MSW Initial/Refresher Training:
Electrical Safe Work

Purpose, Objectives and Scope

Purpose

- Learn the requirements of the Electrical Safe Work standard and its specific safety instructions

Objectives

- Personnel are knowledgeable about the requirements of Electrical Safe Work.
- Personnel understand their role and responsibilities within the Electrical Safe Work Standard.

This training does not make an individual qualified to do electrical work (Qualified Electrical Person).

Scope

The Electrical Safe Work Standard **applies** to:

- Work on or near electrical equipment operating at or above voltage levels 50 Volts (dc or ac)
- Electrical work conducted on ground level equipment, on elevated poles, below grade enclosures and inside confined spaces

The Electrical Safe Work Standard **does not apply** to:

- Low voltage/low current instrumentation systems
  - This class of equipment operates at less than 50 Volts (dc or ac) and is not required to be placed in an electrically safe work condition prior to work.

Electrical Safe Work Standard

Introduction

- Electrical safe work procedures are designed to help prevent personnel injuries, property damage or adverse environmental impact due to electrical shock, arc flash, arc blast and fire ignition.
- Electrical work is any task that involves working on or near (that is, within 10 feet, in most cases) any electrical system or equipment that is operating at a voltage of 50 Volts or more and that has exposed energized electrical conductors or circuit parts;
- This includes work on non-electrical equipment that is within 3.2 meters (10 feet) of equipment or lines operating at 50 Volts or more and that have exposed energized electrical conductors or circuit parts.
- In the absence of specific electrical safety guidance in this SWP, NFPA 70E shall apply.
- Chevron F&L does not allow energized electrical work without the proper approvals. “Stop-Work Authority” is expected to be used for any situation where the de-energized state is unknown.

Electrical Safe Work Standard

Key Definitions

Electricity

- Electricity is energy that involves the movement of electrons along a conductor - also referred to as current

Electrocution

- A human being that is exposed to a LETHAL amount of electrical energy

Electrical shock

- Electrical shock is electric current through the body: a sudden painful physical reaction consisting of nerve stimulation and muscle contraction, caused by an electric current flowing

Arc Flash

- Arc Flash is basically a short circuit through air that flashes over from one exposed live conductor to another conductor or ground

Arc flash hazard

- A dangerous condition associated with the possible release of energy caused by an electrical arc.

Arc flash hazard analysis

- A study investigating a worker's potential exposure to arch flash energy, conducted for the purpose of injury prevention and the determination of safe work practices, arc flash boundary, and the appropriate levels of PPE.

Shock hazard analysis

- A study investigating a worker's potential exposure to electrical energy, conducted for the purpose of injury prevention and the determination of safe work practices, shock boundary, and the appropriate levels of PPE.

Electrical Safe Work Standard

Key Definitions

Flash Protection Boundary (for arc flash burn protection)

- The threshold distance at which unprotected human skin may be subject to a second-degree burn. The distance within which a person needs to wear PPE appropriate for the potential arc flash energy for any exposed part of the body.

Limited Approach Boundary

- A shock protection boundary to be crossed by only qualified employees (at a distance from a live part), which is not to be crossed by unqualified personnel unless escorted by a qualified personnel.

Restricted Approach Boundary

- A shock protection boundary to be crossed only by qualified persons (at a distance from a live part) which, due to its proximity to a shock hazard, requires the use of shock protection techniques and equipment when crossed.

Classified Hazardous Area—Any area classified as a hazardous zone area (Zone 0, 1 or 2 or Class I, Division 1 or 2) in accordance with API RP 505/API RP 500 or other equivalent local standards.

Close Proximity—The state or quality of being close enough to reach, fall into, or otherwise accidentally touch an object (see also Restricted Approach Boundary).

De-energized—The state or quality of being free from any electrical connection to a source of potential difference and discharged of any stored electrical energy; not having a potential different from that of the earth.

Energized Electrical Work Permit—A special permit process applied any time work is to be performed on or near electrical equipment that is in an energized state.

Electrical Safe Work Standard

Key Definitions

Electrical Work—Any task that involves working on or near (that is, within 3.2 meters [10 feet], in most cases) any electrical system or equipment **that is operating at a voltage of 50 volts or more and that has exposed energized electrical conductors or circuit parts.** This includes work on non- electrical equipment that is within 3.2 meters (10 feet) of equipment or lines operating at 50 volts or more and that have exposed energized electrical conductors or circuit parts.

Grounded or Grounding—The act of providing an intentional connection to earth through an electrically conductive connection of sufficiently low impedance and with sufficient current carrying capacity as to prevent voltage build-up that might result in undue hazard to persons or to connected equipment. This also is referred to as “earthing.”

Troubleshooting (temporary re-energizing)—The steps necessary to remove lockout / tagout protections in order to temporarily re-energize to facilitate diagnosis of problems or to test electrical repairs. Usually does not result in the final completion of work or handover of equipment to operations.

Working On (energized electrical conductors or circuit parts)—Coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment a person is wearing. There are two categories of “working on:” Diagnostic (testing) is taking readings or measurements of electrical equipment with approved test equipment that does not require making any physical change to the equipment; repair is any physical alteration of electrical equipment (such as making or tightening connections, removing or replacing components, etc.).

Electrical Safe Work Standard

Roles and Responsibilities

- All individuals performing electrical work shall have clearly defined roles, and shall meet the training and competency requirements of the standard prior to starting work. Country/local regulations may specify additional training and competency requirements. When selecting personnel for electrical work, consideration should be given to their level of experience and their past performance.
- Refresher training must be provided whenever an individual demonstrates insufficient knowledge of the Electrical Safety Standard and/or as required by local regulations.

Qualified Electrical Person

- Knowledgeable about the construction and operation of electrical equipment and installations (e.g., certified electricians, etc.)
- Conduct shock and arc flash hazard analyses
- Review shock and arc flash hazard analyses
- Barricades electrical work areas within 10 feet of the limited approach boundary
- Performs isolation of (electrical) hazardous energy
- Performs electrical work within limited approach boundaries
- Understands when to stop work

Authorized Electrical Person

- Knowledgeable about potential electrical hazards
- Performs isolation of (electrical) hazardous energy
- Understands the planned work and emergency notification procedures
- Only performs electrical work within authorization scope (e.g., electricians vs. mechanics vs. operators, etc.)
- Understands when to stop work

Electrical Safe Work Standard

Roles and Responsibilities

Electrical Standby Person

- Knowledgeable about potential electrical hazards
- Performs isolation of (electrical) hazardous energy
- Understands the planned work and emergency notification procedures
- Observes the person performing electrical work and assist in emergency situations
- Understands when to stop work
- The electrical standby person **must be trained and qualified** as either a Qualified or Authorized Electrical Person.

Unqualified Person

- Must remain outside of the Limited Approach Boundary.

Competent Person

- Identifies existing and potential hazards associated with work
- Knowledgeable of applicable standards within area of expertise
- Subject Matter Expert for specialized work (e.g. excavation inspector, lifting & rigging specialist, etc.)
- Mitigates hazards associated with specialized work
- Understands when to stop work
- Provides technical support and regulatory advice for specific work related topics.

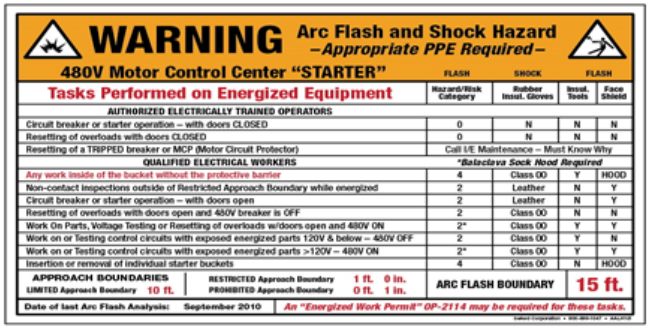
Electrical Safe Work Standard

General Requirements

- Always consider alternatives before beginning energized electrical work activities.
- All electrical system, power lines, electrical equipment or electrical parts shall be considered energized until they are verified to be in an electrically safe work condition.
- All electrical systems, power lines, electrical equipment or electrical parts shall be placed into an electrically safe work condition before personnel performs work unless an Energized Electrical Form has been issued.
- All electrical equipment or systems 50 volts or more must be placed into an electrically safe work condition before performing “work on” or “work near” that equipment or system, unless an Energized Electrical Form has been issued.

- **Establishing an Electrically Safe Work Condition**
  1) De-Energize / Isolate
     - Equipment is disconnected from all sources of energy
     - Equipment is de-energized of any residual or stored energy (grounded where applicable)
  2) Isolated – Locked-Out/Tagged-Out
     - Using SWP defined LOTO procedure and systems

Test for absence of voltage before touching



WARNING Arc Flash and Shock Hazard –Appropriate PPE Required–

480V Motor Control Center “STARTER”

Tasks Performed on Energized Equipment	FLASH Hazard/Risk Category	SHOCK Rubber Insul. Gloves	FLASH Insul. Tools	FLASH Face Shield
AUTHORIZED ELECTRICALLY TRAINED OPERATORS				
Circuit breaker or starter operation – with doors CLOSED	0	N	N	N
Resetting of overloads with doors CLOSED	0	N	N	N
Resetting of a TRIPPED breaker or MCP (Motor Circuit Protector)	Call I/E Maintenance – Must Know Why			
QUALIFIED ELECTRICAL WORKERS	*Balaclava Sock Hood Required			
Any work inside of the bucket without the protective barrier	4	Class 00	Y	HOOD
Non-contact inspections outside of Restricted Approach Boundary while energized	2	Leather	N	Y
Circuit breaker or starter operation – with doors open	2	Leather	N	Y
Resetting of overloads with doors open and 480V breaker is OFF	2	Class 00	N	N
Work On Parts, Voltage Testing or Resetting of overloads w/doors open and 480V ON	2*	Class 00	Y	Y
Work on or Testing control circuits with exposed energized parts 120V & below – 480V OFF	2	Class 00	Y	N
Work on or Testing control circuits with exposed energized parts >120V – 480V ON	2*	Class 00	Y	Y
Insertion or removal of individual starter buckets	4	Class 00	N	HOOD

APPROACH BOUNDARIES — LIMITED Approach Boundary 10 ft. — RESTRICTED Approach Boundary 1 ft. 0 in. — PROHIBITED Approach Boundary 0 ft. 1 in. — ARC FLASH BOUNDARY 15 ft.

Date of last Arc Flash Analysis: September 2010 — *An “Energized Work Permit” OP-2114 may be required for these tasks.*

Low Voltage

(not much electrical work will qualify as low voltage)

Under 50 Volts (AC/DC)

Battery backup for computers, PLC's…

Telephone systems

Normal office/household stuff = 120V

light switches, outlets, office lighting…

Industrial equipment = 220v, 440v.

Mixers, pumps, conveyors

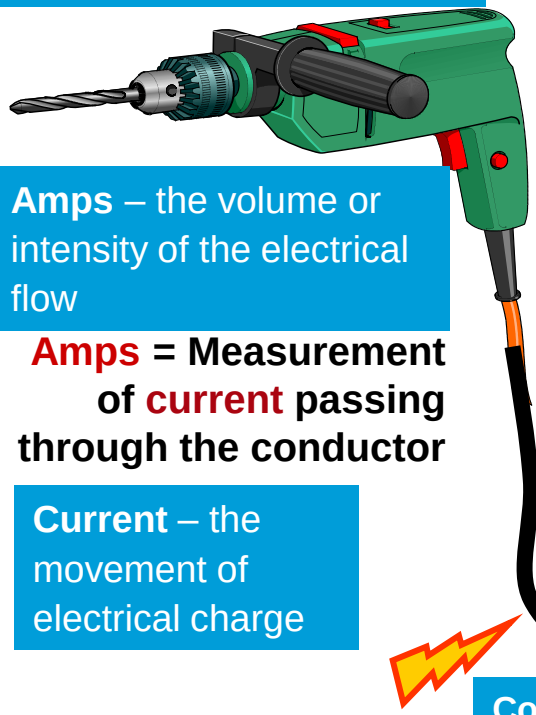
Electrical Safe Work Standard

Electrical Fundamentals

Voltage – a measure of electrical force

Voltage = Force or pressure causing electricity to flow

Watts – the power consumed



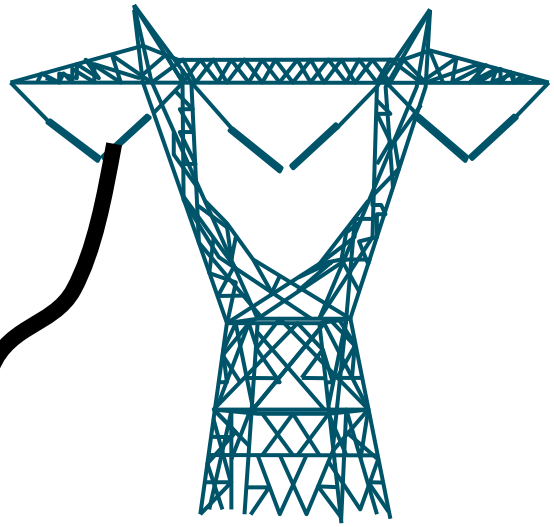
Amps – the volume or intensity of the electrical flow

Amps = Measurement of current passing through the conductor

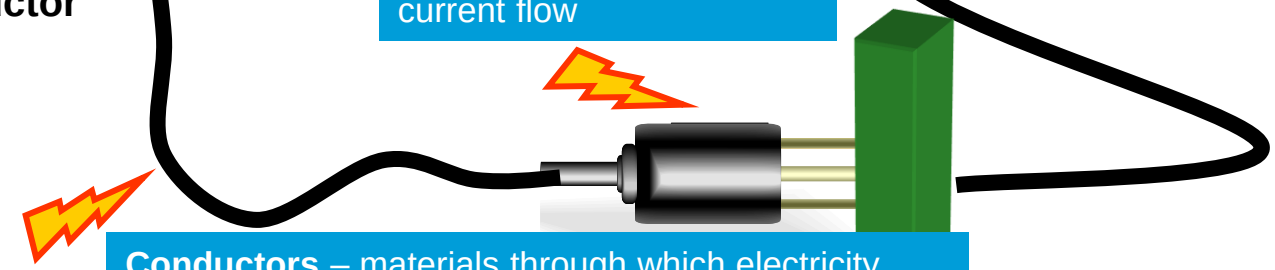
Current – the movement of electrical charge

Resistance – opposition to current flow measured in Ohms Ω

Ω Ohms = Measurement of resistance in the conductor (wire)



Insulators –materials that have high resistance to current flow



Conductors – materials through which electricity flows through with relative ease (low resistance)

Operating an electric switch is like turning on a water faucet. Behind the faucet or switch, there is a source of water or electricity with a way to transport it, and pressure to make it flow. The faucet's water source is a reservoir or pumping station. A pump provides enough pressure for the water to travel through the pipes. For electricity, the source is the power generating station. A generator provides the pressure (voltage) for the electrical current to travel through the electric conductors (wires).

Electrical Safe Work Standard

Checking of Resistance using Ohmmeter

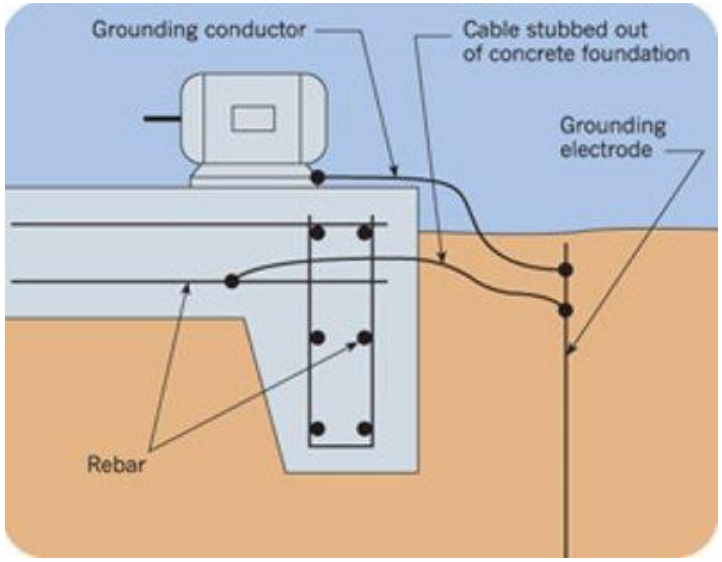
- Used to ensure there is good conductivity (vac truck hoses, grounding cables, bonding cables)
- Can be performed by an Authorized Electrical Person
- Higher the number – the poorer the conductivity
- Lower the number – better the conductivity
- *From Vac Truck Std: Less than 100 ohm per hose connection, Less than 1000 total between end of hose and grounding connection*

Electrical Safe Work Standard

Grounding and Bonding

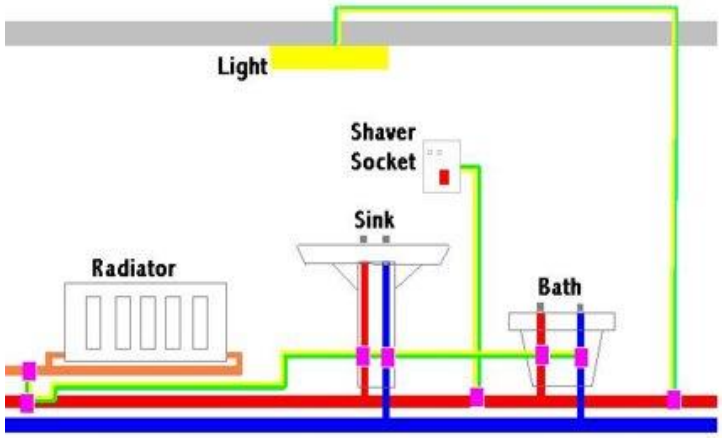
Grounding

- Connecting equipment to earth.
- Grounding metal parts to the earth is only useful to provide a path for lightning, shunting high-frequency noise, or reducing static discharge.



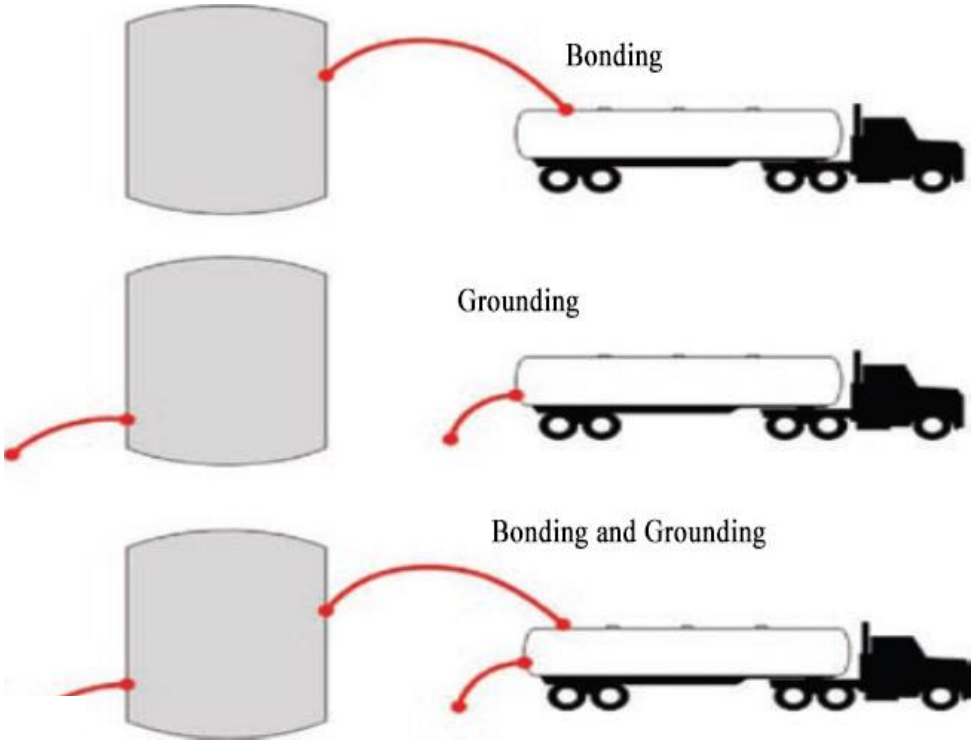
Bonding

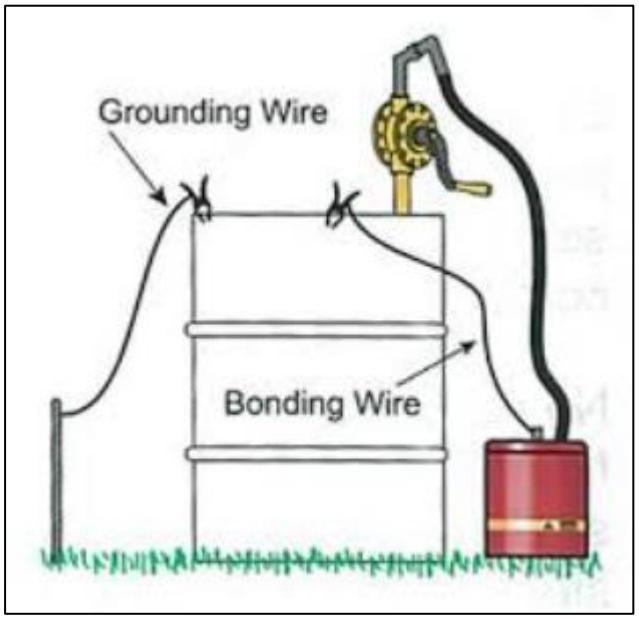
- Joining metal parts to form a conductive path or the practice of electrically connecting all metallic non-current carrying items in a room or building as protection from electric shock



Electrical Safe Work Standard

Areas where you can check the resistance





Electrical Safe Work Standard

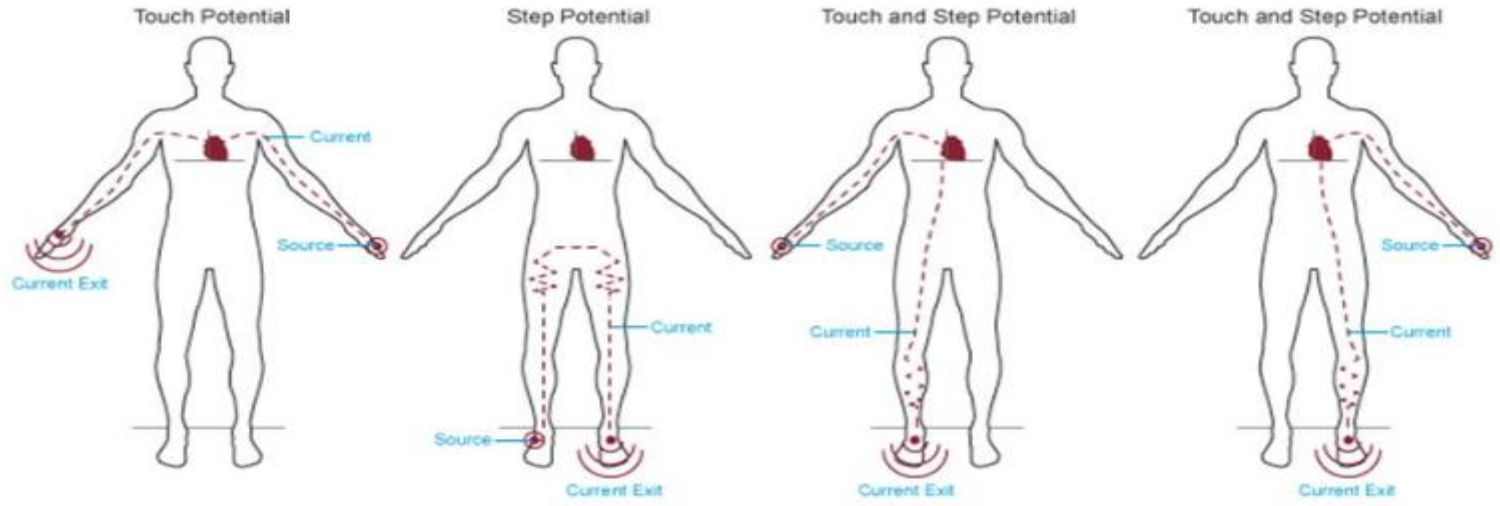
Hazards Associated with Electricity

The goal of Electrical Safe Work Standard is to protect all personnel from the three (3) hazards associated with electricity:

1) Electrical Shock,
2) Arc Flash and,
3) Arc Blast

1. Electrical Shock

Electrical shock is the most well-known electrical hazard where the human body must become part of an energized circuit. Electrical current will flow through your body if you are part of the circuit.

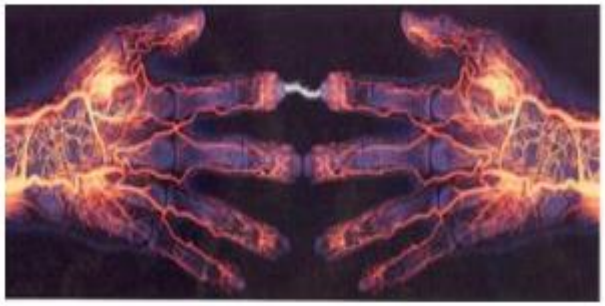


Electrical Safe Work Standard

Hazards Associated with Electricity

1. Electrical Shock (cont.)

- The most damaging path for electric current to flow is through the chest and/or head.
- Shock can cause fatalities resulting from either direct paralysis of the respiratory system, nervous/muscular system, ventricular fibrillation, or immediate heart stoppage.
- Prompt medical attention is needed for anyone receiving an electrical shock that results in heart fibrillation. Many people can be saved with prompt application of Cardiopulmonary Resuscitation (CPR), followed by application of an automated external defibrillator (AED).
- Electrical shock may also cause physical burns due to current flow through the body's tissues.
- This burn is from the inside out.



2. Arc Flash

- When electrical current passes through the air between ungrounded conductors or between ungrounded conductors and grounded conductors, the temperature can reach 35,000° F (19,427° C), or about four times the temperature of the sun.
- Exposure to these extreme temperatures burns the skin directly (like a sunburn) and causes ignition of clothing, which adds to the burn injury.
- The extreme light intensity can also cause short- and long-term eyesight damage.
- Most hospital admissions due to electrical accidents are from arc flash burns, not shocks.
- Arc flashes can and do kill at distances of 10 feet.

Electrical Safe Work Standard

Hazards Associated with Electricity

3. Arc Blast

- The extremely high temperature of the arc causes the explosive expansion of the surrounding air and the metal in the arc path.
- For example, copper expands by a factor of 67,000 times when it turns to a vapor.
- The danger associated with this expansion is one of high pressures (1000+ psf), elevated sound levels (140+ db), and shrapnel.
- The high pressures can easily knock workers off ladders, rupture ear drums, and collapse lungs.
- The sounds associated with these pressures can exceed 160 decibels.
- Finally, material and molten metal expel from the arc at speeds exceeding 700mph (1126 kph)- fast enough for shrapnel to pass right through the human body.

Safety Tip: As the distance between a person and the exposed electrical live part **decreases**, the potential for an electrical accident **increases**. These shorter distances also require higher levels of training and PPE.

Electrical Safe Work Standard

Electrical Isolation

- **Electrical isolation** shall be carried out in accordance with the Chevron F&L Isolation of Hazardous Energy Standard.
- Electrical isolation shall only be carried out by a competent and Qualified Electrician, except for the following which may be carried out by appropriately trained personnel:
  - Switching of circuit breakers on low (<600 volts) voltage circuits as long as there are no exposed electrical contacts greater than 50 volts. ***These are closed breakers***
  - Isolation of circuits not exceeding 50 volts dc or ac (rms) as long as there are no exposed electrical contacts greater than 50 volts.
- The above exceptions are valid only if the protection (shield/barrier within the panel, etc.) offered by the equipment will adequately protect the worker from both electric shock and arc flash. For instance, some guarding that intends to separate the worker from electrical contacts (i.e. some plexiglass barriers) will protect the worker from shock hazard but may not protect against arc flash hazards due to the enormous amount of energy released.

Electrical equipment must always be considered energized until put in an electrically safe work condition

– All electrical equipment or systems 50 volts or more must be placed into an electrically safe work condition before performing “work on” or “work near” that equipment or system, unless reasons such as the following arise:
  - De-energizing is not possible due to equipment design or operational limitations
  - De-energizing introduces additional or increased hazards

Electrical Safe Work Standard

Tasks requiring Energized Electrical Work Form (EEWF)

- An Energized Electrical Work Form (EEWF) is required under certain conditions.
- All Permit to Work requirements need to be met as well as the requirements in the EEWF.
- The following slides review which types of tasks and conditions require an EEWF.

Electrical Safe Work Standard

General Permitting Requirements

- **A General Work Permit** shall be required for work on energized electrical equipment or electrical parts.
- **Energized Electrical Work Permit** shall be required when performing work (e.g., physical work such as replacing fuses, tightening bolts) inside the restricted approach boundary of exposed, energized electrical conductors or circuit parts that are ***not placed in an electrically safe work condition.***
- **The following exceptions are allowed if performed by a Qualified Electrical Person:**
  - Electric diagnostic testing and maintenance troubleshooting where no physical alteration of equipment is required (e.g., testing for voltage, testing for permissive elements).
  - Attach grounds on equipment that is in an electrically safe condition.
  - Perform switching operations using live line tools.
  - Preventive and predictive maintenance observation and infrared thermography performed outside the restricted approach boundary.
  - Reset device overloads.
  - Covering exposed energized circuit parts with voltage rated blankets or covers.
- An Energized Electrical Work Permit shall be used in conjunction with a Permit to Work in accordance with the Chevron Lubricants Permit to Work Standard.

Note: An Energized Electrical Work Permit is not required for diagnostic testing. Diagnostic testing is taking readings or measurements of electrical equipment with approved test equipment that does not require making any physical change to the equipment.

Electrical Safe Work Standard

General Requirements – Pre-Job Hazard Analysis

- The Energized Electrical Work must be evaluated by a Qualified Electrical Person or the Permit Issuer with assistance of a Qualified Electrical Person.
- The pre-job risk assessment is used to complete the Energized Electrical Work Form and must identify the hazards involved, and determine the controls necessary to work safely, including identifying the PPE requirements.
- Arc Flash Hazard Analysis exception:
  - An arc flash hazard analysis shall not be required where all the following conditions exist:
    1. The circuit is rated 120 Volts, nominal, to ground or less.
    2. The circuit is supplied by one transformer.
    3. The transformer supplying the circuit is rated less than 125 kVA.

Note: Flame-resistant (FR) clothing, hard hats, safety glasses, and other PPE are still required for this electrical work. The class of insulating rubber gloves should be chosen based on the system voltage on which work will be done.

Electrical Safe Work Standard

General Requirements – Pre-Job Hazard Analysis

- A shock and arc flash risk assessment shall be performed by a Qualified Electrical Engineer or Qualified Electrical Person before a person approaches any exposed energized electrical conductor or circuit part not placed in an electrically safe work condition. This includes tasks required to:
  - Place the equipment into an **electrically safe work condition** [equipment must be de-energized, locked out and tagged out according to IHE standards, and tested for the absence of voltage and grounded (if applicable)], and
  - Re-energize the equipment to return it to service.
- A **Safe Work Zone** is identified to safeguard personnel from accidentally contacting exposed energized electrical conductors or circuit parts. It is defined as the greater of the limited approach boundary or arc flash boundary.
- The Safe Work Zone is temporarily marked off with rope, tape, or other barricading devices to prohibit entry into the work area for all persons except those authorized by the Qualified Electrical Person.
- A Safe Work Zone is established by the Qualified Electrical Person around the work area where there are exposed energized electrical conductors or circuit parts. The Qualified Electrical Person has total authority over this work area and **must provide approval before ANYONE enters the work area**.

Electrical Safe Work Standard

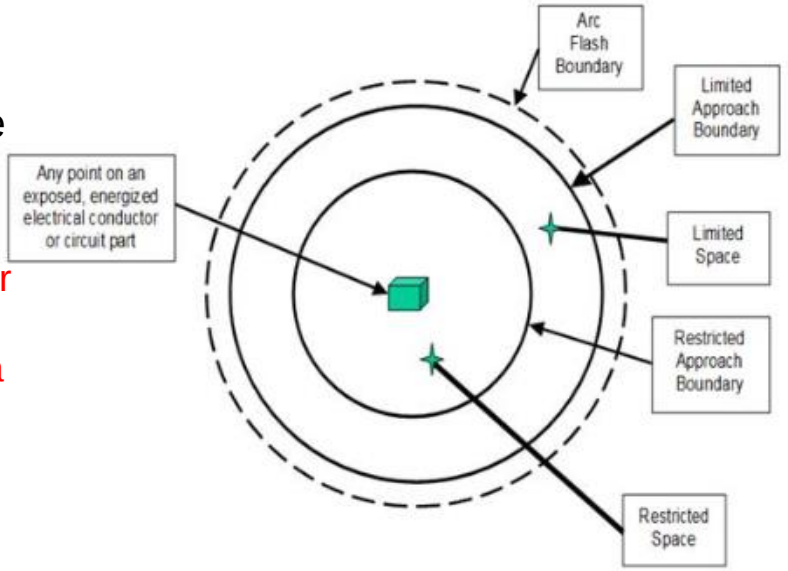
Understanding the limits of approach boundaries

- **Arc Flash Boundary*** = Minimum distance to where a person is exposed to a recoverable 2nd degree burn (1.2 cal/cm^2). Arc flash PPE is required inside this boundary.

- **Limited Approach Boundary*** = Minimum distance from a shock hazard based on voltage level. Shock PPE are required inside this boundary.

  * The Safe Work Zone shall be established at the greater of these boundaries. Unqualified and unauthorized electrical persons must be escorted inside the work area by a Qualified Electrical Person.

- **Restricted Approach Boundary** = Minimum distance from an energized conductor or part within which all work is prohibited. Within this boundary, an **EEWF** is required, and **only** a Qualified Electrical Person is allowed.



Understanding the Limits of Approach Boundaries

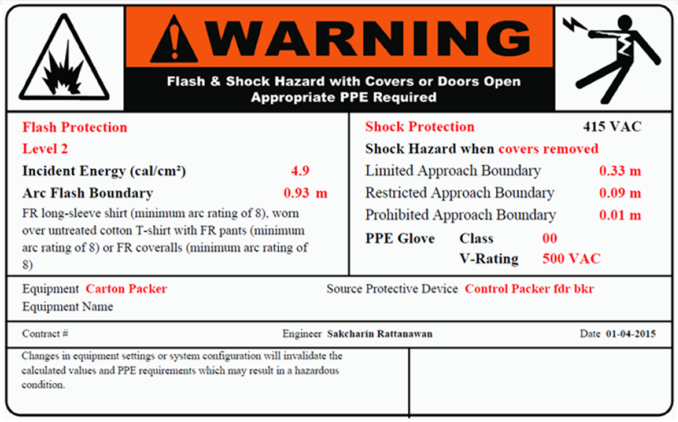
Arc Flash Boundary

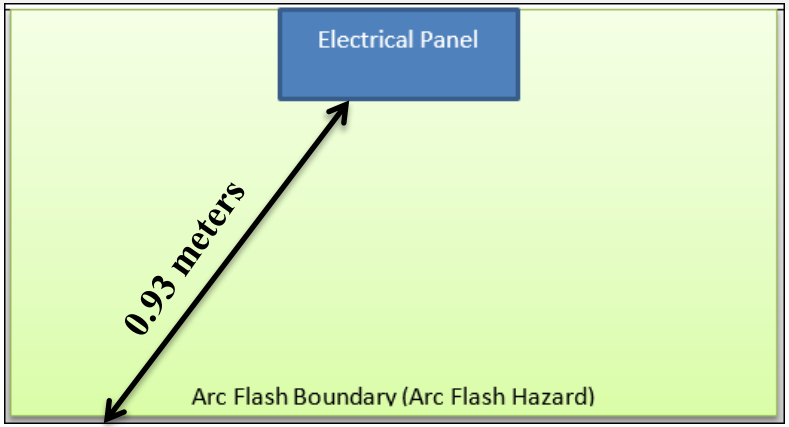
– Distance from exposed live part where hazard of second-degree burns exists from arc flash

- Only Qualified Electrical personnel and Authorized Electrical personnel are allowed to enter the arc flash boundary.
- Personnel working within the arc flash boundary are required to wear full arc flash protection PPE.
- Safe work zones (as defined by the greater of either the limited approach boundary or arc flash boundary, or 10 feet/3.05 meters (whichever is greatest)) shall be visibly barricaded and marked with warning labels

– Arc Flash Protection Boundary is determined by Incident Energy Level:

- The size of the source transformer or the available short-circuit Megavolt Ampere (MVA)
- Clearing time of the upstream protective device (fuse or circuit breaker)
- Should be identified on IEA label on electrical panel
- From the IEA label, you can see that the Arc Flash Boundary is at 0.93 meters from the electrical panel.





Understanding the Limits of Approach Boundaries

Restricted Approach Boundary

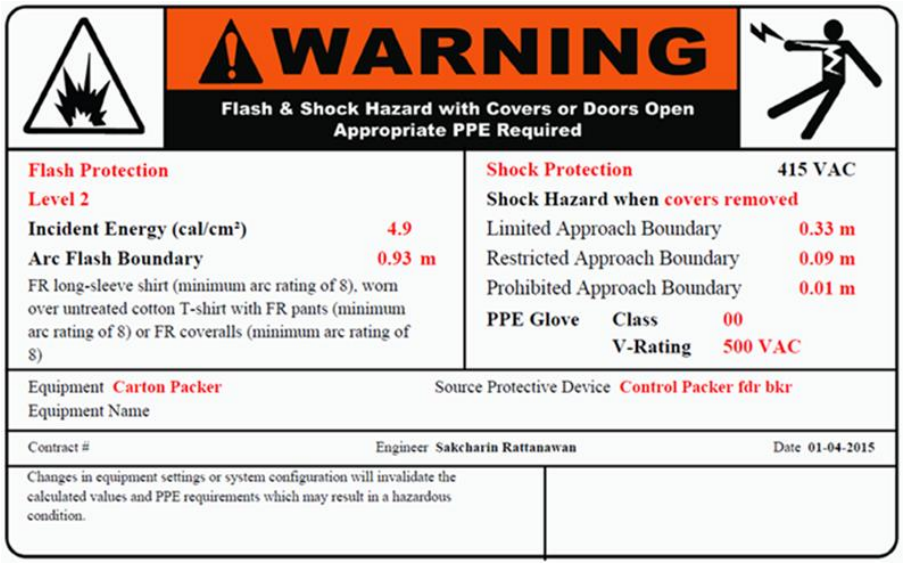
- **The restricted approach boundary** is the distance from an exposed part which is considered the same as making contact with the live part, as there is a significant risk of electric shock or electrocution.
- A minimum of two workers shall be present for work on energized circuit parts 50V or greater. One worker shall be a Qualified Electrical Person and the second worker must be a Qualified Electrical Person or an Authorized Electrical Person shall act as an Electrical Stand-by Person. Only a Qualified Electrical Person can conduct the actual work at or inside the restricted approach boundary.
- Exceptions to this requirement are permitted if one of the following conditions are satisfied:
  - All voltage sources greater than 50 V to the equipment have been proven to be de-energized, including possible back-feeds prior to starting work
  - The equipment has a built-in grounding device that is clearly visible to confirm that grounding has been accomplished.
  - Additionally, prior to working on a previously energized conductor or circuit part, the Qualified Electrical Person shall test for voltage while using insulated rubber gloves rated for the equipment's nominal value.
- Only a Qualified Electrical Person wearing appropriate personal protective equipment (PPE), having specified training to work on energized conductors or components, and a documented plan justifying the need to perform this work may cross the boundary and enter the Restricted Space.

Understanding the Limits of Approach Boundaries

Restricted Approach Boundary

Restricted Approach Boundary

– From the IEA label, you can see that the Restricted Approach Boundary is at 0.09 meters from the electrical panel.



WARNING

Flash & Shock Hazard with Covers or Doors Open
Appropriate PPE Required

Flash Protection		**Shock Protection**	415 VAC
Level 2		**Shock Hazard when covers removed**	
Incident Energy (cal/cm²)	4.9	Limited Approach Boundary	0.33 m
Arc Flash Boundary	0.93 m	Restricted Approach Boundary	0.09 m
FR long-sleeve shirt (minimum arc rating of 8), worn over untreated cotton T-shirt with FR pants (minimum arc rating of 8) or FR coveralls (minimum arc rating of 8)		Prohibited Approach Boundary	0.01 m
		PPE Glove **Class**	00
		V-Rating	500 VAC

Equipment Carton Packer
Equipment Name

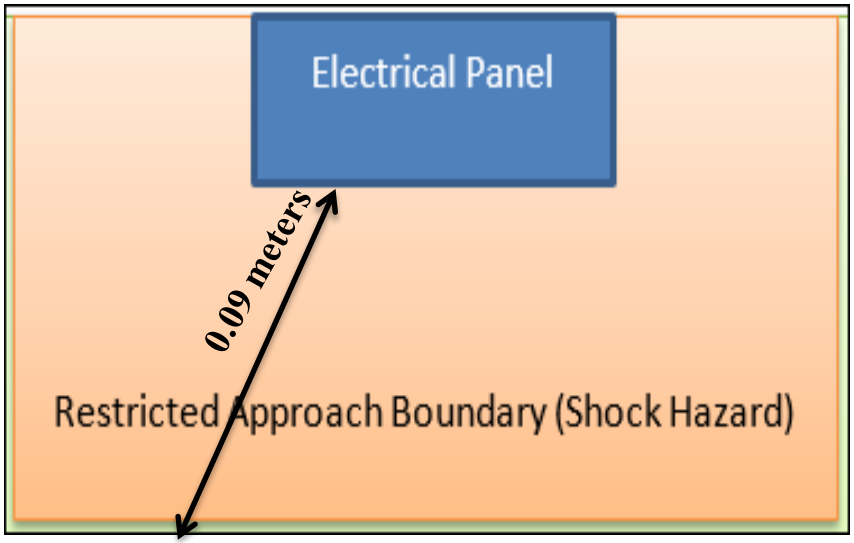
Source Protective Device Control Packer fdr bkr

Contract #

Engineer Sakcharin Rattanawan

Date 01-04-2015

Changes in equipment settings or system configuration will invalidate the calculated values and PPE requirements which may result in a hazardous condition.



Understanding the Limits of Approach Boundaries

Limited Approach Boundary

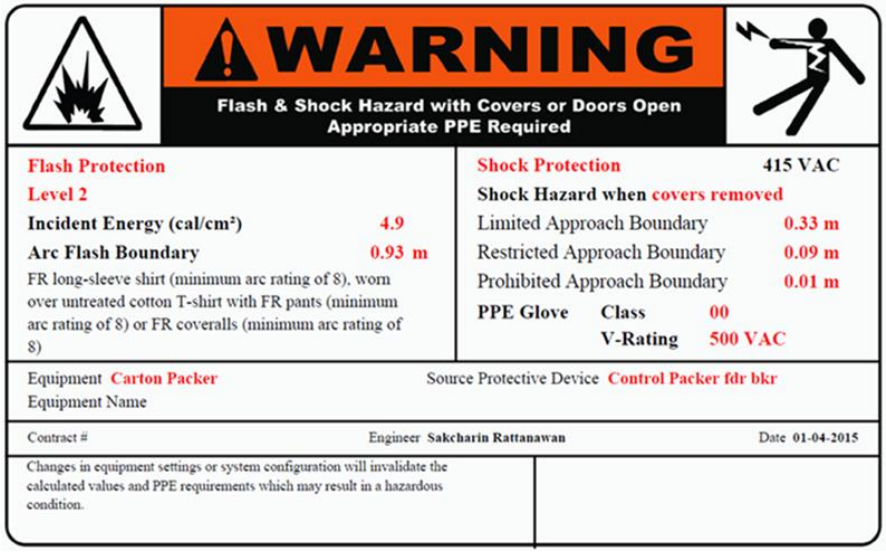
- **The limited approach boundary** is the distance where there is a risk of electric shock and is the minimum distance from an exposed live component where unqualified and unauthorized personnel may safely stand. Only Qualified Electrical personnel and Authorized Electrical personnel are allowed to enter the limited approach boundary.
- Measures (e.g., safety signs and tags, barricades, attendants) shall be taken to prevent or limit access to electrical work areas containing energized conductors or circuit parts.
  - Safe work zones (as defined by the greater of either the limited approach boundary or arc flash boundary, or 10 feet/3.05 meters (whichever is greatest)) shall be visibly barricaded and marked with warning labels
- Personnel working within the limited approach boundary are required to wear full arc flash protection PPE.
- Personnel working within the limited approach boundary of exposed energized electrical conductors or circuit parts shall remove all jewelry and other conductive apparel.
- Only Qualified Electrical personnel and Authorized Electrical personnel are allowed to enter the limited approach boundary. These personnel must use the appropriate PPE and be trained to cross the limited approach boundary and enter the limited space.

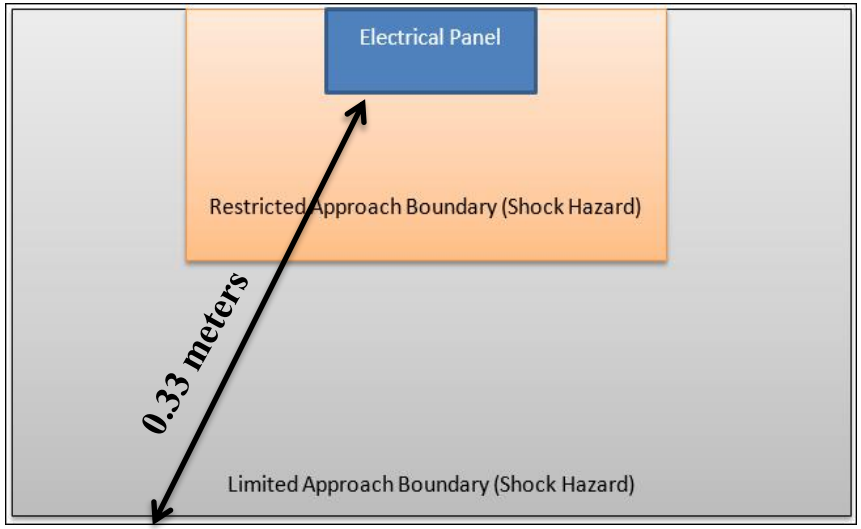
Understanding the Limits of Approach Boundaries

Limited Approach Boundary

Limited Approach Boundary

– From the IEA label, you can see that the Limited Approach Boundary is at 0.33 meters from the electrical panel.





Electrical Safe Work Standard

Barricades of Electrical Areas

Setting up a Barricade:

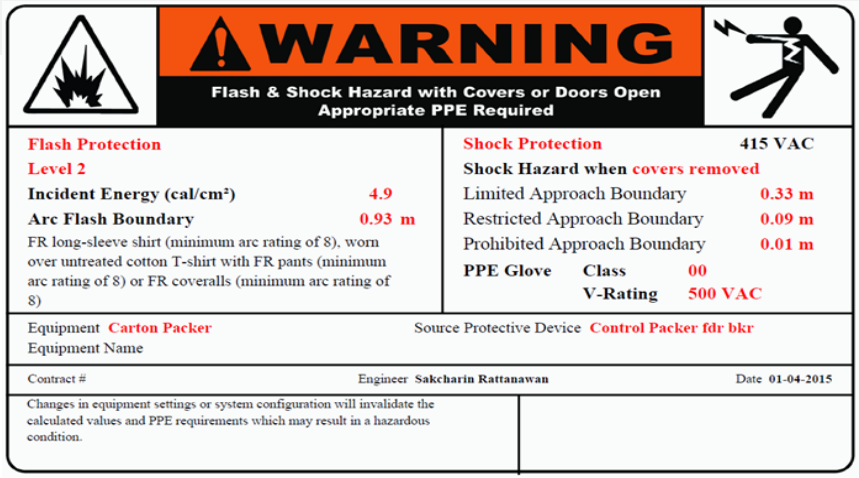
– Any individual that IS NOT an electrically Qualified Person or an Authorized Electrical Person cannot go closer to the exposed live electrical contact than the greater of these three distances:

- The Limited Approach Boundary from the IEA label
- The Arc Flash Boundary from the IEA label
- 10 ft (3.05 meters) from any exposed live part. This is known as the 10 foot rule.

– A barricade must be set up at this distance to keep personnel out of the hazardous area

- Using the IEA label below… you can see that the:

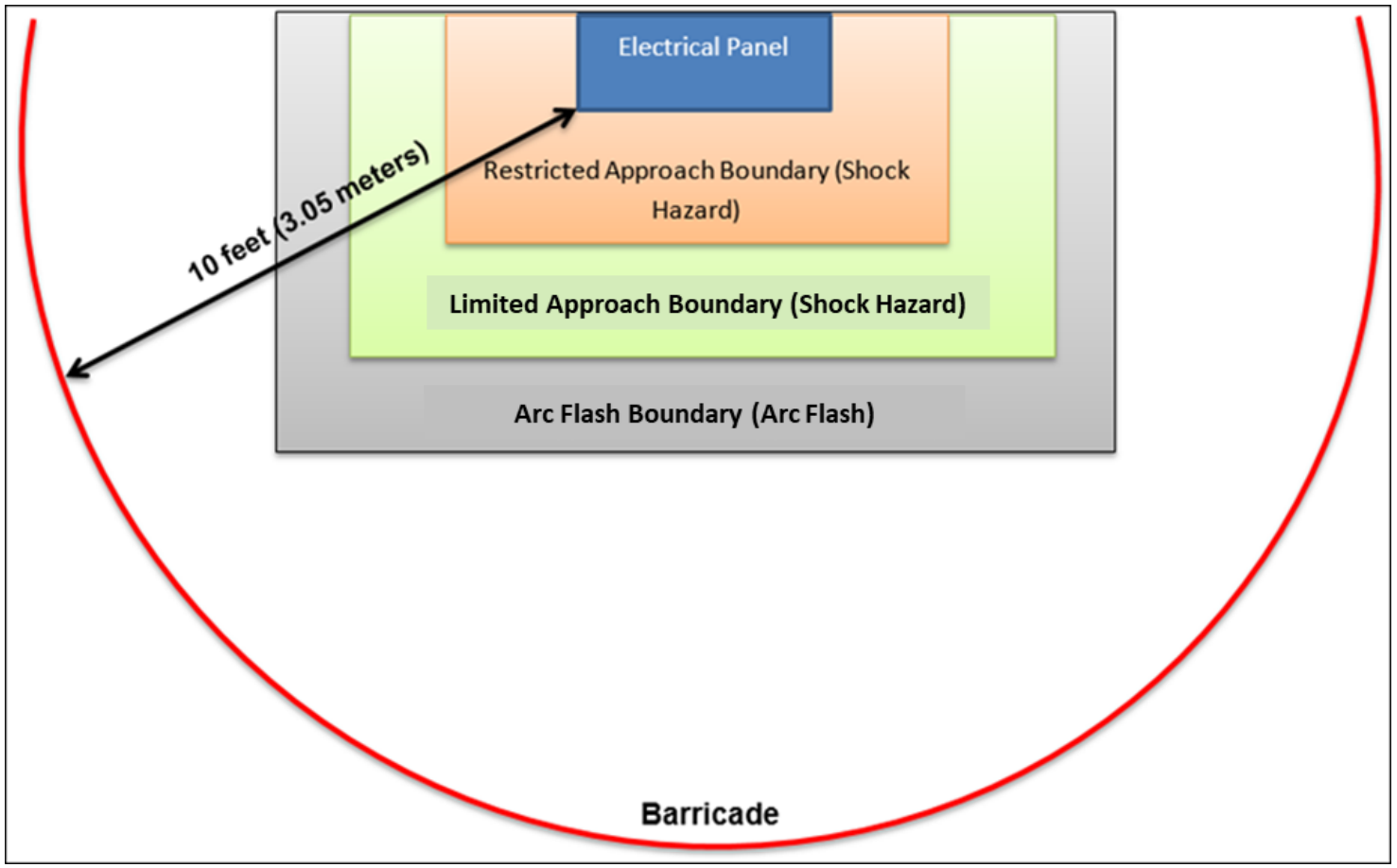
- The Limited Approach Boundary (Limited Protection Boundary) = 0.33 m
- The Arc Flash Boundary (Flash Hazard Boundary) = 0.93 m
- And the 10 foot rule = 3.05 m
- 10 feet (3.05 m) is the greatest, so, the barricade must be set up at 3.05 m or farther away from the panel.



Electrical Safe Work Standard

Barricades of Electrical Areas

The graphic below shows where to set up the barricade to keep unauthorized personnel out of the hazardous area.



Electrical Safe Work Standard

Summary of Electrical Protection Boundaries

Restricted Approach Boundary

- Only Qualified Electrical personnel may enter this area
- Must wear arc flash and shock hazard PPE
- Must have an Electrical Standby person

Limited Approach Boundary

- Only Qualified Electrical and Authorized Electrical personnel may enter this area
- Must wear arc flash and shock hazard PPE

Arc Flash Boundary

- Only Qualified Electrical personnel or Authorized Electrical personnel may enter this area
- Must wear arc flash PPE

Electrical Safe Work Standard

Personal Protective Equipment Requirements

- The Shock and Flash Hazard Analysis will determine the personal protective equipment (PPE) required.
- A Qualified Electrical Person who places any part of their body or a conductive object closer than the Restricted Approach Boundary must be protected from electrical contact by one of the following:
  - The Qualified Electrical Person is insulated from the energized parts operating at 50v or above by using rubber gloves and rubber sleeves. Un-insulated parts of the body must remain out of the Restricted Approach Boundary. OR
  - The energized part operating at 50v, or more is insulated from the qualified person and any other conductive object.
- Additional arc flash PPE may be required based on the calculated incident energy level of the equipment or the task identified in the NFPA 70E tables. Arc flash PPE includes:
  - Insulated tools rated for the system voltage
  - Rubber insulating sleeves or insulating blanket
  - Insulating rubber gloves rated for the voltage level of protection for the task:

Class	Maximum Use Voltage (AC)		Class	Maximum Use Voltage (AC)
00	500 Volts		2	17,000 Volts
0	1,000 Volts		3	26,500 Volts
1	7,500 Volts		4	36,000 Volts

- Visually inspect and air test rubber gloves before each use and after any event that could have resulted in damage to the glove. Air testing involves trapping air in the glove and then squeezing the glove to check for pinhole leaks.
- An EEWF will always require the completion of a shock and arc flash risk assessment to determine additional PPE requirements to safely perform a specific task.

Electrical Safe Work Standard

Personal Protective Equipment Requirements

PPE (General)

- Hard hats shall meet the ANSI / International Safety Equipment Association (ISEA) Z89.1 standards
  - Class E – up to 20,000 volts
  - Class G – up to 2,200 volts
- Hard hats should be kept clean and shall not be altered in any manner with the exception of an SBU authorized logo or stickers with hard-hat-manufacturer approved adhesives;
- Safety glasses shall be approved and be made of non-conductive materials;
- Leather work gloves shall be worn for arc flash protection when insulating rubber gloves are not required;
- Since electrical faults can result in hazardous noise levels, hearing protection is required

PPE (Shock Protection)

- **Employees shall wear rubber insulating gloves with leather protectors** where there is a danger of hand injury from electric shock due to contact with energized electrical conductors or circuit parts (i.e. when a worker's arms will violate the restricted approach boundary).
- **Employees shall wear rubber insulating gloves with leather protectors and rubber insulating sleeves** where there is a danger of hand and arm injury from electric shock due to contact with energized electrical conductors or circuit parts (i.e. when a worker's arms will violate the restricted approach boundary).
- Rubber insulating gloves shall be rated for the voltage for which the gloves will be exposed.
- In order to determine what voltage rating for gloves and hand protection, identify the maximum voltage that could be encountered. The easiest way to do this is to use the IEA label on the panel (or on the panel that is supplying power to the equipment). The PPE needs to be rated for that voltage or greater.

Note: Visually inspect and air test rubber gloves before each use and after any event that could have resulted in damage to the glove. Air testing involves trapping air in the glove and then squeezing the glove and checking for pinhole leaks. Gloves shall also be dielectrically tested every 6 months in accordance with ASTM F 496 or equivalent.

Electrical Safe Work Standard

Personal Protective Equipment Requirements

PPE (Arc Flash)

- Clothing shall be constructed of arc-rated flame-resistant materials (ASTM F 1506), have electrically non-conductive properties, and have long sleeves and long pant legs;
- Meltable fibers such as acetate, nylon, polyester, polypropylene, and spandex shall not be permitted in fabric underlayers (underwear) next to the skin;
- Arc flash ratings are identified on the labels of the clothing.
- In order to determine the appropriate rating needing to be worn, refer to the IEA label on the electrical panel.
- The IEA label may have a Hazard Risk Class (HRC) number or an arc flashing number. Both of which would require referring to the charts in the Appendix.
- In the Electrical Safe Work Standard, Appendix A gives the HRC rating and Appendix B and C have the arc flash ratings. The IEA label may also have all of the PPE identified, so you don’t need to refer to the charts.

Electrical Safe Work Standard

Personal Protective Equipment – Insulating Rubber Gloves

- Insulating gloves with outer protective leather work gloves shall be worn where required by JSA for arc flash protection. Where insulating rubber gloves are used for shock protection, the leather or FR gloves must be worn over the rubber gloves.
- The shelf life of gloves in an unopened package is 12 months.
- Gloves must be replaced every 6 months from the date placed into service.
- Gloves past shelf life (12-months) or use life (6-months) must be tested and recertified by an accredited laboratory or disposed and replaced.

Example: Three pairs of gloves were purchased with a July 1, 2020, certified test date.

- One pair was placed into service July 15, 2020. This pair was no longer in compliance after January 14, 2021 (needs to be tested and recertified).
- A second pair was opened November 16, 2020. Since the gloves were placed in service within the 12-monthy shelf life, these can be used for 6 months (May 15, 2021).
- The third pair can be used if placed in service within the 12-month shelf life (June 30, 2021), and can be used 6 months from the date placed in-service. Should the gloves “expire” before being placed in-service, they will need to be tested and recertified, or replaced.

Electrical Safe Work Standard

Personal Protective Equipment – Electrically Rated Gloves & Tools

- Dielectrically tested every 6 months!
- Inspected before each use
- Inspect after possible damage

- Inspect annually

Electrical Safe Work Standard

Personal Protective Equipment

- One of the difficulties with using the IEA label is to decipher what the appropriate PPE that is required.
- The following slides will aid in this understanding.
- One requirement is that the label provide at least one of the following:
    a. Available incident energy and the corresponding working distance. Incident energy is the amount of energy impressed on a surface, a certain distance away from the source that is generated during an electrical arc event.
    b. Minimum arc rating of clothing. Arc rated clothing indicates it has been tested for exposure to an electrical arc.
    c. Required level of PPE. Arc rating of PPE should correspond with the appropriate hazard level and incident energy present. Depending on when the IEA label was developed, the arc protection can be identified as the “Arc Rating” or the “Hazard Risk Class (HRC)”
    d. In addition, the PPE may be identified specifically on the label instead of referring to a Rating or Class.

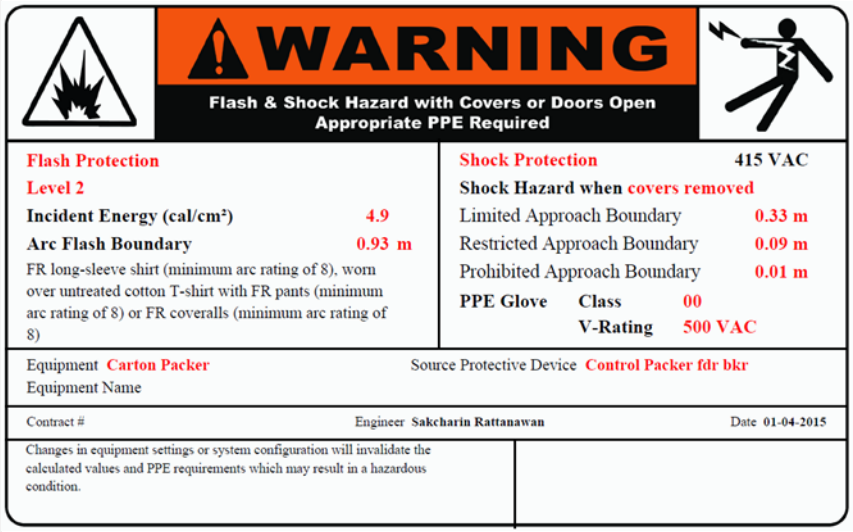
Electrical Safe Work Standard

Working on or Near Energized Electrical Systems

Available incident energy and the corresponding working distance. Incident energy is the amount of energy impressed on a surface, a certain distance away from the source that is generated during an electrical arc event.

- The incident energy exposure level shall be based on the working distance of the employee's face and chest areas from a prospective arc source for the specific task to be performed.
- Typical working distances used for incident energy calculations are as follows:
  - Low voltage (600 V and below) MCC and panelboards— 455 mm (18 in.)
  - Low voltage (600 V and below) switchgear — 610 mm (24 in.)
  - Medium voltage (above 600 V) switchgear — 910 mm (36 in.)

- Using the same information as was used to determine the arc-flash boundary the engineer can calculate the incident energy in cal/cm2 at a specific distance. Since FR clothing is rated in cal/cm2, this allows selection of appropriate clothing to protect against the incident energy.
- For the Bangkok label example at the right, we see the incident energy of 4.9 cal/cm2 but no distance is provided. Typically the working distance for 480 V is 455 mm. We need to protect the person from an incident energy of 4.9 cal/cm2 while they are working. That means that we need to provide PPE for at least 4.9 cal/cm2.
- PPE must provide at least as much protection as the flash hazard.

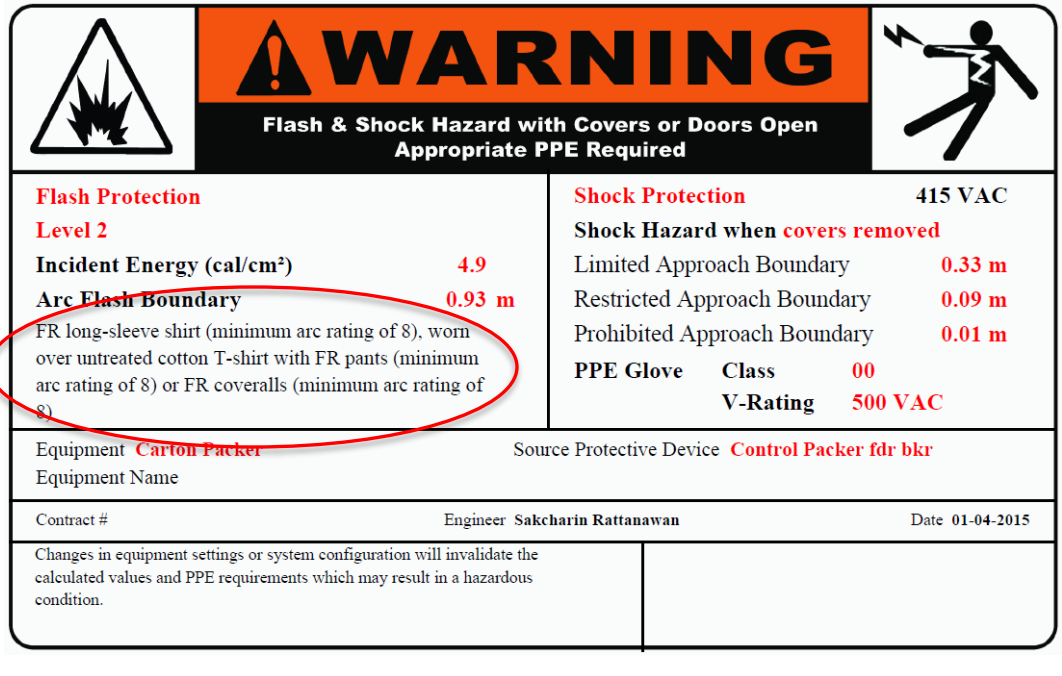


They don't make AR clothing for that particular rating (4.9 cal/cm2) so we will select the next highest protection which is AR rating of 8 cal/cm2.

The common AR clothing comes in the following ratings:
4 cal/cm2
8 cal/cm2
25 cal/cm2
40 cal/cm2

Electrical Safe Work Standard

Working on or Near Energized Electrical Systems



WARNING

Flash & Shock Hazard with Covers or Doors Open
Appropriate PPE Required

Flash Protection	**Shock Protection** 415 VAC
Level 2	**Shock Hazard when covers removed**
Incident Energy (cal/cm²) 4.9	Limited Approach Boundary 0.33 m
Arc Flash Boundary 0.93 m	Restricted Approach Boundary 0.09 m
FR long-sleeve shirt (minimum arc rating of 8), worn over untreated cotton T-shirt with FR pants (minimum arc rating of 8) or FR coveralls (minimum arc rating of 8)	Prohibited Approach Boundary 0.01 m
	PPE Glove **Class** 00
	V-Rating 500 VAC

Equipment Carton Packer
Equipment Name

Source Protective Device Control Packer fdr bkr

Contract #

Engineer **Sakcharin Rattanawan**

Date **01-04-2015**

Changes in equipment settings or system configuration will invalidate the calculated values and PPE requirements which may result in a hazardous condition.

Minimum arc rating of clothing. Arc rated clothing indicates it has been tested for exposure to an electrical arc. Arc rating used to be known as.

- In the example above we can see that it clearly states that a “minimum arc rating of 8” is required.

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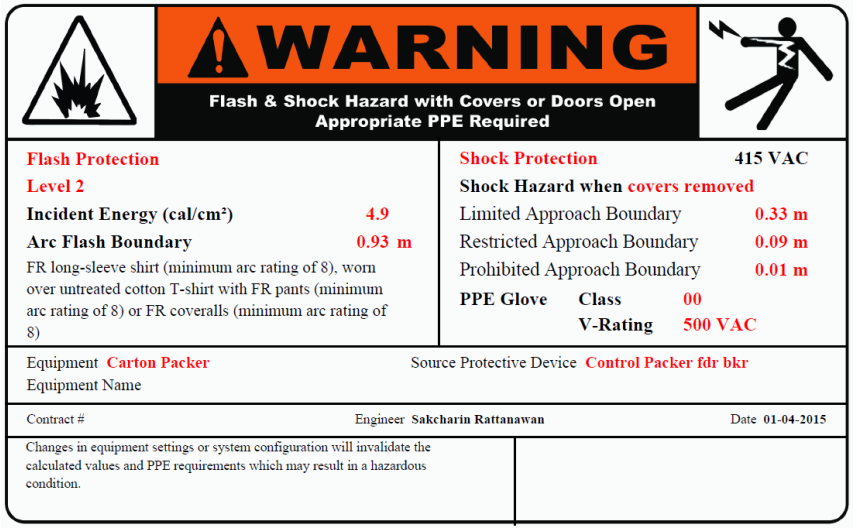
Electrical Safe Work Standard

Working on or Near Energized Electrical Systems

Highest Hazard/Risk Category (HRC) for the equipment. Hazard/risk categories range from 0-4 and help indicate arc rating, appropriate PPE and clothing.

- If the label has an HRC category listed, use the following chart to determine what PPE to wear.

Electrical HRC PPE Matrix



Hazard/Risk Category	Clothing and PPE Selection	Minimum Arc Rating
1	**Arc-Rated Clothing, Minimum Arc Rating of 4 cal/cm2** *(See Note 3.)* Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated face shield *(see Note 2)* or arc flash suit hood Arc-rated jacket, parka, rainwear, or hard hat liner (AN) **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Heavy duty leather gloves *(See Note 1.)* Leather work shoes (AN)	4 cal/cm²
2	**Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm2** *(See Note 3.)* Arc-rated long-sleeve shirt and pants or arc-rated coverall Arc-rated flash suit hood or arc-rated face shield *(See Note 2)* and arc rated balaclava Arc-rated jacket, parka, rainwear, or hard hat liner (AN) **Protective Equipment** Hard hat Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Heavy duty leather gloves *(See Note 1.)* Leather work shoes	8 cal/cm²
3	**Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc**	25 cal/cm²

- As you can see from the label example above, there is a Flash Protection section (left column) that states “Level 2”. This is the same as HRC 2.
- Going to the chart at left, you will see the clothing and PPE selection requirements, as well as the minimum arc rating of clothing to be worn.
- To use this method, you will need to have the chart available (laminate a copy for the Electricians to use).
- **Be extremely careful when interpreting the label. There is some PPE listed on the label, but it is not everything required.**

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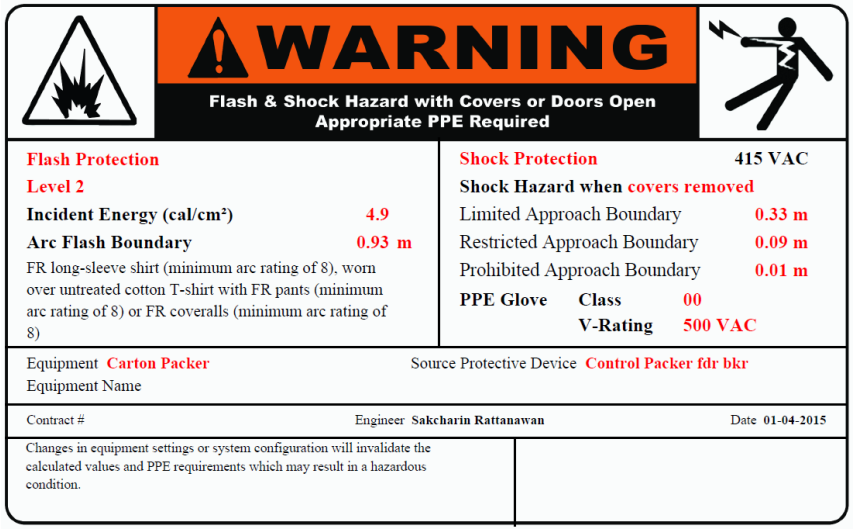
Electrical Safe Work Standard

Determining Correct PPE based on HRC Method

- We've talked most of this time about protection from arc flash but we also need to be concerned with electric shock. So, what shock protection PPE do we need?
- For the label we see that on the Shock Protection side of the label, there is a section for PPE Glove. You can use either the Class or the V-Rating (voltage rating). To the right you'll see a chart that shows how to determine
- So, for this label, you would need Class 00 gloves (and sleeves) or gloves (and sleeves) rated for at least 500V.
- Leather protectors must be worn over rubber insulating gloves to protect the rubber gloves from damage.



Glove Class and Ratings	
Class	Voltage (up to)
00	500
0	1,000
1	7,500
2	17,000
3	26,5000
4	Above 26,500

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Electrical Safe Work Standard

PPE Testing Requirements

- PPE Testing

Insulating Equipment – Testing Intervals		
Insulating Equipment	**When to Test**	**Governing Standard**
Blankets	Before first issue; annually thereafter	ASTM F479
Covers	If insulating value is suspect	ASTM F478
Gloves	Before first issue; every 6 months thereafter	ASTM F496
Sleeves	Before first issue; every 12 months thereafter	ASTM F496

- Tools Testing

Insulating Equipment – Testing Intervals		
Insulating Equipment	**When to Test**	**Governing Standard**
Live Line Tools	Tested annually or as required by local codes or regulations, whichever is more stringent.	IEEE 978

- All PPE and tool testing shall be documented

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Electrical Safe Work Standard

Guidance for GFCI for Portable Worksite Equipment and Extension

- Ground Fault Circuit Interrupter (GFCI) protection shall be used **any time** an employee operates cord- and plug-connected tools and other devices related to maintenance and construction activity (**both indoor and outdoor**).
- GFCI's shall be tested for proper operation prior to each use.
- Before each use of cord-connected power tools, extension cords, and other cord-connected equipment, a visual inspection must be made, and all defective equipment taken out of service.
- Verify the GFCI whip cord is located in the area covered by the daily non-welding hot work permit and has been tested.
- To prevent potential arcs at non-explosion proof connections outdoors and in classified areas, the connection at the explosion-proof receptacle must be:
  - connected last before tool/device usage begins, and
  - disconnected first after tool/device usage is completed
- Always unplug a cord at the source connection first before rolling up for storage.
- All outdoor, non-explosion proof receptacle connections that are not located at the worksite shall be **lockable or suitably secured** to prevent inadvertent disconnection during use.

Electrical Safe Work Standard

Maintenance, Troubleshooting and Diagnostic Testing

- When maintenance troubleshooting and diagnostic testing (such as the following) must be performed on energized equipment, the Qualified Electrical Person is required to take special precautions:
  - Take voltage readings;
  - Perform voltage phasing;
  - Perform preventive maintenance observations and meter checks;
  - Perform predictive maintenance observations and infrared thermography;
  - Reset device overloads.

- Note that an Electrical Standby Person is required if the energized state of the circuit or part cannot be assured. It is strongly recommended that “phasing” be completed utilizing the low-voltage side of instrument voltage transformers, if available. Appropriate use of PPE is required.

Electrical Safe Work Standard

MCC Circuit Breaker and Motor Starter Operations

- Installation or removal of combination circuit breaker and motor starter cubicles, commonly referred to as “buckets”, is not allowed while the Motor Control Center (MCC) bus is energized.

  Exception:

  – MCC that is arc-resistant, designed to insert and retract bus stabs remotely while the doors are closed, and has visual mechanical verification of the bus connection are allowed to have buckets inserted or removed while the bus is energized.

- Operation of circuit breakers and motor starters with the doors open is allowed only for diagnostic purposes on equipment operating at 480 VAC or less, and while wearing the proper PPE.

Electrical Safe Work Standard

Basics in Handling Electrical Emergency Responses

- Know local emergency response procedures
- Never touch an individual that is being shocked
- Both individuals can be “frozen” by electricity
- De-energize the source of electricity, when possible
- If not possible, then break the individual from the source by using an insulated non-conductive object (e.g., dry wood)
- Provide immediate medical attention as trained
- Employees who are part of the emergency response team should be trained in the:

– techniques for recognizing electrical hazards,

– methods for ensuring that power is turned off before attempting rescue,

– techniques for extracting persons from live circuits, and appropriate first aid response.

- The person should also be practiced and proficient in their response to ensure that victims are rescued in the shortest amount of time possible

Electrical Safe Work Standard

Stop Work Scenarios

Electrical work must be stopped/suspended, assess and mitigations executed and the worksite made safe in the following circumstances requiring revalidation of permit to work (not limited to):

- Unauthorized entry into the limited approach boundary
- Failure of testing equipment (e.g., voltage meters, etc.)
- Voltage tests are outside the acceptable safe working limits
- Utilization of improperly rated tools and/or PPE
- An incident and/or near miss occurs
- Exceed established permit conditions
- Unsafe conditions recognized
- Change of entire work crew
- Person Managing Control of Work becomes unavailable
- Change in job site conditions (e.g., leaks, spills, alarm, weather) or specified permit conditions are exceeded (time period, gas testing requirement, etc.)
- Emergency
- Safety concern raised

Electrical Safe Work Standard

Job Completion and Record Retention

Job Completion

- When the work has been completed, the Permit Requester/Holder must return the Permit to Work and all related documents to the Permit Issuer
- The Permit Issuer or the nominated Responsible Person will review the job site to ensure that:
  - i. The work area has been left in a safe, clean and tidy condition
  - ii. The work performed meets the specific work scope and task specifications
- If the above conditions have been met the Issuer or Responsible Person will sign and date the Work Permit as completed.

Record Retention

- Copies of all Permit to Work and associated documents retained one year or from audit to audit, whichever is the lesser
- If an accident occurred while work was in-progress, then documentation must be retained for incident investigation
- If permitted job involved potential health hazard, consider retaining permit documentation for an extended period (beyond 90 days).