Understanding Canadian Electrical Workplace Safety Standards

CSA Z462 & CAN/ULC-S801

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Webinar Plan

- 1. Webinar Objectives
- 2. Introduction : Shock & Arc Flash Hazards
- 3. Electrical Safety Standards in Canada
- 4. CSA Z462 : Workplace Electrical Safety
- 5. CAN/ULC-S801 : Standard on Electric Utility Workplace Electrical Safety for Generation, Transmission, and Distribution
- 6. Conclusions & Recommendations
- 7. Questions?

01

Webinar Objectives

Webinar Objectives

By the end of this webinar, participants will be able to:

- Differentiate the arc flash risks from the shock risks
- Define the risks associated with arc flash
- Read arc flash labels
- Define the personal protective equipment (PPE) to be worn when performing live work
- Determine how to safely perform live work
- Know how and when to use the CSA Z462 and CAN/ULC-S801 standards

Electrical safety training as defined in the CSA Z462 standard

4.1.7 Training

4.1.7.1 Electrical safety training

4.1.7.1.1 General

The training requirements specified in Clause 4.1.7.1 shall apply to workers exposed to an electrical hazard when the risk associated with that hazard is not adequately reduced by the applicable electrical installation requirements. Such workers shall be trained to understand the specific hazards associated with electrical energy, as follows:

a) they shall be trained in the safety-related work practices and procedural requirements necessary to provide protection from the electrical hazards associated with their job or task assignments; and

b) they shall be trained to identify and understand the relationship between electrical hazards and possible injury.

Note: *See CAN/CSA-Z1002 for hazard identification and elimination and risk assessment and control principles.*

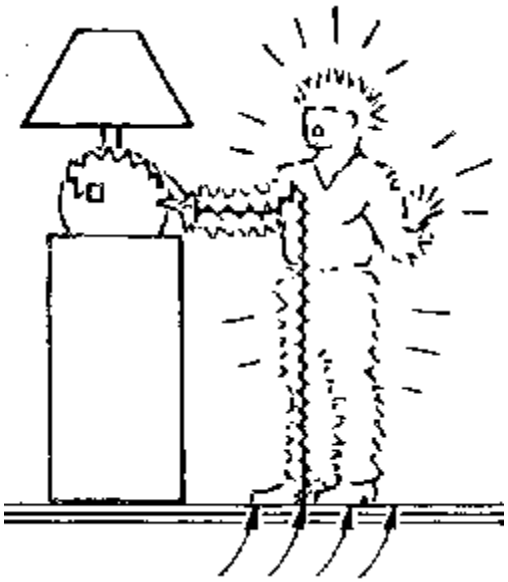
4.1.7.1.5 Type of training

The training required by Clause 4.1.7.1.1 shall be classroom or on-the-job training, or both. The type and extent of the training provided shall be determined in accordance with the risk to the worker.

02

Introduction : Shock & Arc Flash Hazards

Electrical Shock versus Arc Flash



It is imperative to understand the difference between both

Introduction – Shock

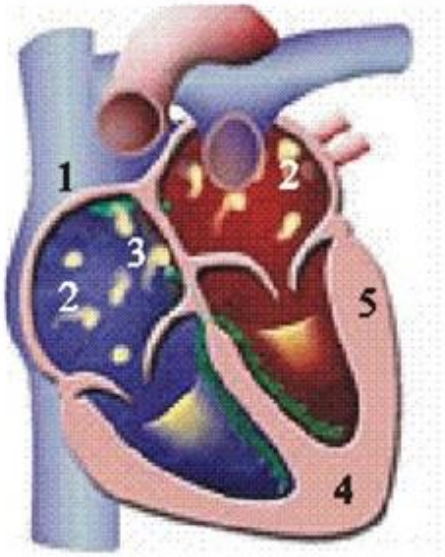
- **Electrical shock** is the physiological reaction or injury caused by the electrical current passing through the body
- When the electrical shock causes death it is called **electrocution**

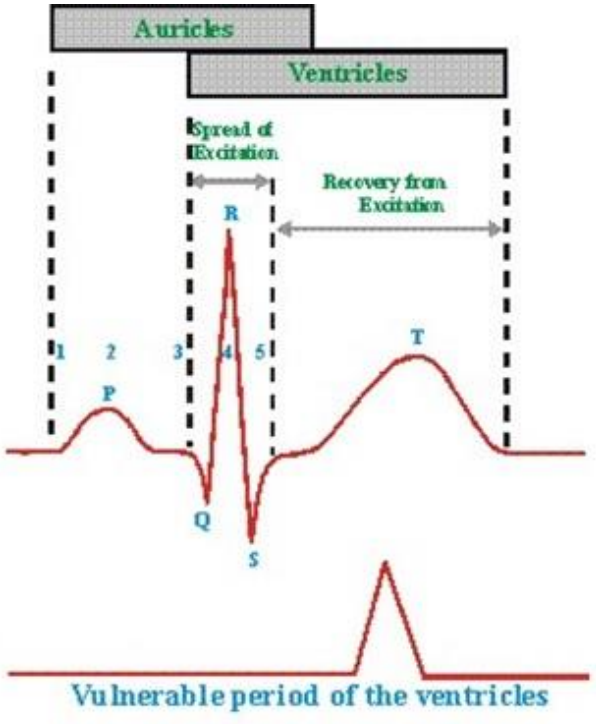
Possible causes of death related to electrical shock

- Heart fibrillation
- Involuntary muscle contraction like respiratory muscles (tetany)
  - Will block the body's ventilation leading to fatal asphyxia in few minutes
- Severe burns
- Trauma associated with electrical shock (involuntary movement, fall hazard, etc.)
- Rhabdomyolysis (rapid break down of skeletal muscles)

Heart fibrillation

- Death will occur in 1 out of 200 occasions
  (based on a 70 kg person being shocked with 164 mA for 0.5 second)

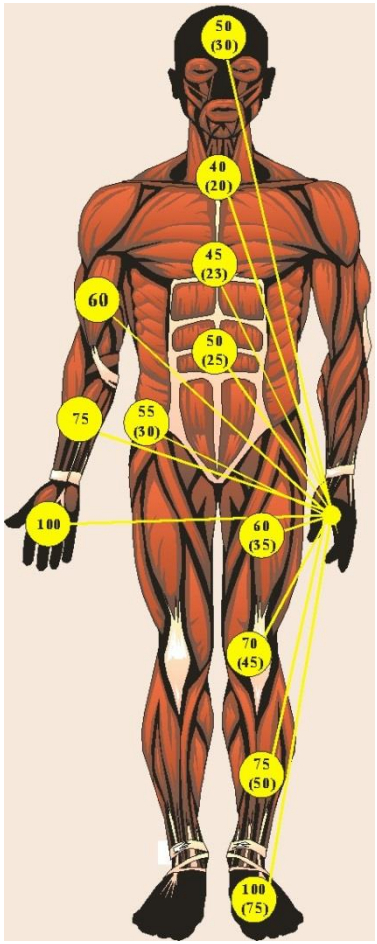




Human body impedance

- Human body internal impedance: 300 Ω
- Human skin impedance: 500 Ω - 3,000 Ω
  (based on IEEE Std-80 for alternating current)

- Typical impedances:
  - Hand to hand: 1,000 Ω
  - Hand to feet: 1,000 Ω



Use case example

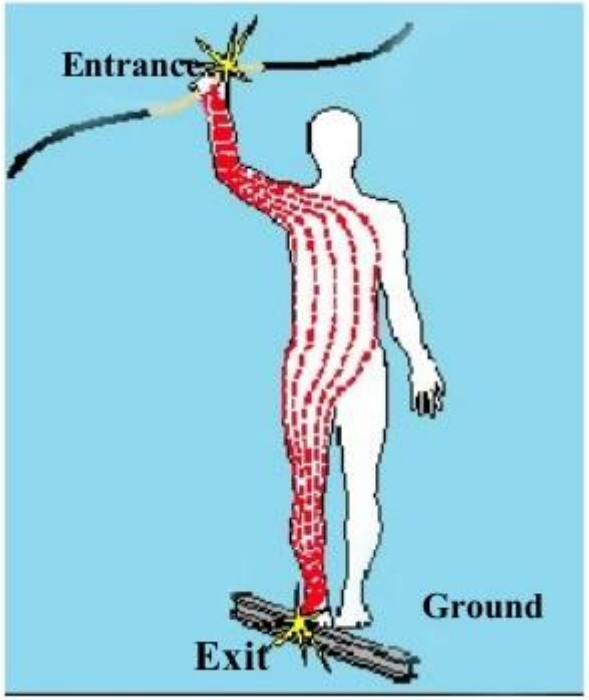
- Example using a domestic outlet (120 V)

$$V = R \times I$$

$$120\ V = \text{Human Impedance} \times I$$

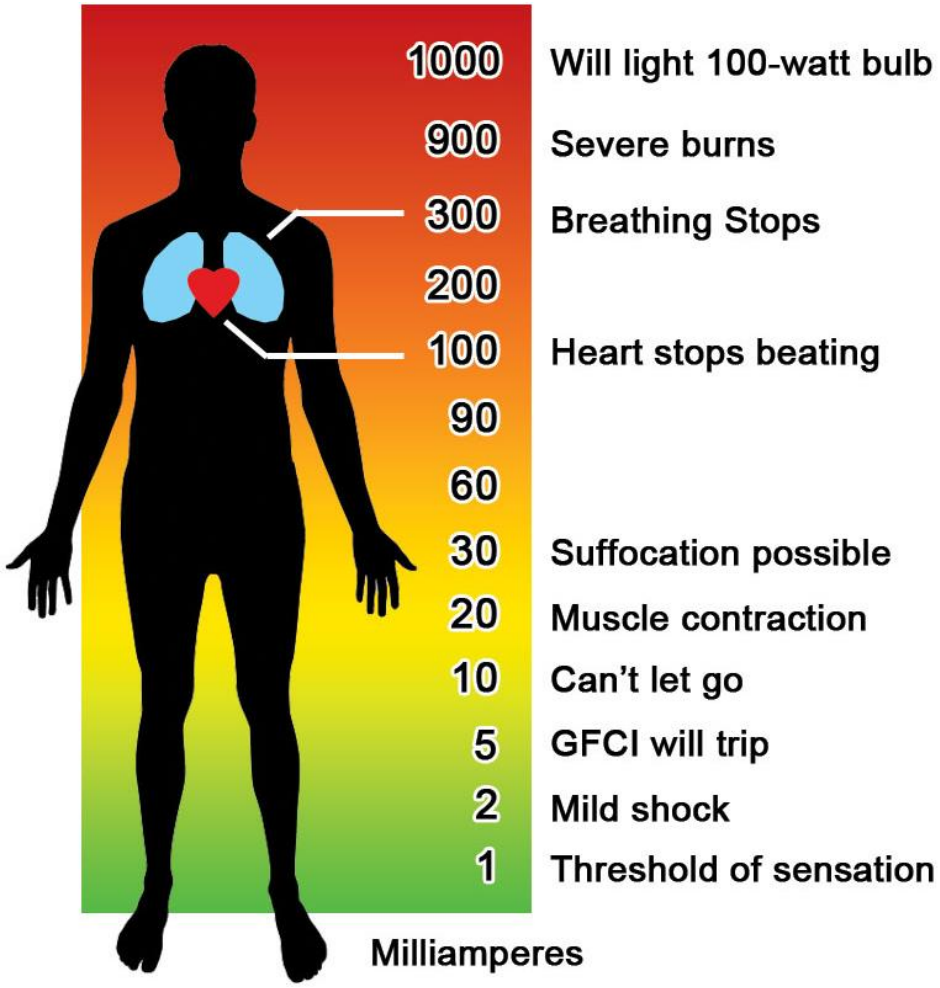
$$120\ V = 1{,}000\ \Omega \times I$$

$$I = 120\ mA$$



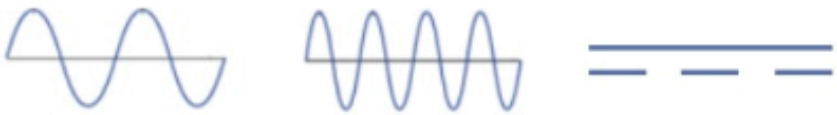
- Impedance does play a big role in the current passing through the body

Effects on the human body



Effects on the human body

- The effect of the current on the human body depends on the following elements:
  - Intensity
  - Duration
  - Person type (height, weight, skin thickness, etc.)
  - Current path inside the body
  - Current frequency (AC/DC)



Fun Facts

According to the Guinness Book of World Records

First Place:

Harry F. Mcgrew has come in direct contact with a 340,000 volts AC transmission line in Huntington Canyon, Utah and survived

Second Place:

Brian Latasa survived to direct contact with a 230,000 volts AC line in Griffith Park, Los Angeles

What to do in case of an electrical shock if the victim:

- Is still (or might still be) in contact with the current source

DO NOT TOUCH THE PERSON

- De-energize the system at the source **then** go help the victim

OR

- Try to eliminate the contact between the victim and the source by using an **insulated** pole/object to free the victim without touching the source

CALL EMERGENCY AND/OR AN AMBULANCE

*The victim should be accompanied **at the emergency** by a witness of the accident*

What to do once the victim is NOT in contact with the source:

CALL EMERGENCY AND/OR AN AMBULANCE

If the victim:

- Has lost consciousness
- Has no pulse or
- Is not breathing

PERFORM CPR UNTIL FIRST AID ARRIVES

Victim of an electrical shock might have no pulse but since the heart wasn't damaged by the accident, the CPR maneuver remains extremely effective!

Arc Flash

- Visible electrical current in an insulated medium such as air
- Created by the ionization of the insulation, which occurs when the potential difference becomes greater than the insulation capacity

Important Notes

- Apart from electrocution or electrical shock, the main dangers related to arc flash are severe burns and amputation due to the related explosion
- Monetary cost of an arc flash incident is often in the million dollar range when you include medical costs, production losses, equipment replacement, insurance, etc.
- Arc flash formulas are found in the IEEE 1584 (up to 15 kV)
- Rule of thumb : ENERGY = $Current^2$ x time

Important Notes

- Up to 4 times the sun's surface temperature
  - At that temperature, clothes are easily ignited causing severe burns, which can be fatal
- During an arc flash event gas and metal will experience rapid expansion
  - The thermo-acoustic effect created can result in damage to the ears (ruptured eardrum), collapsed lungs and even death
  - Metallic sections are vaporized and blasted, which can harm nearby workers and/or ignite their clothes

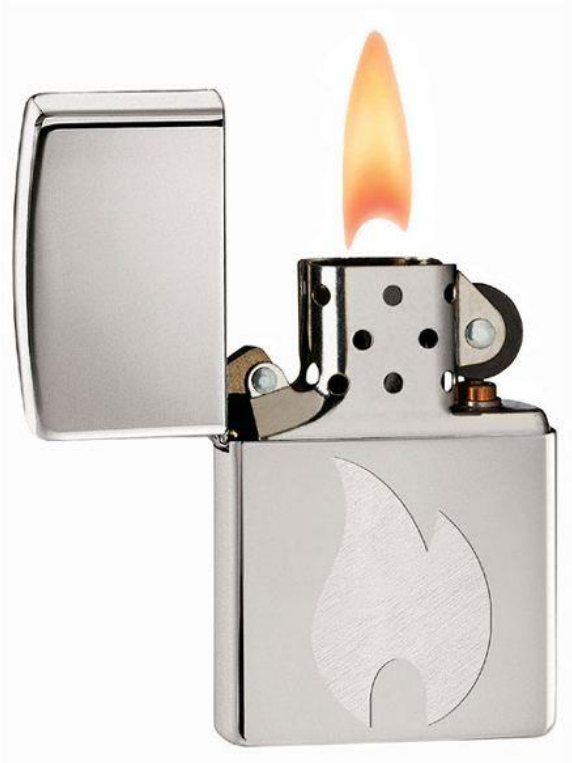
Important Notes

- Apart from a bad maneuver on live equipment, other possible causes of an arc flash are:
  - Dirt, corrosion, condensed water, animals
  - Flashover on two phases

    If an insulated medium has become dry over time, its insulating properties become weaker. During an overvoltage on the network, an arc flash can happen on the equipment
- Poor working procedures
- Poor engineering

1.2 cal/cm^2

- Put a lighter under a finger for 1 second



12 cal/cm^2

- Put your hand on an 8 inches oven element for 6 seconds

Clothing above 8 cal/cm^2

- At 10 cal/cm^2, cotton clothing will be set on fire
- At 18 cal/cm^2, untreated clothing (silk, wool, etc.) will be set on fire

Introduction – Arc Flash

40 cal/cm^2

- Make one litre of **ice** boil (0°C to 100°C) in 5 seconds

Introduction – Arc Flash

> 40 cal/cm²

- Over 40 cal/cm², temperatures of over 3,000°C can be reached and applied to human skin
- The only way to execute a Terminator…

Other Effects

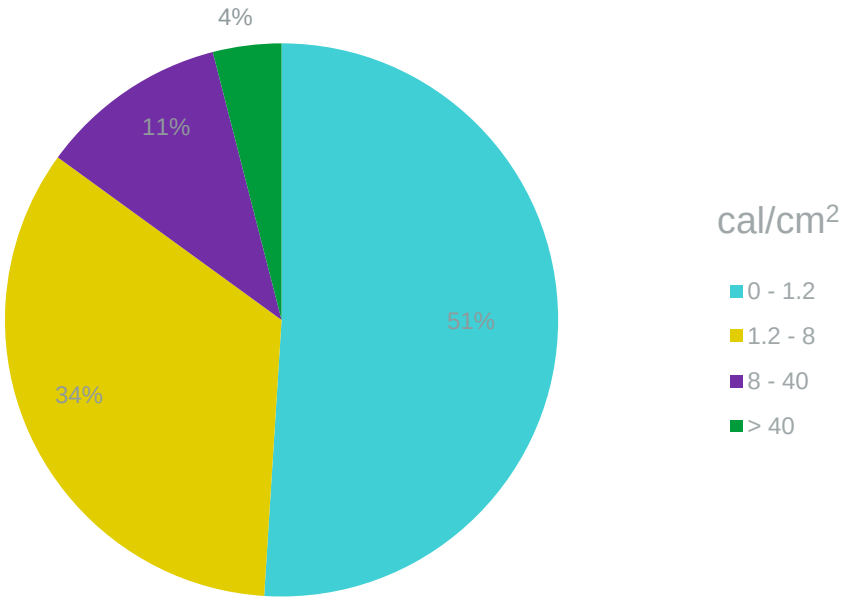
- **Noise**
  - For those of you who do housework:
    80 decibels = domestic vacuum

  - An arc flash can produce a noise level up to 140 decibels.
    Comparable:
    - 130 decibels: Jackhammer
    - 140 decibels: Jet Motor

- **Shrapnel**

Statistics

- Estimated annual exposures of workers



Based on IEEE withe paper “A summary of arc flash hazard assessments and safety improvements”

03 Electrical Safety Standards in Canada

Electrical Safety Standard in Canada

Applicable standards:

- OHSA
- CEC Rule 2-306 and Appendix B
- Canadian Bill C-45
- CSA Z462-18 (NFPA 70E)
- IEEE 1584-2018
- CAN/ULC-S801

Arc flash history:

- 1979 (First version of NFPA 70E)
- 1980 (Lee)
- 1995 (Arcs and limits of approach)
- 2008 (First version of CSA Z462)
- 2012 and 2015 (Reversions of CSA Z462)
- 2018 (Latest version of CSA Z462)

Example case

- An arc flash study is not mandatory but Bill C-45 strongly encourages business owners or employers to complete an arc flash study and implement live work safety procedures
- Reference: https://news.ontario.ca/archive/en/2009/04/20/Court-Bulletin-Domtar-Inc-fined-87000-after-worker-injured.html

Court Bulletin - Domtar Inc. fined $87,000 after worker injured

WAWA, ON, April 20 /CNW/ - Domtar Inc., a Montreal, Quebec company that makes pulp, paper, and wood products at facilities across Canada and the United States, was fined $87,000 on April 16, 2009, for a violation under the Occupational Health and Safety Act, after a worker was injured.

On March 20, 2007, at the company's facility in White River, an electrician was doing maintenance work on a machine in the plant. While the worker was testing the voltage inside an electrical panel on the machine, an arc flash, or electrical blast, burned the worker's hand and face.

A Ministry of Labour investigation found that the worker was not wearing rubber gloves or wearing a shield.

Domtar Inc. pleaded guilty to failing, as an employer, to ensure the worker used protective equipment and procedures adequate for protection against electrical shock and burns.

The fine was imposed by Justice of the Peace Pierre Leclerc. In addition to the fine, the court also imposed a 25-per-cent victim fine surcharge on the total, as required by the Provincial Offences Act. The surcharge is credited to a special provincial government fund to assist victims of crime.

Electrical Safety Standard in Canada

Applicable standard – OHSA

- Every employer ensures, as far as it is reasonably practicable for the employer to do so, to:
  - Take every reasonable precaution to ensure the workplace is safe
  - Train employees about any potential hazards
  - Supply personal protective equipment (PPE) and ensure workers know how to use the equipment safely and properly
- Every worker shall, while engaged in an occupation:
  - Work in compliance with OH&S acts and regulations
  - Use personal protective equipment (PPE) and clothing as directed by the employer
  - Take reasonable care to protect the health and safety of the worker and of other workers present while the worker is working

Electrical Safety Standard in Canada

Applicable Codes

- CEC Rule 2-306

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.

- Appendix B

Rule 2-306

CSA Z462 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/NEMA Z535.4 provides guidelines for the design of safety signs and labels for application to products.

IEEE 1584 provides assistance in determining the arc flash hazard distance and incident energy that workers may be exposed to from electrical equipment.

Electrical Safety Standard in Canada

IEEE 1584-2018

- Latest update of the algorithm used to calculate arc flash energy that can be found in Appendix D of the CSA Z462. The IEEE 1584-2002 version is still in Appendix D of the CSA Z462-2018 standard. The next version of the CSA Z462 will incorporate the IEEE 1584-2018 in Appendix.
- First update since 2002, except the amendments in 2004 and 2011
- The formulas used to calculate the incident energy were replaced by new models based on statistical analysis of over 1,860 tests compared to around 300 tests for the 2002 version
- The electrode configuration (busbars) is now used as a parameter in the equations: VCB, VCBB, HCB, VOA, HOA
- The enclosure size of the equipment cell is now important: height, width, depth

04

CSA Z462 : Workplace Electrical Safety

Summary

- CSA : Canadian Standards Association
- The CSA Z462 “Workplace Electrical Safety” standard defines the requirements and provides guidance for the following items for persons exposed to shock & arc flash hazards when working with live electrical equipment :
  - Safety management systems
  - Safe work procedures
  - Selection of personal protective equipment (PPE) and other safety devices
  - Identification of qualified electrical workers
  - Training of qualified electrical workers
  - Determination of hazardous work to be performed by qualified individuals

History

- Developed in parallel with the NFPA 70E (NFPA : National Fire Protection Agency in the United States) and harmonized as much as possible
- First edition : CSA Z462-2008
- Second edition : CSA Z462-2012
- Third edition : CSA Z462-2015
- Fourth (latest) edition : CSA Z462-2018

Definitions

- Qualified persons (Section 4.1.7.1.2)
  - Trained in and knowledgeable about the construction and operation of the equipment or work method
  - Trained to identify and avoid electrical hazards
  - Familiar with the proper use of the equipment and procedures
  - To enter the limited approach the worker should be trained to:
    - Distinguish exposed energized circuit parts
    - Determine the nominal voltage
    - Know the approach distances
    - Decision-making process to conduct electrically safe work
    - Select appropriate test instrument and use it properly

** The employer shall determine through regular supervision or inspections that each worker is complying with the safety-related work practices*

Definitions

- Host and contract employer's responsibility (Section 4.1.8)
  - Host employer shall inform contract employers of:
    - Known hazards related to the contract employer's work
    - Information about the employer's installation
- Employer's responsibility (Section 4.1.3.1)
  - Establish lockout procedures for the organization
  - Provide training to workers
  - Provide equipment necessary to execute the procedure
  - Audit execution of the procedure at least annually

Definitions

- Establishing an electrically safe work condition (Section 4.2)
  1. Determine all possible sources of electrical supply
  2. Interrupt the load current
  3. Open the disconnecting devices for each sources and visually verify the devices are fully open
  4. Apply lockout devices
  5. Verify that each phase is de-energized using a test instrument
  6. Apply properly rated ground-connecting devices

Definitions

- Electrically safe work condition – Energized work (Section 4.3.2.2)
  - Energized work may be performed when:
    - De-energizing introduces additional hazards or increased risks
    - The task is infeasible in de-energized state because of equipment design or operational limits
    - Voltage is less or equal than 30 V
- Arc flash study review/update frequency (Section 4.3.5.6.2)
  - The arc flash study shall be updated when changes occur in the electrical distribution system that could affect the results of the analysis.
  - The study shall also be reviewed for accuracy at intervals not to exceed 5 years.

CSA Z462
Personal Protective Equipment (PPE)

4.3.5.6 Arc flash PPE

4.3.5.6.1 General

One of the following methods shall be used for the selection of arc flash PPE:

a) the incident energy analysis method in accordance with Clause 4.3.5.6.2; or

b) the arc flash PPE category method in accordance with Clause 4.3.7.3.15.

Either, but not both, methods may be used on the same piece of equipment.

The results of an incident energy analysis to specify an arc flash PPE Category in Table 6C shall be prohibited.

4.3.5.7 Equipment labelling

Electrical equipment such as switchboards, panelboards, industrial control panels, meter socket enclosures and motor control centres (MCCs) that are in other than dwelling units and that are likely to require examination, adjustment, servicing or maintenance while energized shall be marked with a label containing all the following information:

a) nominal system voltage;

b) arc flash boundary; and

c) at least one of the following:
   - i) available incident energy and the corresponding working distance or the arc flash PPE category in Table 6A or 6B for the equipment, but not both;
   - ii) minimum arc-rating of PPE; or
   - iii) site specific level of PPE;

d) date the information required by this Clause was determined.

CSA Z462
Personal Protective Equipment (PPE)

Table 6
Protective clothing characteristics
(See Clauses 4.3.7.3.11 and P.1 and Table 5.)

Hazard/risk category	Description of clothing	Arc [illegible] (minimum), cm² (cal/cm²)
0	Non-melting flammable materials (i.e., untreated cotton, wool, [illegible]von, silk, or blends of these materials) with a fabric weight [illegible] least 4.5 [illegible]yd²	N/A
1	Arc-rated FR shirt and FR pants or FR coverall	16.74 (4)
2	Arc-rated FR shirt and FR pants or FR c[illegible]all	33.47 (8)
3	Arc-rated FR shirt and FR pants or FR [illegible]nd arc flash suit selected so that the system arc rating [illegible] the requ[illegible]d minimum	104.6 (25)
4	Arc-rated FR shirt and FR pa[illegible] FR [illegible]overall, and arc flash suit selected so that the system [illegible] [illegible]he required minimum	167.36 (40)

Note: *Arc rating is defined in Clause[illegible] and c[illegible] be either ATPV or E_{BT}. ATPV is defined in ASTM F 1959 as the incident energy on a material or a mul[illegible] system of materials that results in a 50% probability that sufficient heat transfer through the tested specimen is predicted to cause the onset of a second-degree skin burn injury based on the Stoll curve,* cal/cm². *E_{BT} is defined in ASTM F 1959 as the incident energy on a material or material system that results in a 50% probability of breakopen. Arc rating is reported as either ATPV or E_{BT}, whichever is the lower value.*

OBSOLETE

[cal/cm²]

[0 @ 1.2]

[1.2 @ 4]

[4 @ 8]

[8 @ 25]

[25 @ 40]

CSA Z462
Personal Protective Equipment (PPE)

Table 3
Selection of arc-rated clothing and other PPE when the incident energy analysis method is used
(See Clause 4.3.5.6.2.)

Incident energy exposures equal to 1.2 cal/cm² (5 J/cm²) up to 12 cal/cm² (50 J/cm²)
Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy* • Long-sleeve shirt and pants or coverall or arc flash suit (SR) • Arc-rated faceshield and arc-rated balaclava or arc flash suit hood (SR) • Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) (AN)
Heavy duty leather gloves, arc-rated gloves or rubber insulating gloves with leather protectors (SR)‡
Hard hat
Safety glasses or safety goggles (SR)
Hearing protection
Leather footwear
Incident energy exposures greater than 12 cal/cm ² (50 J/cm²)
Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy* • Long-sleeve shirt and pants or coverall or arc flash suit (SR) • Arc-rated arc flash suit hood • Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) (AN)
Arc-rated gloves or rubber insulating gloves with leather protectors (SR)‡
Hard hat
Safety glasses or safety goggles (SR)
Hearing protection
Leather footwear

Legend:

SR = Selection of one in group is required.

AN = As needed

CSA Z462
Personal Protective Equipment (PPE)

< 1.2 cal/cm^2

CSA Z462
Personal Protective Equipment (PPE)

> 1.2 cal/cm^2 / < 12 cal/cm^2

Contents of typical **Level II Kit**

CSA Z462
Personal Protective Equipment (PPE)

< 40 cal/cm^2

CSA Z462
Personal Protective Equipment (PPE)

> 40 cal/cm^2, “Extreme Danger”

- It is recommended to look for solutions to lower the incident energy
- Some PPE are available to protect the workers up to 100 cal/cm^2
- Due to other effects, it is not recommended to work on live equipment above 40 cal/cm^2, even with PPE

CSA Z462
Personal Protective Equipment (PPE)

Jewellery and other conductive items

- These items are **PROHIBITED** within the restricted and arc flash boundaries

CSA Z462
Personal Protective Equipment (PPE)

Pay special attention to:

- **Underwear**
  - Natural fiber only
  - Prints on shirts
- **PPE maintenance**
  - Oil or flammable product
  - Cuts or broken stitches
  - Particular laundry product
- **Objects and tools**
  - Only the minimum required
  - Beware of the pockets…
  - Inspect your tools' condition
- **Appropriate work equipment**

CSA Z462
Personal Protective Equipment (PPE)

When is it required?

- Table 6A (CSA Z462-2018)

Table 6A
Arc-flash PPE categories for alternating current (ac) systems
(See Clauses 3, 4.3.1, 4.3.5.3, 4.3.5.5, 4.3.7.3.15, 4.3.7.4.2, and B.2, Table 6C, and Annex H)

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

(Continued)

CSA Z462
Personal Protective Equipment (PPE)

When is it required?

- Table 6A (CSA Z462-2018)

Table 6A (Continued)

Equipment	Arc flash PPE category	Arc-flash boundary
Maximum of 65 kA available fault current; maximum of 0.03 s (2 cycles) fault clearing time; minimum working distance 18 in		
600-V class motor control centers (MCCs) Parameters: Maximum of 42 kA available fault current; maximum of 0.33 s (20 cycles) fault clearing time; minimum working distance 18 in	4	4.3 m (14 ft)
600-V class switchgear (with power circuit breakers or fused switches) and 600 V class switchboards Parameters: Maximum of 35 kA available fault current; maximum of up to 0.5 s (30 cycles) fault clearing time; minimum working distance 18 in	4	6 m (20 ft)
Other 600-V class (277 V through 600 V, nominal) equipment Parameters: Maximum of 65 kA available fault current; maximum of 0.03 s (2 cycles) fault clearing time; minimum working distance 18 in	2	1.5 m (5 ft)
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 s (15 cycle) fault clearing time; minimum working distance 36 in	4	12 m (40 ft)
Metal-clad switchgear, 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 s (15 cycle) fault clearing time; minimum working distance 36 in	4	12 m (40 ft)

(Continued)

CSA Z462
Personal Protective Equipment (PPE)

When is it required?

- Table 6A (CSA Z462-2018)

Table 6A (Concluded)

Equipment	Arc flash PPE category	Arc-flash boundary
Arc-resistant switchgear, 1 kV through 15 kV [for clearing times of less than 0.5 s (30 cycles) with a perspective fault current not to exceed the arc-resistant rating of the equipment], and metal-enclosed interrupter switchgear, fused or unfused of arc-resistant-type construction, tested in accordance with CSA 22.2 No. 0.22 or IEEE C37.20.7	N/A (doors closed)	N/A (doors closed)
Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 s (15 cycle) fault clearing time; minimum working distance 36 in	4 (doors open)	12 m (40 ft)
Other equipment 1 kV through 15 kV Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 s (15 cycle) fault clearing time; minimum working distance 36 in	4	12 m (40 ft)

CSA Z462
Personal Protective Equipment (PPE)

When is it required?

- Table 6B (CSA Z462-2018)

Table 6B
Arc-flash PPE categories for direct current (dc) systems
(See Clauses 4.3.1, 4.3.5.3, 4.3.5.5, 4.3.7.3.15.2, and B.2, Table 5, and Annex H.)

Equipment	Arc flash PPE category*	Arc flash boundary
Storage batteries, direct-current switchboards, and other dc supply sources Parameters: Greater than or equal to 100 V and less than or equal to 250 V Maximum arc duration and minimum working distance: 2 s at 455 mm (18 in)		
Short-circuit current less than 4 kA	2	900 mm (3 ft)
Available fault current greater than or equal to 4 kA and less than 7 kA	2	1.2 m (4 ft)
Available fault current greater than or equal to 7 kA and less than 15 kA	3	1.8 m (6 ft)
Storage batteries, direct-current switchboards and other dc supply sources Parameters: Greater than 250 V and less than or equal to 600 V Maximum arc duration and minimum working distance: 2 s at 455 mm (18 in)		
Short-circuit current less than 1.5 kA	2	900 mm (3 ft)
Available fault current greater than or equal to 1.5 kA and less than 3 kA	2	1.2 m (4 ft)
Available fault current greater than or equal to 3 kA and less than 7 kA	3	1.8 m (6 ft)
Available fault current greater than or equal to 7 kA and less than 10 kA	4	2.5 m (8 ft)

CSA Z462
Personal Protective Equipment (PPE)

Evidence of impending failure

- “[…] there is evidence such as arcing, overheating, loose or bound equipment parts, visible damage, or deterioration.” (Section 4.3.2.2.4)
  - Visual inspection of the equipment
  - Verify for signs of previous burns or overheating
  - Verify for signs of water or humidity
  - Gently approach hand toward the equipment to verify any current overheating

CSA Z462
Limits of Approach

Definitions

Boundary, arc flash — when an arc flash hazard exists, an approach limit from an arc source at which incident energy equals 1.2 cal/cm^2 (5 J/cm^2).

Note: *According to the Stoll skin burn injury model, the onset of a second-degree burn on unprotected skin is likely to occur at an exposure of 1.2 cal/cm^2 (5 J/cm^2) for 1 s.*

Boundary, limited approach — an approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists.

Note: *See Clause 4.3.4 and Annex C.*

Boundary, restricted approach — an approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased likelihood of electric shock, due to electrical arc over combined with inadvertent movement.

Note: *See Clause 4.3.4 and Annex C.*

CSA Z462
Limits of Approach

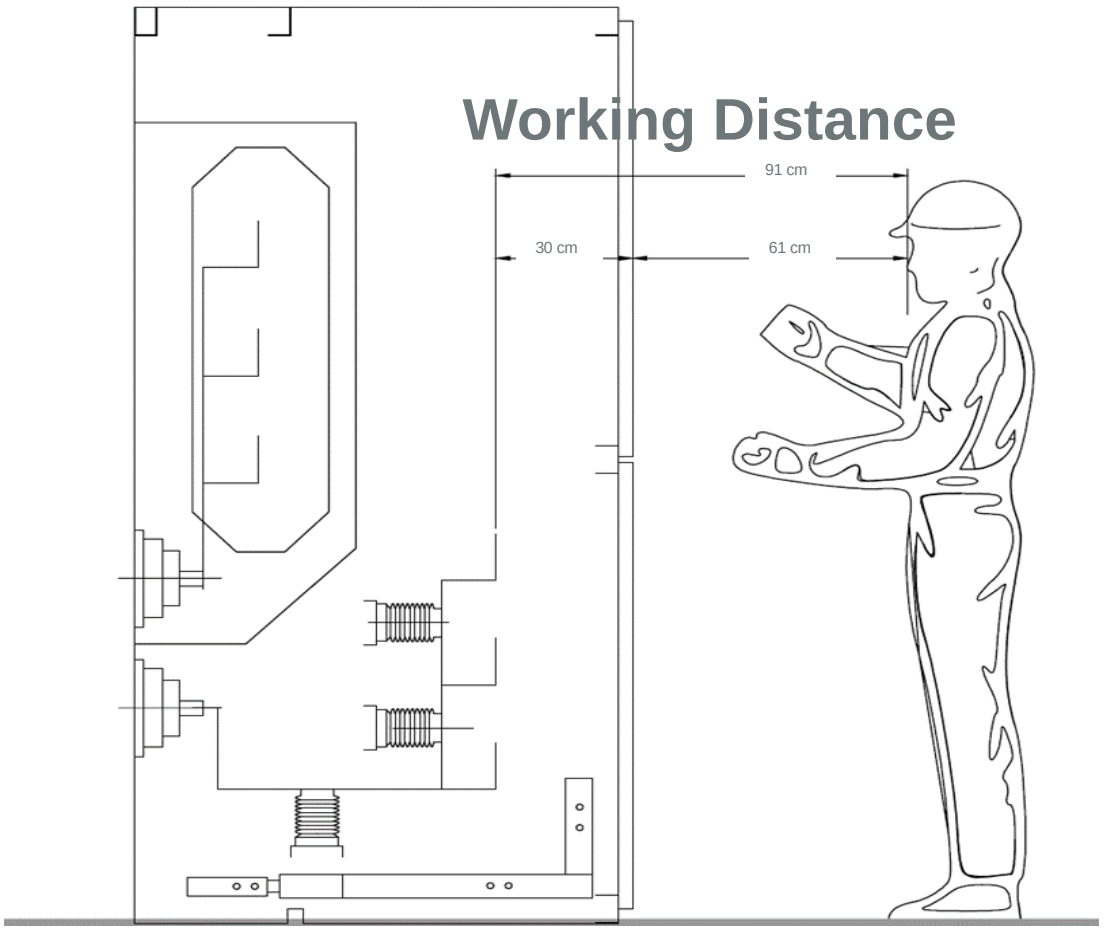
Shock limits

Table 1A
Shock protection approach boundaries to exposed energized electrical conductors or circuit parts for ac systems*
(See Clauses 4.1.7.1.2, 4.3.4.4, 4.3.4.5, 4.3.7.4.11, 4.3.7.5.2, 4.3.8.5, 4.3.8.6.1, 6.2.4.1, A.1, C.2, C.2.1, and R.2.2.)

(1)	(2)	(3)	(4)
	Limited approach boundary		Restricted approach boundary (includes inadvertent movement adder)
Nominal system voltage range, phase to phase†	Exposed movable conductor‡	Exposed fixed circuit part	
Less than or equal to 30 V	Not specified	Not specified	Not specified
31 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 9 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 6 in)
72.6–121 kV	3.3 m (10 ft 8 in)	2.5 m (8 ft 0 in)	1.0 m (3 ft 6 in)
138–145 kV	3.4 m (11 ft 0 in)	3.0 m (10 ft 0 in)	1.2 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 (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 8 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)

CSA Z462
Limits of Approach

Representation



Note: *Typical working distances used for incident energy calculations are as follows:*

a) *low-voltage (600 V and below) MCC and panelboards: 460 mm (18 in);*

b) *low-voltage (600 V and below) switchgear: 610 mm (24 in); and*

c) *medium-voltage (above 600 V) switchgear: 900 mm (36 in).*

CSA Z462
Limits of Approach

Representation

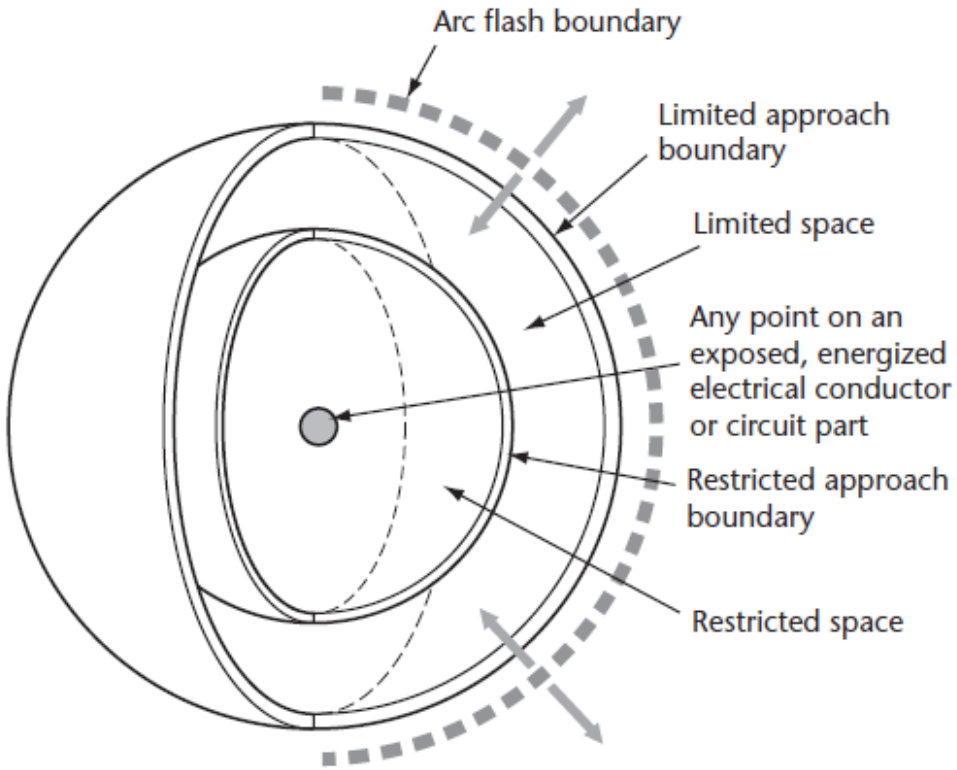
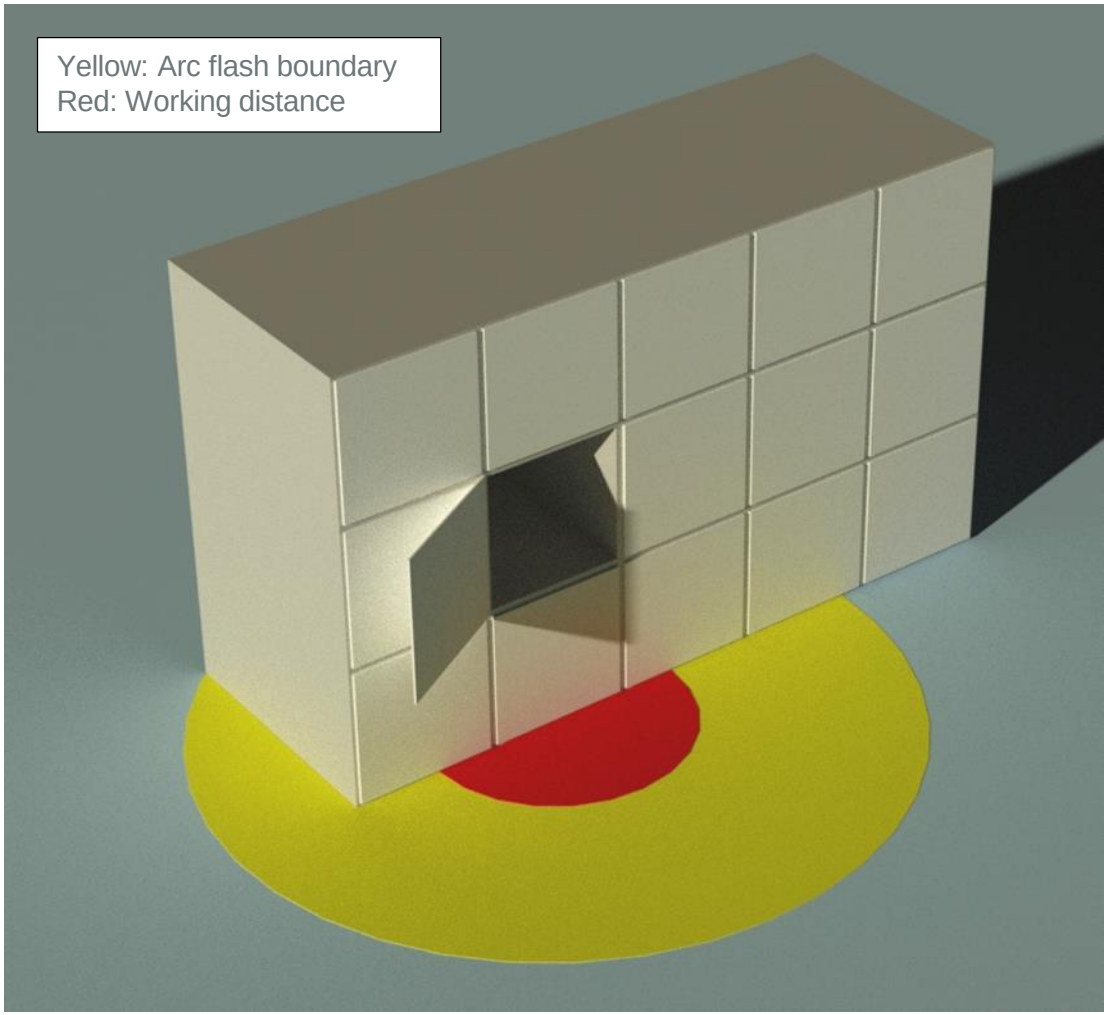


Figure C.1
Limits of approach

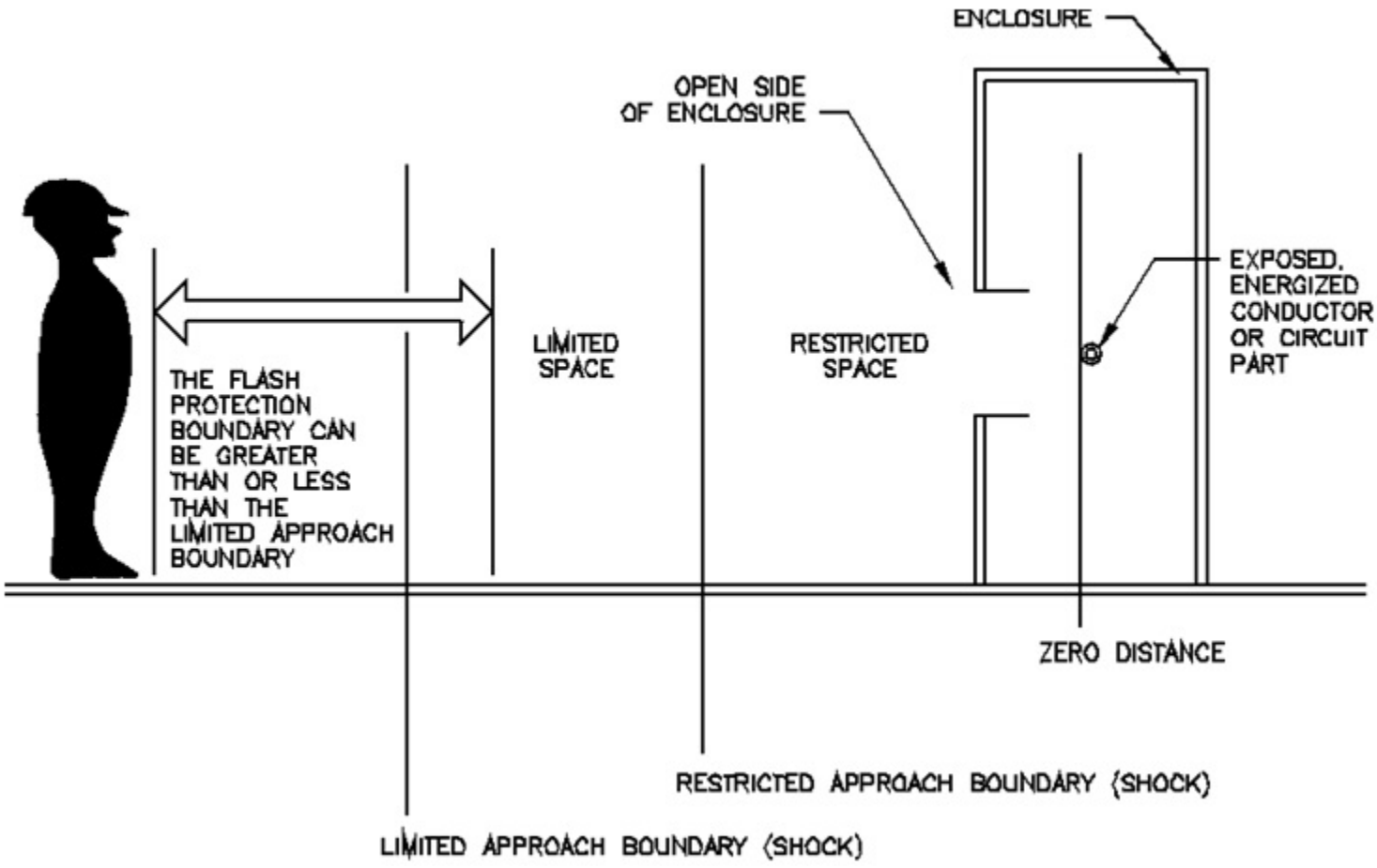
CSA Z462
Limits of Approach

Representation



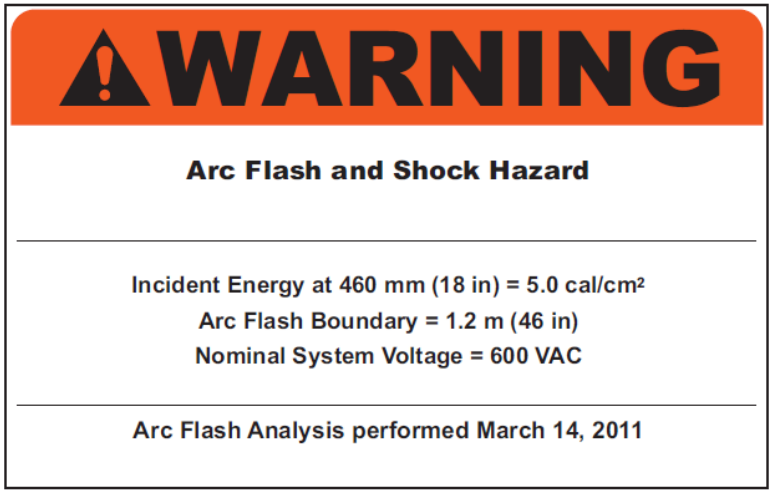
CSA Z462
Limits of Approach

Representation

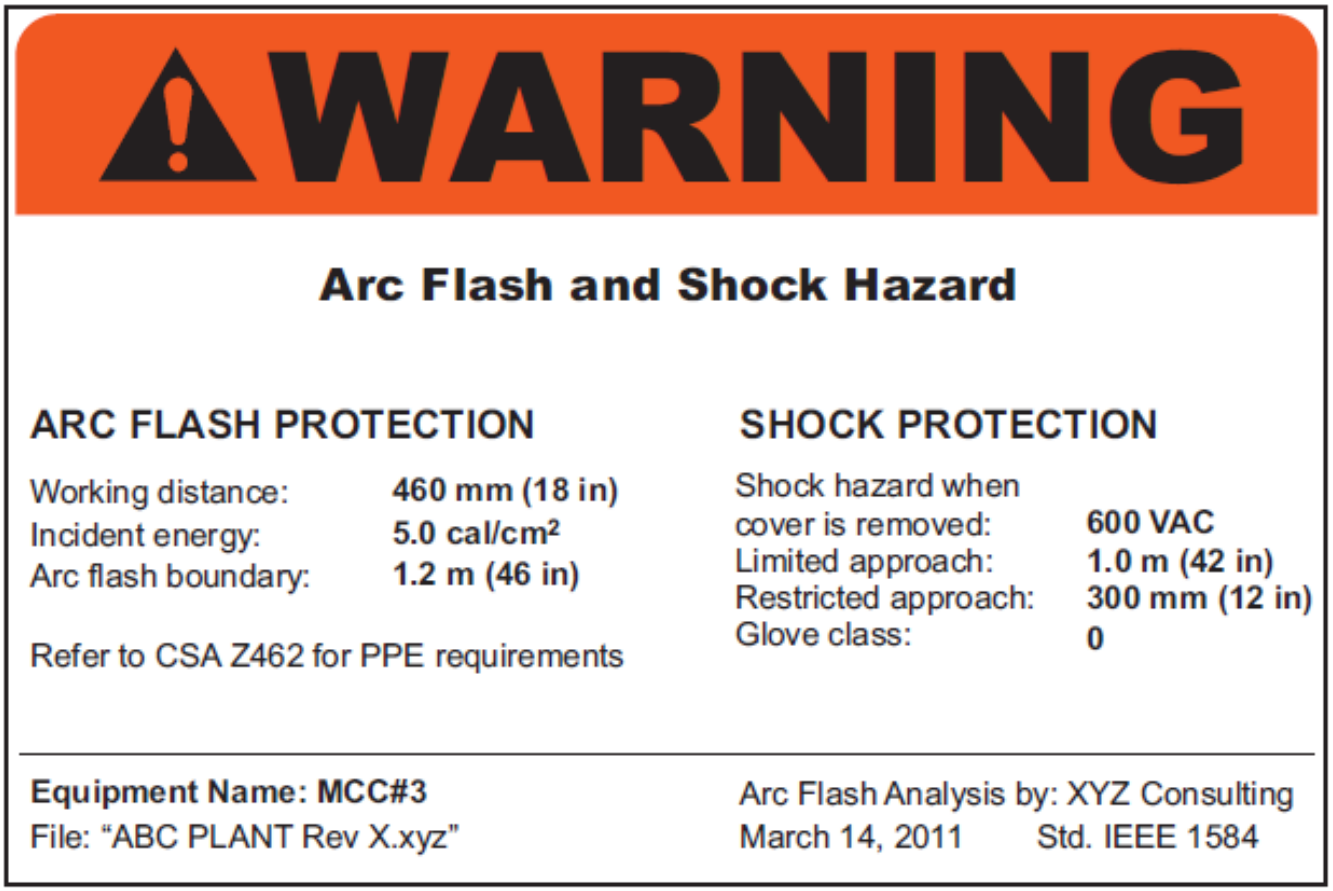


CSA Z462
Arc Flash Labels

Labels recommended by CSA Z462



Labels recommended by CSA Z462



CIMA+ Labels

Arc Flash and Shock Hazard

FLASH PROTECTION		SHOCK PROTECTION	
Flash Hazard at:	**61 cm / 36 in**	Shock Hazard:	**600 VAC**
Incident energy:	**10 cal/cm²**	Limited Approach:	**1 m / 3.5 ft**
Arc flash boundary:	**2 m / 6 ft**	Restricted Approach:	**30 cm / 1 ft**
		Glove Class :	**0**

PPE Requirement (CSA Z462):

Fire resistant clothing, minimum arc rating of 10 cal/cm²

Hard hat + Safety Glasses + Hearing protection

Arc Rated faceshield + Balaclava or Hood

Leather work shoes and gloves

Equipment : Main Disconnect
July 19, 2017

CIMA+

05

CAN/ULC-S801 : Standard on Electric Utility Workplace Electrical Safety for Generation, Transmission, and Distribution

Summary

- CAN/ULC : Underwriters Laboratories of Canada
- The CAN/ULC-S801 “Standard on Electric Utility Workplace Electrical Safety for Generation, Transmission, and Distribution” standard defines electrical safety requirements for utilities / high-voltage work (linesmen, etc.)
- First edition : CAN/ULC-S801-2010
- Second (latest) edition : CAN/ULC-S801-2014

1. SCOPE

1.1 This Standard applies to the construction, operation, maintenance and replacement of electric utility systems that are used to generate, transform, transmit, distribute or deliver electrical power or energy to consumer services or their equivalent, including:

A Equipment located in easements, rights of way, or in other recognized agreements;

B Equipment located on property owned or leased by the electric utility for the purpose of communication, metering and control of electrical power or energy;

C Service drops or laterals, associated metering, and street lighting under the exclusive control of electric utilities;

D Facilities used to generate electrical power or energy for electric utility systems; and

E Voltage levels up to 800 kV a.c. line-to-line (L-L) and 600 kV d.c.

1.2 The purpose of this Standard is to provide safety performance requirements for electric utilities, workers and employers involved in work on or *near* electric generation, transmission and distribution systems.

1.3 If a difference of interpretation arises with respect to the application of this Standard, the decision of the employer or the employer's representative shall be final. This decision shall not result in any worker performing work in a manner that is hazardous to the worker, fellow workers or the public.

Roles & Responsibilities

- Section 4.1 defines the:
  - Roles & responsibilities of employers : safety training, visitors, etc.
  - Roles & responsibilities of workers : rules, safe work practices, tools, how to report unsafe practices, etc.

4. FUNDAMENTAL REQUIREMENTS

4.1 ROLES & RESPONSIBILITIES

4.1.1 Employers

4.1.1.1 Protection for Workers

4.1.1.1.1 Every employer shall ensure:

A The safety and health at work of all its workers;

B Only *qualified* and *authorized workers* perform work on the power system;

Qualification, Identification & Location

- Section 4.2 defines the qualification of workers : similar to CSA Z462

4.2.2 Qualification of Workers

4.2.2.1 To be recognized as a *qualified worker*, a worker shall:

A Be trained in the skills necessary to safely and proficiently carry out all tasks assigned; and

B Demonstrate competence in carrying out such tasks.

- Section 4.3 defines the identification and location requirements for all equipment : they shall all be identified and located easily

4.3 IDENTIFICATION AND LOCATION

4.3.1 Fundamental Requirements

4.3.1.1 All electrical components used in the control of an electrical generation, transmission or distribution system shall be identified so their locations and configurations are known and can be confirmed before work is undertaken.

4.3.1.2 Records shall be maintained on all electric utility systems, such as civil and electrical drawings or diagrams identifying location and normal operating status.

Work Planning

- Section 4.4 defines the work planning requirements:
  - Safety planning : site visit to identify and document high risk hazards and critical issues
  - All workers shall be informed of the hazards that affect them
  - How to identify hazards, eliminate them, assess and control risks
  - Recommends record keeping methods
  - Specifies emergency response plan requirements

4.4 WORK PLANNING

4.4.1 Fundamental Requirements

4.4.1.1 The employer shall have in place a process for project safety planning and safe work planning as well as pre-job on-site safe work planning for all work on an electric generation, transmission or distribution system.

4.4.2 Project Safety Planning

4.4.2.1 A project safety plan should be developed for large, complex or high *risk* projects that are generally lengthy in duration and may present unusual or unexpected *hazards*. In the initial stages, after a project has been identified as complex, a site visit should be conducted in order to identify and document:

A High *risk hazards* with potentially fatal consequences; and

B Critical issues or conditions which may impede safe completion of the project (outage requirements, equipment location and status, specialized equipment, work methods or training required, etc.).

4.4.2.2 All workers affected by the project safety plan shall be informed of the *hazards* that affect them. Refer to Appendix A – Figure A2, Project Planning Hazard Assessment Report Form.

Personal Protective Equipment (PPE)

- Section 4.5 defines how to select PPE :
  - General
  - Head
  - Eye & Face
  - Hearing
  - Skin (Body)
  - Foot
  - Hand
  - Fall

4.5 PERSONAL PROTECTIVE EQUIPMENT (PPE)

4.5.1 General PPE

4.5.1.1 *Personal protective equipment* (PPE) shall be selected and used to protect the worker based on the *hazard* or hazards to which the worker is *exposed*.

4.5.1.2 Workers shall use PPE approved by the utility to protect their health and safety.

4.5.1.3 Workers shall inspect their PPE prior to use to ensure it is in good condition.

4.5.2 Head Protection

4.5.2.1 Head protection shall be in compliance with CAN/CSA-Z94.1, Industrial Protective Headwear – Performance, Selection, Care and Use, or an industry standard(s) of equivalent or greater worker protection.

4.5.3 Eye and Face Protection

4.5.3.1 Eye and face protection shall be in compliance with CSA-Z94.3, Eye and Face Protectors, or an industry standard(s) of equivalent or greater worker protection. Also reference should be made to CSA-Z94.3.1, Selection, Use and Care of Protective Eyewear.

4.5.3.2 Workers *exposed* to electric arcs shall wear *arc-rated* protection that complies with (or meets the requirements of) ASTM F2178, Standard Method for Determining the Arc Rating and Standard Specification for Eye or Face Protective Products, or an industry standard(s) of equivalent or greater worker protection.

Emergency Response & First Aid

- Section 4.6 defines how to build an emergency response and first aid plan
  - Plan must exist
  - Plan must contain risks, emergencies, procedures, communication methods, location of emergency facitities, etc.
  - Training requirements for emergency response and first aid
  - Fire protection

4.6 EMERGENCY RESPONSE AND FIRST AID

4.6.1 Emergency Response Plan

4.6.1.1 Every employer shall establish and maintain an emergency response plan for work situations, which may require the rescue or evacuation of workers.

4.6.2 Contents of Plan

4.6.2.1 An emergency response plan for electrical *workplace* incidents should consider:

A Identification of potential emergencies;

B Procedures for dealing with the identified emergencies, including rescue and evacuation;

C Identification of, location of and operational procedures for emergency equipment;

D Emergency response training requirements;

E Location and use of emergency facilities;

F Fire protection requirements;

G Alarm and emergency communication requirements;

H First aid services requirements;

I Procedures for rescue and evacuation; and

J Designated rescue and evacuation workers.

4.6.3 Emergency Response

4.6.3.1 All workers shall be informed of, and knowledgeable in, procedures for requesting assistance in and responding to emergency situations caused by electrical or related *hazards*, including provision of first aid and approved methods of resuscitation. Emergency response related information appropriate to the work being performed shall be readily available or *accessible* to workers.

4.6.3.2 First aid supplies shall be available and kept current at each *workplace*.

4.6.3.3 Any critical *hazard* encountered shall be assessed and reported; then, where *practicable*, *guarded* and controlled.

Approach Distances

- Section 5 defines the approach distances
  - Minimum approach distances shall be established by the utility and approved by a P.Eng.

5. MINIMUM APPROACH DISTANCES FOR WORKING NEAR OR ON ENERGIZED ELECTRICAL LINES OR EQUIPMENT

NOTE: Observing *minimum approach distances* (MAD) reduces the *risk* of electrical flashover while working with special tools and methods on or *near energized* lines or equipment, and is distinct from other system design *clearances* such as vertical *clearances* in CAN/CSA-C22.3 No.1, Overhead Systems.

5.1 FUNDAMENTAL REQUIREMENTS

5.1.1 GENERAL

5.1.1.1 *Minimum approach distances* shall be established by the utility and approved by a professional *engineer*, using recognized industry standards (see Appendix B) such as:

A CAN/ULC-61472, Live working – Minimum approach distances for a.c. systems in the voltage range of 72.5 kV to 800 kV – A method of calculation; and/or

B IEEE 516, Guide for Maintenance Methods on Energized Power Lines.

5.1.2 ERGONOMIC DISTANCE

5.1.2.1 *Ergonomic distance* allows for the inadvertent movement of workers, equipment or tools and for errors in judgment.

Protective Tools, Equipment & Devices

- Section 6 defines how to select and how to use protective tools, equipment and devices
  - Insulated/conductive equipment
  - Protective covers
  - Temporary grounds & bonds
  - GFCI
  - Voltage detectors
  - Volt meters

6. PROTECTIVE TOOLS, EQUIPMENT & DEVICES

6.1 FUNDAMENTAL REQUIREMENTS

6.1.1 Protective tools, equipment and devices shall be used according to manufacturers' instructions and good work practices.

6.1.2 Protective tools, equipment and devices shall be manufactured to a recognized standard for work on or *near* electrical lines or equipment in an *energized* or *isolated* state. The voltage limits and mechanical strengths of the tool, equipment or device shall be specified by the manufacturer.

6.1.3 When required, utilities may design and fabricate protective tools so long as they are *engineered*.

6.1.4 An employer shall ensure that workers' electrical safety equipment and products are inspected and tested in accordance with the manufacturers specifications or specifications provided by a professional *engineer* and in compliance with the applicable standard(s).

NOTE: For information on the terminology used to describe tools, equipment and devices and methods used in *live working*, refer to the following standard(s):

A CAN/ULC-60743, Live Working – Terminology for Tools, Devices and Equipment; and

B IEC 60050 (651), International Electrotechnical Vocabulary (IEV) – Chapter 651: Live Working.

6.1.5 Employers shall provide:

A Protective tools, equipment and devices for their workers that comply with the standards referenced in this Standard or industry standards of equivalent or greater worker protection;

B Training for workers on how to use, inspect and maintain protective tools, equipment and devices; and

C An in-service testing and maintenance program in compliance with the standards to which the protective tools, equipment and devices are manufactured.

Live Work

- Section 7 defines the requirements and methods for live work
  - Training requirements
  - Insulating materials and work procedures
  - How to locate and identify the equipment
  - Categories of line work : Ground / Line potential
  - Metering units
  - Battery banks, UPS, Chargers
  - Underground systems

7. WORKING ON ENERGIZED ELECTRICAL LINES AND EQUIPMENT

7.1 FUNDAMENTAL REQUIREMENTS

7.1.1 General

7.1.1.1 *Live work* on systems of all voltages shall be in compliance with this section.

7.1.1.2 For *live work* on *low voltages*, the utility shall establish work methods, procedures and *live working* techniques with appropriate tools and protective equipment to eliminate and/or control the *live work hazards*.

7.1.1.3 For *live work* on *medium* or *high voltages*, the utility shall establish a *live work* program in compliance with the following standard(s), or an industry standard(s) of equivalent or greater worker protection:

A CAN/ULC-61472, Live working – Minimum approach distances for a.c. systems in the voltage range of 72.5 kV to 800 kV – A Method of Calculation; and

B IEEE 516, Guide for Maintenance Methods on Energized Power Lines.

7.1.2 High Voltage (HV) Live Work Program

7.1.2.1 A HV *live work* program shall consider the following *live work* methods and techniques related to *insulating* gloves (*rubber* gloves), *insulating* sticks and bare handed work.

7.1.2.2 A HV *live work* program shall include, but not be limited to:

Arc Flash Protection

- Section 8 defines the requirements for arc flash protection
  - How and when to perform risk assessments
  - How to control arc flash risks
  - Arc flash PPE
  - Care of arc flash PPE

8. ELECTRIC ARC HAZARD PROTECTION

8.1 FUNDAMENTAL REQUIREMENTS

8.1.1 When workers are required to work in *proximity* to *energized* equipment above 50 V a.c., all potential sources of *electric arc hazard* shall be identified and *risk* assessed.

8.1.2 Measures shall be taken to protect workers from the harmful effects of all forms of *electric arc hazard* (including arc flash). These measures shall include one or a combination of the following:

A *Engineered* controls (i.e., minimized fault currents, reduced clearing times, arc-resistant switchgear, remote equipment operation, *barrier* boards, arc-flash blankets, etc.);

B Administrative controls (i.e., electrically safe work zones, increased working distance, specific safe work methods, etc.); and/or

C The use of appropriate PPE based on risk assessment.

8.2 ARC FLASH RISK ASSESSMENTS

8.2.1 All electrical *arc flash hazards* presented to workers by *energized* equipment shall be identified and quantified through determination of the potential *incident energy*.

8.2.2 When workers are required to perform work in *proximity* to such identified *hazard* at any nominal voltage level above 240 V a.c., a work activity specific arc flash assessment shall be referenced or, if necessary, performed in order to determine the actual *risk* to workers and the maximum actual exposure should an arc flash be initiated.

8.2.3 When workers are required to perform work in *proximity* to *energized* three phase a.c. equipment operating at 240 V or below but with a 125 kVA (or greater capacity) individual transformer or bank in its power supply, a work activity specific arc flash *risk* assessment shall also be referenced or performed. (see Appendix C)

8.2.4 A professional *engineer* shall approve the *arc flash hazard* identification methods and *risk* assessment performed. The calculations and methodology used shall be documented.

Radio Frequency Hazards

- Section 9 defines the radio frequency hazards
  - When working near communication antennas

9. RADIO FREQUENCY HAZARDS

NOTE: This section addresses current electric utility practices and minimum requirements for radio frequency (RF) protection of workers in the vicinity of wireless communication antennas mounted on electrical power line structures.

9.1 FUNDAMENTAL REQUIREMENTS

9.1.1 When working in *proximity* to communication antennas operating in the range of 3 kHz to 300 GHz, workers shall not be *exposed* to radiation levels that exceed Health Canada – Safety Code 6, Limits of Human Exposure to Radio Frequency Limits for Radiation from 3 kHz to 300 GHz.

9.1.2 The employer shall ensure work standards are developed and implemented for:

A Exposure limits (use of personal monitors, signage, etc.);

B RF *minimum approach distances*;

C *Lockout* and/or *tagging* procedures;

Working on Isolated Electric Utility Systes

- Section 10 defines how to isolate electrical equipment
  - How to ground / block electrical systems when isolation is necessary
  - Lockout / tagging requirements

10. WORKING ON ISOLATED ELECTRIC UTILITY SYSTEMS

10.1 FUNDAMENTAL REQUIREMENTS

10.1.1 One method of performing work safely on the power system involves isolation. When equipment or conductors are to be placed in an *isolated* state, appropriate safety precautions shall be taken. The following shall be considered:

A Whether there are multiple sources of *hazardous energy* supply;

B Whether the *circuit* has been unloaded, or is the isolating device capable of interrupting load; and

C Whether the equipment possibly develops a hazardous induced potential or capacitive charge.

10.2 ISOLATING AND GROUNDING/BLOCKING OF ELECTRIC UTILITY SYSTEMS

10.2.1 Conductors and electrical equipment shall be considered *live* and *minimum approach distances* shall be maintained (see Section 5., Minimum Approach Distances for Working Near or on Energized Electrical Lines or Equipment) unless the equipment is *isolated* and *grounded* or *blocked* to effectively control hazardous energies.

10.2.2 All electrical isolation shall provide a visual opening except when not *practicable* or an *authorized* equivalent is provided.

10.2.3 When work procedures or requirements are such that *portable grounding equipment* is left in service overnight or longer, it shall not be depended upon until a voltage absence test has been done.

10.2.3.1 For *grounding* equipment installed in an overhead location, a daily check to see that the assemblies are well secured shall be conducted.

10.2.3.2 For *grounding* equipment installed in underground locations where public access and weather impacts do not affect them, there is no requirement to check daily.

Working Near Electric Utility Systems

- Section 11 defines how work safely near electric utility systems
  - Non-utility workers safety
  - Vegetation management plan
  - Generation systems (rotating machines) safe work procedures

11. WORKING NEAR ELECTRIC UTILITY SYSTEMS

NOTE: This Section applies to work activities *near exposed energized* electrical lines and equipment that may present the possibility of encroachment on *minimum approach distances*.

11.1 FUNDAMENTAL REQUIREMENTS

11.1.1 *Minimum approach distances* shall be maintained as required by Section 5., Minimum Approach Distances for Working Near or on Energized Electrical Lines or Equipment.

11.1.2 The employer shall ensure that workers working *near energized* electrical lines and equipment shall have the appropriate tools, equipment, PPE and clothing for the application.

11.1.3 When necessary to measure and assure appropriate *clearances* are maintained from *exposed energized* electrical lines or other system parts, only devices approved for the purpose shall be used.

06

Conclusion & Recommendations

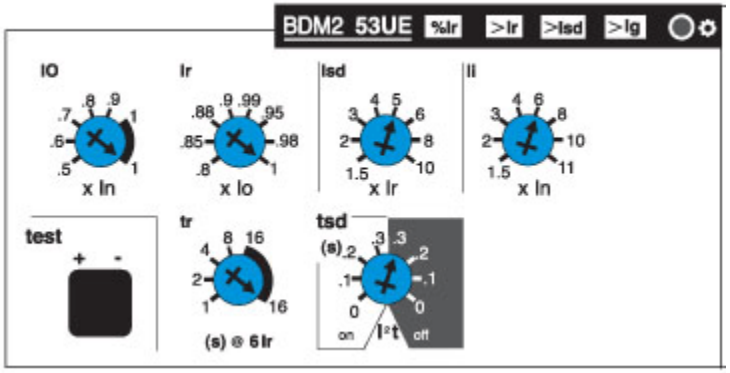
Conclusion & Recommendations

While integrating electrical (shock & arc flash) safety

- Some advice:
  - PPE management process
  - Work procedures
  - Limits of approach management
  - Keep an up-to-date single-line diagram
  - Plan for spare fuses of the same size and types than the ones in place
  - An arc flash study must be completed by a competent engineer and revised for every major modifications without exceeding 5 years

Solutions to mitigate arc flash events

- Protection setting modification
- Protection addition
- Protection replacement
- Work procedure modification



Conclusion & Recommendations

Solutions to mitigate arc flash events

- Additional protection
  - Arc flash detection with fibre optic (Available with most electronic relays)
- Arc proof switchgear
- Maintenance mode protection setting
  - Activated with a switch
  - Activated with motion sensor
- Automated rack-in/out breakers

Solutions to mitigate arc flash events

- Arc-proof switchgears

Solutions to mitigate arc flash events

- Working procedure modification
  - Racking/de-racking from a distant location
  - Use of insulated tools
  - Proceed with a maintenance schedule based on the manufacturer’s recommendation

Conclusion & Recommendations

This webinar allowed you to

- Differentiate the arc flash risks from the shock risks
- Define the risks associated with arc flash
- Read arc flash labels
- Define the personal protective equipment (PPE) to be worn when performing live work
- Determine how to safely perform live work
- Know how and when to use the CSA Z462 and CAN/ULC-S801 standards

AVOID LIVE WORK WHEN POSSIBLE

Conclusion

- And finally…
  - An arc flash study allows workers to **KNOW** the potential risk associated with live work and **SECURE** the workplace to qualified workers only
  - Electricity **WILL ALWAYS** be a source of potential **DANGER**

Questions?
(submit them through the question box)

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