LISTEN. THINK. SOLVE.

Arc flash and electrical safety - the Canadian approach

Rockwell Safety Services – Canada

Canadian Electrical Safety Requirements
CSA Z462-15 (Electrical Safety in the Workplace)

Rockwell Automation

Canadian Electrical Safety Standards and Regulations

- Canadian Electrical Code – CEC
  - Forms the basis for Provincial and Municipal codes
- Canadian Labour Code (Part II)
  - Applies to federally regulated organizations
- Provincial Regulations
  - Apply to Provincially regulated organizations, including most private industry, hospitals / healthcare, and education
- 'Voluntary' Standards (CSA Z462)

CANADIAN STANDARDS ASSOCIATION

Canadian Electrical Safety Regulations

What Canadian regulations and standards exist to address electrical safety in the work place?

- Canadian Labour Code, Part II (Sections 122 – 160).
  - Specifies duties of employers and employees; establishment of health and safety committees, representatives and officers; refusal to work, appeals, penalties, etc.
- CSA – Canadian Standards Association.
  - Writes industry consensus standards that are much more specific than laws and regulations.
- CEC – Canadian Electric Code.
  - Intended for those who design, install and inspect electrical installation. Safety related work practices are not always found in the Canadian Electric Code.
- Provincial Acts and Regulations

6

Electrical Safety in Canada Provincial Regulations

Many regulations that address electrical safety are specific to each Province.

- British Columbia (BC)
  - Workers Compensation Act – Part 3 Occupational Health and Safety
  - Enforced by Work Safe BC (www.worksafebc.com)
- Alberta
  - OHS (Occupational Health and Safety) Act, Regulation, and Code
  - Enforced by Employment and Immigration – Safe & Fair Workplaces (http://humanservices.alberta.ca/working-in-alberta.html)
- Saskatchewan
  - OHS Act and Regulation
  - Enforced by Labour Relations and Workplace Safety (www.lrws.gov.sk.ca)

 7

Electrical Safety in Canada Provincial Regulations

- Manitoba
  - Workplace Safety and Health Act and Regulation
  - Enforced by Family Services & Labour (www.gov.mb.ca/labour)
- Ontario
  - Occupational Health and Safety Act (OHSA) and Regulations
  - Enforced by the Ministry of Labour (MOL) (http://www.labour.gov.on.ca/english/hs/faqs/molrole.php)
- Quebec
  - OHS Act and Regulation
  - Enforced by CSST (Commission de la sante et de la securite du travail) (www.csst.qc.ca)

Electrical Safety in Canada Provincial Regulations

- New Brunswick
  - OHS (Occupational Health and Safety) Act and Regulation
  - Enforced by Worksafe NB (www.worksafenb.ca)
- Nova Scotia
  - Occupational Health and Safety Act and Regulations
  - Enforced by Labour and Advanced Education (http://www.gov.ns.ca/lae)
- Newfoundland and Labrador
  - OHS Act and Regulation
  - Enforced by Workplace Health, Safety & Compensation Commission (WHSCC) (www.whscc.nf.ca); and also Service NL (www.servicenl.gov.nl.ca)

Electrical Safety in Canada Provincial Regulations

- Prince Edward Island (PEI)
  - OHS (Occupational Health and Safety) Act and General Regulation
  - Enforced by Workers' Compensation Board of PEI (www.wcb.pe.ca)
- Yukon
  - Occupational Health and Safety Act and Regulations
  - Enforced by Yukon Workers Compensation Health & Safety Board (http://www.wcb.yk.ca)
- Northwest Territories and Nunavut
  - Mine Health & Safety Act (+ regulations) and also Safety Act (+ regulations)
  - Enforced by Workers' Safety and Compensation Commission (www.wcb.nt.ca)

What are the odds?

- For a worker in Ontario, the odds of going home at least once this year because of an electrical injury at work is about 1 in 82,000.* (This is average across the workforce – if your work requires you to be in close proximity to exposed, energized, conductors, the likelihood will be much higher).

* Statistics were obtained from the Association of Workers Compensation Boards of Canada (AWCBC) and Statistics Canada

What are the odds?

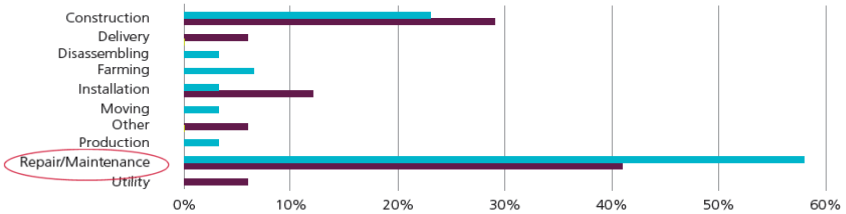
- Not including lightning strikes and contact with power lines, over 5000 people have had lost time injuries due to exposure to electrical energy in Canada since 1999, and more than 100 people have died.*
- Also, from 1999 – 2009, in Ontario alone, 48 people have suffered 3rd degree burns, and in 2009, 82 people were injured and lost time at work in Ontario because of exposure to electrical energy (shock, arc flash, or arc blast).*
- **Electrical workers** accounted for 22% of all occupational fatalities in Ontario between 2006 and 2010. There are at least two critical injuries to electricians each year. Safety incidents tended to be associated with unsafe work practices.

  * Statistics presented here were obtained from the Association of Workers Compensation Boards of Canada (AWCBC), and the Electrical Safety Authority (ESA)

 12

How does it happen?

5 Occupational Electrical-Related Fatalities by Type of Work in Ontario, 2002-2006 & 2007-2011



	Construc-tion	Delivery	Disassem-bling	Farming	Installation	Moving	Other	Production	Repair/ maint	Utility
2002 – 2006	23%	0.0%	3.2%	6.5%	3.2%	3.2%	0.0%	3.2%	58%	0.0%
2007 – 2011	29%	5.9%	0.0%	0.0%	12%	0.0%	5.9%	0.0%	41%	5.9%

Conclusion: Increase in percentage for utility, other, installation, delivery, and construction.

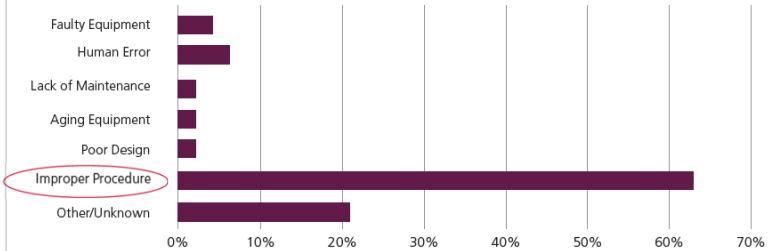
Source: ESA and Coroner's records

 13

How does it happen?

Rockwell Automation

6 Probable Cause of Occupational Electrical-Related Fatalities in Ontario, 2002-2011



	Faulty Equipment	Human Error	Lack of Maintenance	Aging Equipment	Poor Design	Improper Procedure	Other/ Unknown
Probable Cause of Fatalities	4.2%	6.3%	2.1%	2.1%	2.1%	63%	21%

Conclusion: Over 60% are possibly due to improper procedures.

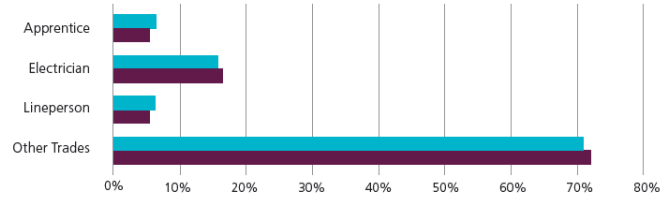
Source: ESA and Coroner's records

 14

Who does it happen to?

Rockwell Automation

7 Percentage of Occupational Electrical-Related Fatalities by Work Type in Ontario, 2002-2006 and 2007-2011



	Apprentice	Electrician	Lineperson	Other Trades
2002-2006	6.5%	16%	6.5%	71%
2007-2011	5.6%	16.6%	5.6%	72.2%

Conclusion: No change in electrical-related fatality percentage for all electrical trades people.

Source: ESA and Coroner's records

 15

History of CSA Z462

- 2004 – NFPA 70E was first reviewed by the CSA Z460 technical committee for reference in their new LOTO standard.
- Technical Committee recommends that CSA consider adopting NFPA 70E and converting it into a Canadian National Standard.
- May 2005 – CSA approached by two provincial regulators with requests to adopt NFPA 70E and reduce workplace accidents.
- July 2005 – CSA brought proposals before the CAALL-OHS Committee (Canadian Regulatory Authorities)
- April 2006 – A written request is sent to NFPA to adopt.
- CSA Z462 committee is formed and the new standard is published in December of 2008. Harmonized with NFPA 70E - 2009, the publications' requirements are virtually identical.

21

The CEC (Canadian Electrical Code - 2009) on shock and arc flash hazards

Canadian Electrical Code Part 1 Rule 2-306

Rule 2-306 Shock and arc flash protection (see Appendix B)

(1) Electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centres that are installed in other than dwelling units and are likely to require examination, adjustment, servicing, or maintenance while energized shall be field marked to warn persons of potential electric shock and arc flash hazards.

(2) The marking referred to in Subrule (1) shall be located so that it is clearly visible to persons before examination, adjustment, servicing, or maintenance of the equipment.

Rule 2-306 (from Appendix B)

CSA Z462-08, *Workplace electrical safety*, provides assistance in determining the severity of potential exposure, planning safe work practices, and selecting personal protective equipment to protect against shock and arc flash hazards.

ANSI Z535.4-2002, *Product Safety Signs and Labels*, provides guidelines for the design of safety signs and labels for application to products.

IEEE 1584-2002, *Guide for Performing Arc-Flash Hazard Calculations*, provides assistance in determining the arc flash hazard distance and incident energy that workers may be exposed to from electrical equipment.

What employee workplaces are covered by CSA Z462?

- Public & private premises
- Yards, parking lots, industrial substations
- Installations of conductors & equipment that connect to electricity
- Installations used by the electric utility
- Not covered are: ships, aircraft, underground mines, power generation facilities and some others

25

Summary of Z462

- Section 1 – Scope and Purpose
- Section 2 – Reference publications (other standards that relate to specific topics, etc.)
- Section 3 – Definitions
- Section 4 – Safety-related work practices
  - 4.1 – General requirements
  - 4.2 – Electrically safe work condition
  - 4.3 – Work involving electrical hazards (energized work)
- Section 5 – Maintenance
- Section 6 – Special equipment
- Then there are the Annexes …

26

Reference Standards

- Standards related to Electrical Safety Programs (ESP's)
  - CAN/CSA Z1000 and Z1002 – 'provides a framework' for an ESP as part of an employer's OHS management system.
  - IEEE 3007.1 – implementation of the ESP
  - IEEE 3007.3 – electrical safety in the workplace
  - ANSI Z10 – OHS management systems
  - ISO 12100 – Risk Assessment
- Electrical equipment design and installation standards:
  - CSA C22 (Canadian Electrical Code)
  - IEC 60204 – Safety of machinery – Electrical equipment
  - IEEE – Various (80, 937, 946, 1106, C37.20)
  - NFPA 70 and 79

Reference Standards

- Work practice standards:
  - CSA M421-11 – Use of electricity in mines
  - CSA Z460 – Control of hazardous energy (lockout)
  - CSA Z463 / NFPA 70B – Maintenance of electrical systems
  - Infrastructure Health and Safety Association – Electrical Utility Safety Rules, 2014
  - IEEE – Various (4, 450, 463, 516)
  - ANSI/NETA-MTS-2011 – Maintenance Testing Specifications
  - CSA Z462 / NFPA 70E – Workplace Electrical Safety
  - NFPA 77 – Recommend Practice on Static Electricity

Reference Standards

- Arc-rated clothing, PPE and tools standards:
  - CAN/ULC-60900 / ASTM F1505 – Insulated Hand Tools
  - CAN/ULC-61112 / ASTM D1048 – Electrical Insulating Blankets
  - ASTM F1449/F2757 – Guides for Laundering of Arc Rated Clothing
  - ASTM F2178 / CSA Z94 – Head and Face Protection
  - ASTM F1506 / F1959(M) – Arc Rated Clothing and Materials
  - ASTM F2522 – Test Method for Arc Rating of Shields
  - ASTM F855 – Temporary Protective Grounds
  - ASTM D120 / D1051 – Rubber Insulating Gloves / Sleeves
  - ASTM F696 – Leather protectors for Insulating Gloves
  - ASTM F1116 / F1117 / CSA Z195 – Footwear
  - ANSI/ASC A14 / CSA Z11 - Ladders

Reference Standards

- Other standards related to electricity and/or safety:
  - CSA Z432 / ISO 13849 / IEC 62061 – Safeguarding of machinery
  - CSA Z434 – Industrial robot safety
  - CSA Z1003 – Psychological health and safety in the workplace
  - ANSI Z535 – Safety signs and symbols
  - IEC 60479 – Effects of current on human beings and livestock
  - IEEE 1584 – Guide for arc flash hazard calculations

Responsibility

- The “employer” is responsible for
  - Meeting government and/or CSA requirements
  - Electrical safety program (Clause 4.1.5) – this includes:
    - Safety policies / principles and procedures (Refer to Annex E)
    - Risk assessment procedure (Refer to Annex F)
    - Maintenance of equipment (Clause 4.1.5.2)
    - Electrical safety auditing (Clause 4.1.5.9)
  - Safety training (Clause 4.1.6)
- The “employee” is responsible for
  - Implementing and/or supervising procedures
  - Completing a job briefing (Clause 4.1.5.8 and Annex I)
- The “contractor” & “employer” are responsible for
  - Contractors and third parties on site
  - Refer to Clause 4.1.7 for more details

36

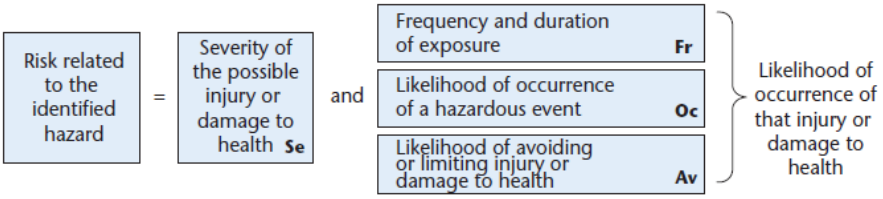
4.1.5 Electrical Safety Program

- Employers shall **implement** and **document** an overall electrical safety program that directs activity **appropriate to the risk** associated with electrical hazards.
  - Part of an overall OHS management system (refer to Annex A, CSA-Z1000, IEEE 3007.1 and IEEE 3007.2 for additional information and guidance)
  - Must consider the **condition of maintenance** of electrical equipment and systems
  - Must identify procedures to be used **before** work is started
  - Must include a **risk assessment** procedure to **identify hazards, assess risks**, and **implement risk control methods** (refer to hierarchy of risk control methods in CSA Z1002)

37

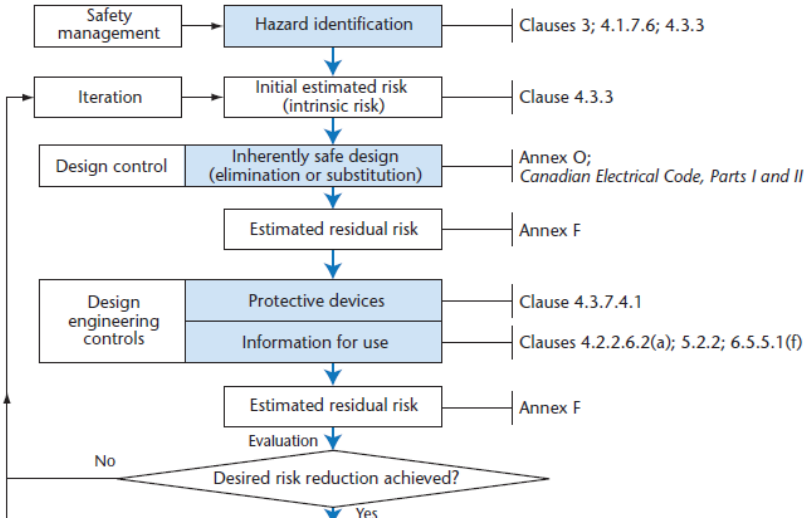
Risk assessment – Annex F

- Elements of risk
  - Severity of injury or damage to health (Se); and
  - Likelihood of occurrence of that injury or damage, which consists of:
    - Frequency and duration of exposure to the hazard (Fr);
    - Likelihood of occurrence of a hazardous event (Oc);
    - Likelihood of avoiding or limiting the injury or damage (Av)
- A risk estimation should be carried out for each hazard:



39

Risk assessment – Annex F



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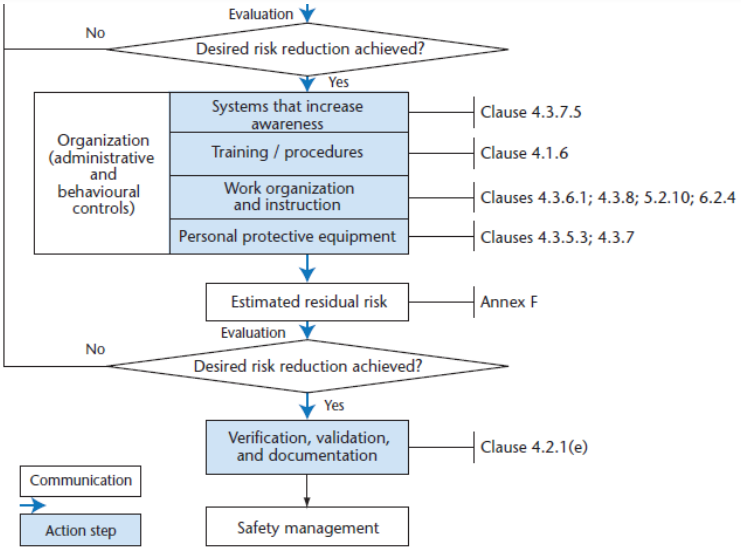
Risk assessment – Annex F



41

4.1.5 Electrical Safety Program

- 4.1.5.8 **Job briefing**
  - **'Worker in charge'** vs. 'workers involved'
  - Hazards associated with the job, work procedures involved, special precautions, energy source controls, PPE requirements, and energized work permit
  - May need to happen more than once during the work if something changes
  - Refer to Annex I for guidance
- 4.1.5.9 **Electrical safety auditing**
  - Audit the **program** at least every 3 years
  - Audit **field work** at least once per year
  - **Document** the audits

42

4.1.6 Training

- Type and extent of training is to be determined according to the risk to the worker.
  - For example, the level of training required to operate a piece of electrical equipment will likely be different than the training required to maintain, troubleshoot, install or modify equipment.
  - Available energy, type of equipment, and condition of equipment are other factors that affect the risk to the worker.
  - Training needs to include safety-related work practices, procedural requirements (including emergency procedures), and the relationship between electrical hazards and possible injury.
  - Training is required for both qualified and unqualified workers (although the type of training will likely be different)
  - Retraining needs to occur at least every 3 years.

43

Qualified & Unqualified Personnel

- Unqualified personnel (Clause 4.1.6.4.2):
  - *'Unqualified persons exposed to electrical hazards shall be trained in and familiar with any electrical-safety-related practices necessary for their safety.'*
- In General, unqualified persons should:
  - Not work on or near energized electrical circuits, including testing or troubleshooting on circuits above 50V
  - Be aware of live work being performed in proximity
  - Not enter a barricaded area, or cross the limited approach boundary of energized conductors (normally 3 ft 6 in for 600V and below), unless escorted by a qualified person

44

4.1.8 Use of electrical equipment

- Section 4.1.8 of the standard covers use and inspection of test instruments and portable equipment under normal conditions as well as outdoors and wet (conductive) environments.

46

CSA Z462 Clause 4.2

Process of Achieving an Electrically Safe Work Condition. An electrically safe work condition shall be achieved when performed in accordance with the procedures specified in Clause 4.2.2 and verified by the following process:

Determine all electrical sources to the equipment. Check applicable *up-to-date* drawings, diagrams, and ID tags

48

Electrically Safe Work Condition

Until these six steps have been executed, some exposure to an electrical hazard still exists and proper PPE is required

52

Lockout

- Section 4.2.2 covers electrical equipment lockout. Aspects include training, responsibilities, and audits. Also:
  - Procedure shall be appropriate for the experience and training of workers and conditions as they exist in the workplace.
  - Involves everyone who could be exposed directly or indirectly to a source of electrical energy. This could include mechanical and other trades.
  - Refer to Annex G for a sample lockout procedure.
  - CSA Z460 – Control of Hazardous Energy, covers lockout of electricity as well as other energy sources, and alternative methods to lockout.

53

4.3 Work involving electrical hazards

- Clause 4.3 covers the following:
  - When an electrically safe work condition must be established; and
  - The electrical safety-related work practices when an electrically safe work condition cannot be established.
- 4.3.2.1 "Energized electrical conductors and circuit parts shall be put into an electrically safe work condition before a worker works within the limited approach boundary of those conductors or parts."

58

LOTO is the preferred

The preferred method is Lockout/ Tag Out or "electrically safe work condition" prior to commencing.

For more information on LOTO, refer to CSA standard Z460 - Control of hazardous energy — Lockout and other methods

Financial considerations are not an adequate reason to work on or near energized circuits. IEEE Std 1584-2002

Canadian Electrical Code requires that 'no repairs or alterations be carried out on any live equipment except where complete disconnection of the equipment is not feasible'.

60

4.3.2.2 Energized work

- The rest of 4.3.2 essentially discusses exceptions to clause 4.3.2.1
- De-energizing of circuits that operate at less than 50V isn't required, provided that 'there will be no increased exposure to electrical burns or to explosion due to electric arcs.'
- Normal operation of electric equipment is permitted, provided that:
  - It is properly installed and maintained
  - All doors and covers are closed and secured
  - There is no evidence of impending failure (refer to the note in clause 4.3.2.2.4)

61

Energized Work Permits (4.3.2.3)

Energized work permits and written policies are required by CSA Z462.

Refer to Clause 4.3.2.3 and Annex J

ENERGIZED ELECTRICAL WORK PERMIT

PART I: TO BE COMPLETED BY THE REQUESTER:

Job Work Order Number:_____

1. Description of circuit/equipment/job location: **SWG-1 / Switchgear**
2. Description of work to be done:
   Remove bolted covers (to expose live parts)
3. Justification of why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage: **Hazardous Chemical Reactions under power loss.**

_____ _____

Requester/Title Date

1. Detailed job description procedure to be used in performing the above described work:
   Detailed Infrared inspection - Open doors remain at distance.
2. Description of the Safe Work Practices to be employed:
   Shock Blankets, and testing voltage rating of all tools, and review of safety procedures manual.

Shock hazard: **480 V**	Restricted Shock Boundary: **1.0"**	V-rated Gloves: **No**
Flash Hazard: **14.7 cal/cm2**	Flash Boundary: **8' - 2"**	V-rated Tools: **No**
HCR: **-1**	Required PPE: **#2**	
Cotton underwear plus FR shirt and FR pants		

3. Means employed to restrict the access of unqualified persons from the work areas:
   Hazard signs, and yellow hazard tape outside Switchgear Room door,. Red Cones outlining AF boundary. Email all Electricians/Engineers of Work scope and time.
4. Evidence of completion of a Job Briefing including discussion of any job-specific hazards:
   See Attached Job Briefing Report
5. Do you agree the above-described work can be done safely?
   ☐ Yes ☐ No (If no, return to requester)

_____ _____

Electrically Qualified Person(s) Date

 62

4.3.3 Working while exposed to electrical hazards

- Safety-related work practices that are consistent with the electrical hazards and associated risk shall be used.
- Appropriate practices shall be determined before any person is exposed to the hazards, using both shock risk assessment and arc flash risk assessment.
- Only qualified persons

63

4.3.4 Shock protection

- 4.3.4.1 Shock Risk Assessment *shall determine:*
  - Voltage (to which personnel will be exposed)
  - Boundary requirements (see tables 1A and 1B)
  - Necessary PPE (minimize the possibility of electric shock)
- The protection boundaries apply 'where approaching personnel are exposed to energized electrical conductors or circuit parts'.
- There are 2 boundaries:
  - Limited approach (requires a qualified person to cross)
  - Restricted approach (refer to 4.3.4.4)

65

Shock Protection Boundaries For AC systems

	Limited approach boundary		Restricted approach
Nominal system voltage range, phase to phase†	Exposed movable conductor‡	Exposed fixed circuit part	boundary (includes inadvertent movement adder)
Less than 50 V	Not specified	Not specified	Not specified
50 V–150 V	3.0 m (10 ft 0 in)	1.0 m (3 ft 6 in)	Avoid contact
151 V–750 V	3.0 m (10 ft 0 in)	1.0 m (3 ft 6 in)	0.3 m (1 ft 0 in)
751 V–15 kV	3.0 m (10 ft 0 in)	1.5 m (5 ft 0 in)	0.7 m (2 ft 2 in)
15.1–36 kV	3.0 m (10 ft 0 in)	1.8 m (6 ft 0 in)	0.8 m (2 ft 7 in)
36.1–46 kV	3.0 m (10 ft 0 in)	2.5 m (8 ft 0 in)	0.8 m (2 ft 9 in)
46.1–72.5 kV	3.0 m (10 ft 0 in)	2.5 m (8 ft 0 in)	1.0 m (3 ft 3 in)
72.6–121 kV	3.3 m (10 ft 8 in)	2.5 m (8 ft 0 in)	1.0 m (3 ft 4 in)
138–145 kV	3.4 m (11 ft 0 in)	3.0 m (10 ft 0 in)	1.3 m (3 ft 10 in)
161–169 kV	3.6 m (11 ft 8 in)	3.6 m (11 ft 8 in)	1.3 m (4 ft 3 in)
230–242 kV	4.0 m (13 ft 0 in)	4.0 m (13 ft 0 in)	1.7 m (5 ft 8 in)
345–362 kV	4.7 m (15 ft 4 in)	4.7 m (15 ft 4 in)	2.8 m (9 ft 2 in)
500–550 kV	5.8 m (19 ft 0 in)	5.8 m (19 ft 0 in)	3.6 m (11 ft 10 in)
765–800 kV	7.2 m (23 ft 9 in)	7.2 m (23 ft 9 in)	4.9 m (15 ft 11 in)

67

Shock Protection Boundaries

- For DC systems, refer to Table 1B. At 15 kV and below, table 1A can also be used (it will be conservative)
- Limited approach boundary
  - Entered only by qualified persons or unqualified persons escorted by qualified person
- Restricted approach boundary
  - Entered only by qualified persons required to use shock protection techniques and equipment
- *Prohibited approach boundary*
  - Eliminated from the standard in 2015

69

4.3.5 Arc flash risk assessment

- 4.3.5.1 Arc Flash Risk Assessment *shall:*
  - Determine if an arc flash hazard exists, and if so:
    - The appropriate safety-related work practices
    - The arc flash boundary; and
    - The PPE that personnel shall use inside the boundary
  - Assessment needs to be reviewed at least every 5 years, and updated when changes are made to the system.
  - The assessment needs to take into consideration the design of the overcurrent protective device, its opening time, and condition of maintenance.

70

4.3.5.3 Arc flash boundary

- The arc flash boundary shall be the distance at which the incident energy equals 5 J/cm^2 (1.2 cal/cm^2).
  - This value relates directly to the 2nd degree burn threshold.
- Tables 4B (AC systems) or 4C (DC systems), Annex D, and IEEE 1584 can be used to estimate the arc flash boundary.
- When an arc flash risk assessment / incident energy analysis has been completed, the arc flash boundary can be found on the label applied on the equipment being worked on.
- The arc flash boundary could be larger or smaller than the limited approach (shock) boundary.

71

4.3.5.4 Arc flash PPE (selection)

- There are 2 methods for the selection of PPE. Only one method can be used for a particular piece of equipment. Do NOT use the results of an incident energy analysis to specify a PPE category from table 5.
- The first (and preferred) method is the incident energy analysis method. PPE and arc-rated clothing are selected based on the incident energy exposure associated with a specific task.
  - Incident energy varies with distance from the arc source. A working distance of 18" is typically used for equipment rated at 600V and below. Additional PPE shall be used for any parts of the body that are closer than the working distance.
  - For information on calculating incident energy, refer to Annex D

72

4.3.5.4 Arc flash PPE

- The second method, often called the 'table method', or category method, utilizes some tables from the standard based on tasks. Depending on the task to be performed, a 'Hazard / Risk Category' (HRC) can be selected in order to determine the appropriate PPE. There are several limitations to this method:
  - The maximum available short-circuit current, and maximum fault clearing times must be known (these are typically found by doing an incident energy analysis).
  - The default working distance must be used (normally 18" for 600V and below).
  - Only applies to tasks listed in table 4A.

73

4.3.5.5 Equipment labelling

- Equipment that is likely to require examination, adjustment, servicing or maintenance **while energized** shall be field marked with a label containing **all** the following information:
  - Nominal system voltage;
  - Arc flash boundary;
  - Available incident energy (with corresponding working distance), - OR - PPE category (from the tables), **but not both**; the label could also contain the required level of PPE (minimum arc rating or site specific level of PPE)
  - The date that the information was determined.

74

CSA Z462 Example Labels

- Annex Q – Arc flash and shock warning labels

Basic Example

Detailed Example

CEC REQUIREMENT

⚠WARNING

Arc Flash and Shock Hazard

Incident Energy at 460 mm (18 in) = 5.0 cal/cm²
Arc Flash Boundary = 1.2 m (46 in)
Nominal System Voltage = 600 VAC

Arc Flash Analysis performed March 14, 2011

⚠WARNING

Arc Flash and Shock Hazard

ARC FLASH PROTECTION		SHOCK PROTECTION	
Working distance:	460 mm (18 in)	Shock hazard when cover is removed:	600 VAC
Incident energy:	5.0 cal/cm²	Limited approach:	1.0 m (42 in)
Arc flash boundary:	1.2 m (46 in)	Restricted approach:	300 mm (12 in)
		Glove class:	0

Refer to CSA Z462 for PPE requirements

Equipment Name: MCC#3
File: "ABC PLANT Rev X.xyz"

Arc Flash Analysis by: XYZ Consulting
March 14, 2011 Std. IEEE 1584

Z462 REQUIREMENTS

DATE OF ANALYSIS

4.3.5.5 Equipment labelling

- The calculation method and supporting data need to be documented (not necessarily on the label)
- When a review of the risk assessment (minimum every 5 years) identifies a change 'that renders the label inaccurate', the label shall be updated
- The **owner** of the electrical equipment (not the installer or supplier) is responsible for the **documentation, installation, and maintenance** of the **field-marked** label
- Labels applied prior to 2015 are acceptable if they contain the available incident energy OR required level of PPE

76

4.3.6 Other precautions for personnel activities

- Alertness
  - Be aware of potential hazards AT ALL TIMES
  - Report any impairment due to illness, injury, fatigue, even personal distractions, etc. You are NOT ALLOWED to work on or around energized equipment (within the limited approach) while your alertness is impaired for any reason.
  - Communicate changes in scope, and re-evaluate the hazards (update job briefings, etc.) whenever the scope changes
- Do not reach blindly into equipment that could contain exposed energized parts.

77

4.3.7 Personal and other protective equipment

- PPE needs to be designed and constructed for the specific part of the body to be protected, and for the work to be performed
  - The protection outlined here is designed to reduce any burn injury and make it survivable. It does not guarantee that there will be no injury, even if the appropriate equipment is selected and used properly.
  - It only protects against the thermal effects of arc flash. Because of the explosive nature of some arc events, physical injuries can occur, sometimes fatal ones (due to blast pressures and shrapnel, etc.)
  - When IE is above 40 cal/cm^2, it is recommended not to work energized on that equipment.

82

Personal Protective Equipment (PPE) and Arc-Rated Clothing

Protection is required for the head/face/neck; eyes; ears; body; hands, arms, feet and legs.

- Wear arc-rated clothing when the energy level exceeds 5J (or 1.2cal)/cm^2
  - This is the threshold incident-energy level for a second-degree burn
- Wear non-conductive and arc-rated head, face, neck, and chin protection
  - Hairnets and beard nets must be non-melting and arc-rated
- Separate eye protection (glasses) and hearing protection are required
- Wear rubber insulating gloves with leather protectors
- Wear heavy-duty leather work shoes

"All parts of the body inside the arc flash boundary shall be protected."

 85

Personal Protective Equipment (PPE) and Arc-Rated Clothing

Arc rating — the value attributed to materials that describes their performance on exposure to an electrical arc discharge.

- Arc thermal performance value (ATPV)
  - At the rated incident energy, there is a 50% probability that there will be enough heat under the material to cause the onset of a 2nd degree burn
- Breakopen threshold energy (E_{BT})
  - The amount of incident energy that results in a 50% probability of forming one or more holes (16mm^2 or 25mm in any dimension)

Wearing arc rated clothing is not a guarantee that no injury will happen.

 86

Personal Protective Equipment (PPE) and Arc-Rated Clothing

Table 4A

Task	Equipment condition (2)	Arc flash PPE required (1)
Reading a panel meter while operating a meter switch	Any	No
Normal operation of a circuit breaker (CB), switch, contactor or starter	All of the following: • the equipment is properly installed; • the equipment is properly maintained; • all equipment doors are closed and secured; • all equipment covers are in place and secured; and • there is no evidence of impending failure.	No
	One or more of the following: • the equipment is not properly installed; • the equipment is not properly maintained; • equipment doors are open or not secured; • equipment covers are off or not secured; or • there is evidence of impending failure.	Yes
For ac systems: Work on energized electrical conductors and circuit parts, including voltage testing	Any	Yes

91

Personal Protective Equipment (PPE) and Arc-Rated Clothing

Table 4B

Equipment	Arc flash PPE category	Arc flash boundary
Panelboards or other equipment rated 240 V and below Parameters: Maximum of 25 kA short-circuit current available; maximum of 0.03 s (2 cycles) fault clearing time; working distance 455 mm (18 in)	1	485 mm (19 in)
Panelboards or other equipment rated > 240 V and up to 600 V Parameters: Maximum of 25 kA short-circuit current available; maximum of 0.03 s (2 cycles) fault clearing time; working distance 455 mm (18 in)	2	900 mm (3 ft)
600 V class motor control centers (MCCs) Parameters: Maximum of 65 kA short-circuit current available; maximum of 0.03 s (2 cycles) fault clearing time; working distance 455 mm (18 in)	2	1.5 m (5 ft)
600 V class motor control centers (MCCs) Parameters: Maximum of 42 kA short-circuit current available; maximum of 0.33 s (20 cycles) fault clearing time; working distance 455 mm (18 in)	4	4.3 m (14 ft)

92

Overhead and underground lines, cutting and drilling

- Section 4.3.8 covers work around overhead lines
  - Insulated as well as uninsulated lines are covered
  - De-energizing vs. guarding
  - Employer and worker responsibilities
  - Approach distances
  - Vehicular, mechanical, and elevated equipment
- Section 4.3.9 covers underground electrical lines and equipment
  - Locate lines before excavating
- Section 4.3.10 covers cutting or drilling
  - Locate conductors and perform a risk assessment first

96

Minimizing energy levels and exposure to workers

- Proper equipment maintenance (refer to section 5 and Annex B)
  - Regularly scheduled electrical maintenance is critical. Ontario's ESA indicate 66% of safety incidents can be attributed to maintenance-related issues. A NETA survey indicated that 22% of service-aged breakers had some type of malfunction, and 10.5% did not operate at all during maintenance testing.
  - Refer to manufacturer's recommendations and CSA standard Z463 for more information on equipment maintenance.
- Maintaining electrical drawings (up-to-date and accurate)

99

Clause 5 – Safety-related maintenance requirements

- Does not specify particular methods or procedures, only lays out requirements
- The requirements are geared only towards worker safety
- For more guidance, refer to CSA Z463, NFPA 70B, ANSI/NETA MTS and IEEE 3007.2
- Equipment shall be maintained according to manufacturer's instructions or industry consensus standards to reduce the risk associated with failure
- Maintenance, tests, and inspections shall be documented

100

Clause 5 – Highlights

- 5.3.5 Protective devices
  - Protective devices shall be maintained to adequately withstand or interrupt available fault current and to function in accordance with their designed operating times. When applicable, protective devices shall be tested to operate in accordance with their time current characteristics.
  - Note: *Improper or **inadequate maintenance** can result in **increased opening time** of the overcurrent protective device, thus **increasing the incident energy**.*

101

Clause 5 – Highlights

- 5.4 Premises wiring
- 5.5 Control equipment
- 5.6 Fuses and circuit breakers
- 5.7 Rotating equipment
- 5.8 Hazardous locations
- 5.9 Batteries and battery rooms
- 5.10 Portable electric tools and equipment
- 5.11 Personal safety and protective equipment

102

Clause 6 – Special Equipment

- Clause 6 highlights safety requirements for special equipment. It is broken down into the following sections:
  - Clause 6.1 specifies general requirements;
  - Clause 6.2 specifies requirements for electrolytic cells;
  - Clause 6.3 specifies requirements for batteries and battery rooms or battery enclosures;
  - Clause 6.4 specifies requirements for lasers;
  - Clause 6.5 specifies requirements for power electronic equipment; and
  - Clause 6.6 specifies requirements for research and development laboratories.

103

Summary of Z462 - Annexes

- Annexes are 'informative' (that is, they are not mandatory parts of the standard). They can, however, be very helpful. They are as follows:
- Annex A – Aligning implementation with OHS standards
  - This is especially useful for health and safety professionals and people responsible for creating and implementing an overall safety program
- Annex B – Safety-related electrical maintenance
- Annex C – Limits of approach
  - Some more detailed information about boundaries and how they apply
- Annex D – Incident energy and arc flash boundary calculation methods
- Annex E – Electrical safety program
  - Annexes E and F work in conjunction with Annex A
- Annex F – Risk assessment procedure

104

Summary of Z462 - Annexes

- Annex G – Sample lockout policy, program, and procedure
- Annex H – Guidance on selection of PPE and arc-rated clothing
- Annex I – Sample job briefing and planning checklist
- Annex J – Sample energized electrical work permit and flow chart
- Annex K – General categories of electrical hazards
- Annex L – Typical applications of safeguards in the cell line working zone
- Annex M – Layering of protective clothing and total system arc rating
- Annex N – Example of policies and procedures for overhead and buried power lines and equipment
- Annex O – Safety-related design
  - Discusses risk assessment during design phase, design considerations, and risk reduction and control methods

105

Summary of Z462 - Annexes

- Annex P – reserved for future development
- Annex Q – Arc flash and shock warning and information labels
  - Very useful for label designers
- Annex R – Substation systems and equipment
  - Information and recommendations for working around substations
- Annex S – Guidance for preventing shock injuries from electrostatic discharges in manufacturing operations
- Annex T – reserved for future development
- Annex U – Human performance and workplace electrical safety
- Annex V – Bibliography
- Annex W – How to request an amendment to CSA Z462

106

Summary

- Equipment should be placed in an electrically safe work condition prior to servicing the equipment
- A shock and arc flash risk assessment is required to approach equipment that is not in an electrically safe work condition
- There are many factors that can influence the level of risk you are exposed to at work, including:
  - Design and condition of maintenance of equipment
  - Training, procedures, documentation, signage and labeling
  - Human factors, such as alertness, attitude, workplace culture and level of experience

109

LISTEN. THINK. SOLVE.

To speak to a Rockwell Automation Safety Consultant in your area, contact your local Allen-Bradley / Rockwell distributor.

Thank You!

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