

### **PURPOSE/APPLICATION**

Regarding Arc Flashes and how to avoid them.

#### **PPE**

- See PPE Section Below

#### **TRAINING**

#### **HAZARDS & CONCERNS**

- Personal injury (burns)
- Explosions
- Electrical

### **DEFINITIONS:**

**Arc Flash** – Arc Flash is a dangerous condition associated with the release of energy caused by an electric arc. It occurs when electrical insulation or isolation between conductors is broken or can no longer withstand the applied voltage.

Arc Flash can occur under any of the following conditions:

1. If an employee is working on or near energized conductors or circuits.
2. If an employee moves near or comes into contact with the equipment.
3. A failure of the equipment occurs.

Any of these may cause a phase-to-phase and/or phase-to-ground electrical fault.

### **ELECTRIC SAFETY PRINCIPLES**

#### **Perform a Hazard Assessment or Job Briefing**

##### **Identify:**

- The hazards
- The voltage levels involved
- The skills required
- Is there any secondary voltage source
- Any unusual conditions
- The number of people needed to do the job
- The protection boundaries
- The available incident energy

##### **Ask:**

- Can the equipment be de-energized?
- Is a "Standby Person" required?
- Are the back feeds of the circuits to be worked on possible?

##### **Check:**

- The job plans
- The single line diagrams and vendor prints
- The safety procedures
- The vendor information

**Know:**

- What the job is
- Who is in charge
- Who else needs to know about the job – communicate

**Think:**

- About the unexpected events – what if?
- Lock-Tag-Test-Try
- Test for the voltage first
- Use the right tools and equipment, including all PPE
- What else...?

**Prepare for an Emergency**

- Is the Standby Person CPR trained?
- Is the required equipment available? Where is it?
- Where is the nearest telephone? What are the emergency telephone numbers?
- Where is the fire alarm?
- Is confined space rescue available
- What is the exact work location?
- How is the equipment shutoff in an emergency?
- Where are the fire extinguishers?

**Minimize Hazards**

If possible, de-energize the equipment or insulate or isolate any exposed live parts so you cannot come into contact with them. Wear proper PPE when doing so.

**Anticipate Problems**

If it can go wrong, it might. Make sure you have the right PPE and tools for the worst-case scenario.

**TO DE-ENERGIZE OR NOT TO DE-ENERGIZE**

Whenever possible, live parts to which you might be exposed should be de-energized unless who you are working for can demonstrate that de-energizing creates more or worse hazards, or is not practical because of equipment design or operational limitations. You might have to work on it energized because of a critical need of keeping power supplied.

Remember when de-energizing a system you are working on the system in the energized state. It takes as little as switching a breaker to cause an arc flash. It is a must to wear the proper PPE when de-energizing equipment.

**DE-ENERGIZING**

**An Electrically Safe Work Condition**

The most important principle of electric safety is, assume electric circuits are energized unless you make sure they are not. Test every circuit and conductor every time you work on them.

Six steps to ensure conditions for electrically safe work are:

1. Identify all sources of power to the equipment.

2. Interrupt the load current, then open the disconnecting devices for each power source.
3. Where possible, visually verify that blades of disconnecting devices are fully open of that drawout-type circuit breakers are fully withdrawn.
4. Apply lock-out/tag-out devices in accordance with lock-out/tag-out policy.
5. Test each phase conductor or circuit part with an adequately rated voltage detector to verify that that equipment is de-energized. Check the voltage detector before and after each test to be sure it is working.
6. Properly ground all possible sources of induced voltage and stored electric energy (such as, capacitors) before touching. If conductors or circuit parts that are being de-energized could contact other exposed conductors or circuit parts, apply ground-connecting devices rated for the available fault current.

The process of de-energizing is "live" work and can result in an arc flash due to equipment failure. When de-energizing, follow the procedures described below in "Working On or Near Live Circuits."

### **WORKING ON OR NEAR LIVE CIRCUITS**

Working on live circuits means actually touching energized parts.

Working near live circuits means working close enough to energized parts to pose a risk even though you may be working on de-energized parts.

Common tasks where you need to work on or near live circuits include:

- Taking voltage measurements
- Opening and closing disconnects and breakers
- Racking breakers on and off the bus
- Removing panels and dead fronts
- Opening electric equipment doors for inspection

***When working on energized equipment an "Energized Electrical Work Permit" must be filled out.***

### **PROPER PERSONAL PROTECTIVE EQUIPMENT**

When working on or around live circuits, you must wear the right PPE to protect against electric shock and arc flash. Never wear clothing made from synthetic materials, such as acetate, nylon, polyester, or rayon – alone or combined with cotton. Such clothing is dangerous because it can burn and melt into the skin.

The type of PPE worn depends of the type of electric work being done. Once the hazard/risk category has been identified, check the requirements for clothing and other PPE when working on or near energized equipment within the flash protection boundary. These PPE requirements protect against electric shock and incurable arc flash burns. They do not protect against physical injuries from arc blasts.

**Hazard/Risk Category Classifications**

Tasks Performed on Energized Equipment	Hazard/Risk Category	Rubber Insulating Gloves	Insulated Hand Tools
<b>Panelboards or other Equipment Rated 240 V and Below</b>			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	0	N	N
Circuit breaker or fused switch operation with covers on	0	N	N
Circuit breaker or fused switch operation with covers off	0	N	N
Work on exposed energized electrical conductors and circuit parts, including voltage testing	1	Y	Y
Remove/Install circuit breakers fused switches	1	Y	Y
Removal of bolted covers	1	N	N
Opening hinge covers	0	N	N
Work on exposed energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard	1	Y	Y
<b>Panelboards or Switchboards Rated &gt;240 V and up to 600 V</b>			
Perform infrared thermography and other non-contact inspection outside the restricted approach boundary	1	N	N
Circuit breaker or fused switch operation with covers on	0	N	N
Circuit breaker or fused switch operation with covers off	1	Y	N
Work on exposed energized electrical conductors and circuit parts, including voltage testing	2*	Y	Y
Work on exposed energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard or switchboard	2*	Y	Y
<b>600 V Class Motor Control Centers (MCC's)</b>			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	1	N	N
Circuit breakers or fused switch or starter operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
Circuit breakers or fused switch or starter operation with enclosure doors open	1	N	N
Work on exposed energized electrical conductors and circuit parts, including voltage testing	2*	Y	Y
Work on control circuits with exposed energized electrical conductors and circuit parts 120 V or below; exposed	0	Y	Y

Work on control circuits with exposed energized electrical conductors and circuit parts >120 V; exposed	2*	Y	Y
Insertion or removal of individual starter buckets from MCC	4	Y	N
Application of safety grounds, after voltage test	2*	Y	N
Removal of bolted covers	4	N	N
Opening hinge covers	1	N	N
Work on exposed energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard or switchboard	2*	Y	Y
<b>600 V Class Switchgear (with power circuits or fused switches)</b>			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	2	N	N
Circuit breakers or fused switch with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
Circuit breakers or fused switch with enclosure doors open	1	N	N
Work on exposed energized electrical conductors and circuit parts, including voltage testing	2*	Y	Y
Work on control circuits with exposed energized electrical conductors and circuit parts 120 V or below; exposed	0	Y	Y
Work on control circuits with exposed energized electrical conductors and circuit parts >120 V; exposed	2*	Y	Y
Insertion or removal of CB's from cubicles, doors open or closed	4	N	N
Application of safety grounds, after voltage test	2*	Y	N
Removal of bolted covers	4	N	N
Opening hinge covers	2	N	N
<b>Other 600 V Class (277 V through 600 V nominal) Equipment</b>			
<b>Lighting or small power transformers (600 V max.)</b>			
Removal of bolted covers	2*	N	N
Opening hinged covers	1	N	N
Work on exposed energized electrical conductors and circuit parts, including voltage testing	2*	Y	Y
Application of safety grounds, after voltage testing	2*	Y	Y
<b>Revenue Meters</b>			
Insertion or Removal	2*	Y	N
Cable trough or tray cover removal or installation	1	N	N

Miscellaneous equipment cover removal or installation	1	N	N
Work on energized electrical conductors and circuit parts, including voltage testing	2*	Y	Y
Application of safety grounds, after voltage test	2*	Y	N
Insertion or Removal of plug-in devices into or from busways	2*	N	N
<b>NEMA E2 (fused contactor) Motor Starters, 2.3 kV through 7.2 kV</b>			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	3	N	N
Contactor operation with enclosure doors enclosed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
Contactor operation with enclosure doors open	2*	N	N
Work on exposed energized electrical conductors and circuit parts 120 V or below; exposed	0	Y	Y
Work on exposed energized electrical conductors and circuit part >120 V; exposed	3	Y	Y
Insertion or removal of CB's from cubicles, doors open or closed	4	N	N
Application of safety grounds, after voltage test	3	Y	N
Removal of bolted covers	4	N	N
Opening hinge covers	3	N	N
Insertion or removal of starters from cubicles of arc-resistant construction, doors closed only	0	N	N
<b>Metal Clad Switchgear, 1 kV through 38 kV</b>			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	3	N	N
Circuit breaker operation with enclosure doors enclosed	2	N	N
Reading a panel meter while operating a meter switch	0	N	N
Circuit breaker operation with enclosure doors open	4	N	N
Work on exposed energized electrical conductors and circuit parts, including voltage testing	4	Y	Y
Work on control circuits with exposed energized electrical conductors and circuit parts 120 V or below; exposed	2	Y	Y
Work on control circuits with exposed energized electrical conductors and circuit parts >120 V; exposed	4	Y	Y
Insertion or removal of CB's from cubicles, doors open or closed	4	N	N
Application of safety grounds, after voltage test	4	Y	N

Removal of bolted covers	4	N	N
Opening hinge covers	3	N	N
Opening voltage transformer or control power transformer compartments	4	N	N
<b>Arc Resistant Switchgear Type 1 or 2</b>			
CB operation with enclosure door closed	0	N	N
Insertion or removal of circuit breakers from cubicles, door closed	0	N	N
Insertion or removal of circuit breakers from cubicles, door open	4	N	N
Work on control circuits with energized conductors and circuit parts 120 V or below; exposed	2	Y	Y
Insertion or removal of ground and test device with door closed	0	N	N
Insertion or removal of voltage transformers on or off the bus, door closed	0	N	N
<b>Other Equipment 1 kV through 38 kV</b>			
Switch operation of arc-resistant type construction, doors closed only	0	N	N
Switch operation, door open	2	N	N
Work on exposed energized electrical conductors and circuit parts, including voltage testing	4	Y	Y
Removal of bolted covers	4	N	N
Opening hinged covers	3	N	N
Outdoor disconnect switch operation (hook stick operated)	3	Y	Y
Outdoor disconnect switch operation (gang-operated, from grade) Insulated cable examination, in manhole or confined space	2	Y	N
Insulated cable examination, in manhole or other confined space	4	Y	N
Insulated cable examinations, in open area	2	Y	N

**Protective Clothing and Personal Protective Equipment (PPE)**

Hazard Risk Category 0	
Protective clothing, non-melting or untreated natural fiber	<ul style="list-style-type: none"> <li>▪ Shirt; long sleeve</li> <li>▪ Pants; long</li> </ul>
Other protective equipment	<ul style="list-style-type: none"> <li>▪ Safety glasses or Safety goggles (SR)</li> <li>▪ Hearing protection (ear canal inserts)</li> <li>▪ Leather gloves (note 2)</li> </ul>

<b>Hazard Risk Category 1</b>	
FR Clothing, Minimum Arc Rating of 4 cal/cm2 (note 1)	<ul style="list-style-type: none"> <li>▪ Arc rated long-sleeve shirt and pants (note ); or</li> <li>▪ Arc rated coverall (note 4)</li> <li>▪ Arc rated faceshield or arc flash suit hood (note 7)</li> <li>▪ Arc rated jacket, parka or rainwear (AN)</li> </ul>
Other protective equipment	<ul style="list-style-type: none"> <li>▪ Hard hat</li> <li>▪ Safety glasses or safety goggles (SR)</li> <li>▪ Hearing protection (ear canal inserts)</li> <li>▪ Leather gloves (note 2)</li> <li>▪ Leather work shoes</li> </ul>

<b>Hazard Risk Category 2</b>	
FR Clothing, Minimum Arc Rating of 8 cal/cm2 (note 1)	<ul style="list-style-type: none"> <li>▪ Arc rated long-sleeve shirt and pants (note 5); or</li> <li>▪ Arc rated coverall (note 6)</li> <li>▪ Arc rated faceshield or arc flash suit hood (note 7)</li> <li>▪ Arc rated jacket, parka or rainwear (AN)</li> </ul>
Other protective equipment	<ul style="list-style-type: none"> <li>▪ Hard hat</li> <li>▪ Safety glasses or safety goggles (SR)</li> <li>▪ Hearing protection (ear canal inserts)</li> <li>▪ Leather gloves (note 2)</li> <li>▪ Leather work shoes</li> </ul>

<b>Hazard Risk Category 2*</b>	
FR Clothing, Minimum Arc Rating of 8 cal/cm2 (note 1)	<ul style="list-style-type: none"> <li>▪ Arc rated long-sleeve shirt and pants (note 5); or</li> <li>▪ Arc rated coverall (note 6)</li> <li>▪ Arc rated flash suit hood (note 9)</li> <li>▪ Arc rated jacket, parka or rainwear (AN)</li> </ul>
Other protective equipment	<ul style="list-style-type: none"> <li>▪ Hard hat</li> <li>▪ Safety glasses or safety goggles (SR)</li> <li>▪ Hearing protection (ear canal inserts)</li> <li>▪ Leather gloves (note 2)</li> <li>▪ Leather work shoes</li> </ul>



<b>Hazard Risk Category 3</b>	
FR Clothing, Minimum Arc Rating of 25a1/cm2 (note 1)	<ul style="list-style-type: none"> <li>▪ Arc rated long-sleeve shirt and pants (note 8)(AR);or</li> <li>▪ Arc rated coverall (note 8)(AR)</li> <li>▪ Arc rated arc flash suit hood</li> <li>▪ Arc rated jacket, parka or rainwear (AN)</li> <li>▪ Arc rated arc flash suit jacket (AR)(note 8)</li> <li>▪ Arc rated arc flash suit pants (AR)(note 8)</li> <li>▪ Arc rated gloves (note 2)</li> </ul>
Other protective equipment	<ul style="list-style-type: none"> <li>▪ Hard hat</li> <li>▪ FR hard hat liner (AR)</li> <li>▪ Safety glasses or safety goggles (SR)</li> <li>▪ Hearing protection (ear canal inserts)</li> <li>▪ Leather work shoes</li> </ul>

<b>Hazard Risk Category 4</b>	
FR Clothing, Minimum Arc Rating of 40 cal/cm2 (note 1)	<ul style="list-style-type: none"> <li>▪ Arc rated long-sleeve shirt and pants (note 9)(AR)</li> <li>▪ Arc rated coverall (note 9)(AR)</li> <li>▪ Arc rated jacket, parka or rainwear (AN)</li> <li>▪ Arc rated arc flash suit hood</li> <li>▪ Arc rated arc flash suit jacket (AR)(note 9)</li> <li>▪ Arc rated arc flash suit pants (AR)(note 9)</li> <li>▪ Arc rated gloves (note 2)</li> </ul>
Other protective equipment	<ul style="list-style-type: none"> <li>▪ Hard hat</li> <li>▪ FR hard hat liner (AR)</li> <li>▪ Safety glasses or safety goggles (SR)</li> <li>▪ Hearing protection (ear canal inserts)</li> <li>▪ Leather gloves (note 2)</li> </ul>

AN = As Needed

SR = Selection Required

AR = As Required

Notes:

Arc rating for a garment or system is expressed in cal/cm2

1. If rubber insulating gloves with leather protectors are required (shown in Category classification table) additional leather or arc rated gloves are not required

2. The FR shirt and pants used for the category 1 shall have minimum arc rating or 4
3. Alternate is to use FR coverall (minimum arc rating of 4) instead of FR shirt and pants
4. FR shirt and pants used for Category 2 shall have a minimum arc rating of 8
5. Alternate is to use FR coverall (minimum arc rating of 8) instead of FR shirt and pants
6. A faceshield with a minimum arc rating of 4 for Category 1 or a minimum arc rating of 8 for Category 2, with a wrap around guarding to protect not only the face, but the forehead, ears and neck is required.
7. Alternate is to use a total FR clothing system and hood, which shall have a minimum arc rating of 25 for category 3
8. The total clothing system consisting of FR shirt and pants and/or FR coveralls and/or arc flash coat and pants and hood shall have a minimum arc rating of 40 for Category 4
9. Alternate is to use a faceshield with a minimum arc rating of 8 and a balaclava (sock hood)

### **Approach Distances to Exposed Live Parts**

There are 3 approach distances for shock hazards and one for arc flash:

1. **Limited Approach Boundary** – is the closest distance an unqualified person can approach, unless accompanied by a qualified person
2. **Restricted Approach Boundary** – is the closest distance to exposed live parts a qualified person can approach without proper PPE and tools. To cross this restricted approach boundary, the qualified person must:
  - Have a documented plan that is approved by the manager responsible for the safety plan
  - Use PPE suitable for working near exposed live parts and rated for the voltage and energy level involved
  - Be certain that no part of the body enters the prohibited space
  - Minimize the risk from unintended movement, by keeping as much of the body as possible out of the restricted space; any body parts in the restricted space should be protected accordingly
3. **Prohibited Boundary** – is the minimum approach distance to exposed live parts to prevent flashover or arcing. Approaching any closer is comparable to making direct contact with a live part. To cross the prohibited approach boundary, the qualified person must:
  - Have specified training to work on exposed live parts
  - Have a documented plan with proper written work procedures and justifying the need to work that close
  - Do a written risk analysis
  - Have points 2 or 3 approved by the manager responsible for the safety plan
  - Use appropriate PPE for working near exposed live parts and rated for the voltage and energy level involved

The **Flash Protection Boundary** is the distance at which PPE is needed to prevent incurable burns (2<sup>nd</sup> degree or worse) if an arc flash occurs (you can still get 1<sup>st</sup> or 2<sup>nd</sup> degree burns).

For systems that are 600 V or less, the flash protection boundary is 4ft. Otherwise it can be calculated with the formula:  $D = (2.65 \times MVA \times T)^{1/2}$

D = distance in feet from an arc source for a second degree burn

MVA = capacity rating

T = time of arc exposure

Nominal system voltage range, phase to phase (kV)	Limited approach boundary, exposed movable conductor	Limited approach boundary, exposed fixed circuit part	Restricted approach boundary; includes inadvertent movement adder	Prohibited approach boundary
Less than 50	Not specified	Not specified	Not specified	Not specified
50 to 300	3.05 m	1.07 m	Avoid contact	Avoid contact
301 to 750	3.05 m	1.07 m	304.8 mm	25.4 mm
751 to 15	3.05 m	1.53 m	660.4 mm	177.8 mm
15.1 to 36	3.05 m	1.83 m	787.4 mm	254 mm
36.1 to 46	3.05 m	2.44 m	838.2 mm	431.8 mm
46.1 to 72.5	3.05 m	2.44 m	965.2 mm	635 mm
72.6 to 121	3.25 m	2.44 m	991 mm	812.8 mm
138 to 145	3.36 m	3.05 m	1.093 m	939.8 mm
161 to 169	3.56 m	3.56 m	1.22 m	1.07 m
230 to 242	3.97 m	3.97 m	1.6 m	1.45 m
345 to 362	4.68 m	4.68 m	2.59 m	2.44 m
500 to 550	5.8 m	5.8 m	3.43 m	3.28 m
765 to 800	7.24 m	7.24 m	4.55 m	4.4 m

**REGULATIONS**

**Alberta OHS Code**

*None*

**Saskatchewan OHS Regulation**

*None*

**British Columbia OHS Regulation**

*None*

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