance on the use of this document		Annex A – Aligning implementation of this Standard with CSA Z45001 Annex F – Risk assessment and risk control Annex U – Human performance and workplace electrical safety
Bibliography		Annex W — Bibliography

Table A.1 (Concluded)

* All Clause references in Column 2 are for CSA Z45001.

Annex B (informative) Safety-related electrical maintenance

Note: This informative (non-mandatory) Annex has been written in normative (mandatory) language to facilitate adoption where users of the Standard or regulatory authorities wish to adopt it formally as additional requirements to this Standard.

B.1 General

Regularly scheduled electrical maintenance is a critical part of any electrical safety program (see Clauses 4.1.7.3 and 5.3.1).

Improper equipment operation can drastically increase the risk associated with worker exposure to electrical hazards. Studies by the Electrical Safety Authority of Ontario indicate that 66% of safety incidents can be attributed to maintenance-related issues. A survey performed by the InterNational Electrical Testing Association (NETA) in October 2007 indicated that 22% of service-aged circuit breakers had some type of malfunction and 10.5% did not operate at all during maintenance testing.

B.2 Maintenance, protective device operating times, and incident energy

Incident energy and the arc flash boundary are a function of the operating times of protective devices such as fuses, relays, and circuit breakers. The arc flash PPE category method requires careful attention to the clearance times specified in Tables $\underline{6A}$ and $\underline{V.1}$ for ac and Table $\underline{6B}$ for dc.

Figure <u>B.1</u> shows a typical power system time–current curve used in determining incident energy levels. In Figure <u>B.1</u>, a circuit breaker instantaneous setting has been changed from 5X to 4X, reducing the operating time during an arc flash event from 1.5 to 0.04 s. This lowers the incident energy from 33.5 to 1.1 cal/cm². However, these curves are based on manufacturer's data for equipment in as-new condition. If the protective device's graph does not correspond with how the breaker actually performs in the field, a dangerous situation exists, as these devices are typically slower than indicated in the manufacturer's performance specifications.

In some cases, the devices do not operate at all. Lengthening the operating time will vastly increase the incident energy values, arc flash boundaries, and PPE requirements. Operating times with relaying and circuit breakers can increase when regularly scheduled maintenance practices are not followed.

It is vitally important to this process to ensure that the entire system functions properly, including the current sensors, relays, and trip circuits. Ensuring that power fuses follow a replacement-in-kind procedure is also an important part of this maintenance process. Assuming that electrical power distribution equipment will operate as designed without verifying the operating condition can result in an unexpected increase in incident energy.

B.3 Electrical maintenance management system

A written electrical maintenance program based on the latest codes and standards would include the following elements:

- a) strategies on the type and frequency of maintenance for apparatus in the electrical system based on criticality, environment, duty, equipment vintage and budget;
- b) personnel involvement of owners, management, staff, and contractors including their qualifications to manage and execute the program;

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- c) documentation and storage systems for keeping up to date electrical drawings, power systems studies, settings, equipment service manuals and equipment lists as well as electrical test and inspection reports;
- d) on-line and off-line electrical testing and inspection routines; and
- e) a contingency system using failure mode analysis, critical equipment identification, and spare parts inventory.

Note: See CSA Z463 for information regarding electrical maintenance management.

B.4 Maintenance Standards

Standards and Guidelines for maintenance of electrical power distribution equipment and systems can be used along with the manufacturer's recommendations to provide an overall quality program.

CSA Z463 provides guidance for the development of an electrical equipment and asset management maintenance program and the execution of maintenance for equipment and systems. This Guideline applies to new and existing electrical equipment. For new installations of electrical equipment, this Guideline can be applied during the early design stages to allow for the implementation of proactive electrical maintenance practices and maintenance safety. CSA Z463 provides information related to the principles for establishing an effective electrical maintenance program as part of a quality management system (QMS) and provides guidance for an electrical maintenance management system (EMMS). Specifically, CSA Z463 outlines that effective electrical equipment maintenance should address the following:

- a) worker safety;
- b) prevention of losses and property damage;
- c) enhancement of system performance; and
- d) reduction of the probability of failure (POF).

NFPA 70B provides a complete guideline on maintenance requirements for electrical, electronic, and communications systems and equipment used in industrial and commercial applications and can be used in combination with CSA Z463.

ANSI/NETA MTS specifies procedures for evaluating equipment for continued safe and reliable service, including recommended test levels and test values. Visual and mechanical inspection and electrical test requirements are provided for nearly every commonly known type of equipment. Guidance on frequency of maintenance testing is also provided.



