

## **2.4.4 - PROCEDURES FOR SAFE WORKING AND TESTING OF ENERGIZED ELECTRICAL EQUIPMENT**

### **1 SCOPE**

The electrical safety procedure shall be part of the Peel District School Board (PDSB) Building and Maintenance Operating Procedures and shall be followed by all employees and contractors. This procedure applies during any work on, testing (see Appendix A. Electrical Testing Procedure), troubleshooting or verification that involves exposed energized electrical parts where a person, their tools or test probes could come into contact with power. Electrical equipment must be de-energized and locked out according to EHS Procedure 2.4.2 Lockout, Tagout and Test unless absolutely impossible. Where work on exposed energized equipment must be carried out as a last resort, this procedure applies. Examples of this work include, but not be limited to:

- Testing, including voltage, current, phasing meter checks, system tuning and other testing,
- Circuit identification, and
- All other tasks where electrical conductors are exposed.

All persons involved in work under this policy are responsible for ensuring that work performed on energized electrical equipment is performed in compliance with this procedure. Employees involved in such work must successfully complete training on this procedure. No PDSB staff member will work on any electrical equipment, systems or machines rated above 600 Volts. Contract workers may conduct work on equipment, systems and machines rated above 600 Volts if qualified as High Voltage Electricians. Contractors involved in such work must be licensed electricians and must provide proof of qualifications to PDSB. See Appendix B. Electrical Contractor Agreement for more information. It is the responsibility of Persons In Charge to ensure that only Authorized / Qualified persons as defined in this procedure complete work on exposed energized equipment.

### **2 LEGISLATION AND STANDARDS**

Legislation, standards, guidelines and procedures referenced for this procedure include:

- ASTM F496-14 – Standard Specification for In-Service Care of Insulating Gloves and Sleeves
- ASTM F478-14 - Standard Specification for In-Service Care of Insulating Line Hose and Covers
- ASTM F696-06 - Standard Specification for Leather Protectors for Rubber Insulating Gloves and Mittens
- ASTM F1506-10a - Standard Performance Specification for Flame Resistant and Arc Related Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards
- CAN/CSA C22.2 No. 61010-1-12 – Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use
- CAN/CSA Z195 – Guideline on the Selection, Care and Use of Protective Footwear
- CAN/CSA Z462–15 - Workplace Electrical Safety Standard
- E&USA - Electrical Utilities Safety Rules Handbook, revised 2009
- PDSB EHS Procedure 2.4.2 Lockout, Tagout and Test
- Ontario Electrical Code Part 1 C22.1 – 2009 – 24<sup>th</sup> edition
- Ontario Occupational Health and Safety Act and Regulations

### 3 DEFINITIONS

*Accessible* (as applied to equipment) – admitting close approach because the equipment is not guarded by locked doors, elevation or other effective mean

*Alive* (Live) (also Energized) – electrically connected to or having a source of voltage

*Approved* (as applied to electrical equipment) – equipment that:

- a) has been certified by an accredited organization in accordance with the requirements of CSA Standards (or other recognized documents, where such CSA Standards do not exist or are not applicable); or
- b) conforms to the requirements of the regulatory authority having jurisdiction

*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 arc flash energy, conducted for the purpose of injury prevention and the determination of safe work practices, arc flash boundary and the appropriate levels of personal protective equipment

*Arc Rating* – the value attributed to materials that describe their performance to exposure to an electrical arc discharge. The arc rating is expressed in cal/cm<sup>2</sup> and is derived from the determined value of the arc thermal performance value (ATPV) or energy of breakdown threshold (E<sub>BT</sub>) (if a material system exhibits a breakdown response below the ATPV). Arc-rated clothing or equipment indicates that it has been tested for exposure to an electric arc. Flame-resistant (FR) clothing without an arc rating has not been tested for exposure to an electric arc.

*Authorized / Qualified Person* – an employee of PDSB or a contractor to the PDSB who has the skills and knowledge related to the construction and operation of electrical equipment and installations and has received specific training on this procedure. The skills and knowledge related to electrical equipment and installations is achieved only once an employee or contractor becomes a licensed electrician. Refer to Section 7 Training.

*Boundary* (for arc flash) – when an arc flash hazard exists, an approach limit at a distance from a prospective arc source within which a person could receive a second degree burn if an electrical arc flash were to occur

*Boundary* (generally) – an approach limit at a distance from an exposed energized electrical conductor or circuit part within which:

- a) a shock hazard exists – defined as *Limited Approach Boundary*;
- b) there is an increased risk of shock, due to electrical arc over combined with inadvertent movement, for personnel working in close proximity to the energized electrical conductor or circuit part – defined as *Restricted Approach Boundary*

*Circuit Breaker* (CB) – a device designed to open and close a circuit by non-automatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its ratings

*Control Circuit* – the circuit that carries the electrical signals directing the performance of a control device, but does not carry the power which the device controls

*Controller* – a device or group of devices that govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected

CSA – Canadian Standards Association

*Dead* (also de-energized) – free from any electrical connection to a source of potential difference and from electrical charge i.e.: not having a potential different from that of the earth

*Disconnecting Means* – a device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their power supply

*Electrical Equipment* – any apparatus, appliance, device, instrument, fitting, fixture, machinery, material, or thing used in or for, or capable of being used in or for, the generation, transformation, transmission, distribution, supply or utilization of electrical power or energy

*Electrical Hazard* – a dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn or blast

*Electrical Safety* – recognizing hazards associated with the use of electrical energy and taking precautions so that hazards do not cause injury or death

*Electrically Safe Work Condition* – a state in which an electrical conductor or circuit part has been disconnected from energized parts, locked out in accordance with established procedures, testing to ensure the absence of voltage, and grounded (if grounding is determined to be necessary)

ESA – Electrical Safety Authority of Ontario

*Exposed* (as applied to energized electrical conductors or circuit parts) – capable of being inadvertently touched or approached nearer than a safe distance by a person, as applied to electrical conductors or circuit parts that are not suitably guarded, isolated or insulated

*Flame Resistant (FR)* – the property of a material whereby combustion is prevented, terminated or inhibited following the application of a flaming or non-flaming source of ignition, with or without subsequent removal of the ignition source

*Ground* – a connection to earth obtained by a grounding electrode

*Ground Fault* – an unintentional, electrically conducting connection between an ungrounded conductor of an electrical circuit and the normally non-current carrying conductors, metallic enclosures, metallic raceways, metallic equipment or earth

*Guarded* – covered, shielded, fenced, enclosed or otherwise protected by means of suitable cover or casings, barriers, rails, screens, mats or platforms to remove the potential for dangerous contact or approach by persons or objects

*Incident Energy* – the amount of energy impressed on a surface a certain distance from the source, generated during an electrical arc event

*Insulated* – separated from other conducting surfaces by a dielectric (including air spaces) offering a high resistance to the passage of current and to disruptive discharge sufficiently high for the conditions of use

*Lockout* – the placement of a lock on an energy-isolating device in accordance with an established procedure, thereby indicating that the energy-isolating device is not to be operated until removal of the lock. Refer to EHS Procedure 2.4.2

*Person In Charge* – a Manager or Supervisor of the PDSB who has authority over employees doing work under this procedure, or a person designated by one of the above as the person in charge of the work. A Person In Charge should also be an Authorized / Qualified person so as to enable them to recognize unsafe electrical work practices.

*Readily Accessible* – capable of being reached quickly for operation, renewal, or inspection without requiring persons seeking access to climb over or remove obstacles, resort to portable ladders, etc.

*Shock Hazard* – a dangerous condition associated with the possible release of energy caused by contact or approach to energized electrical conductors or circuit parts

*Switchgear, arc-resistant* – equipment designed to withstand the effects of an internal arcing fault and that directs the internally released energy away from the worker

*Switchgear, metal-clad* – a switchgear assembly completely enclosed on all sides and top with sheet metal having drawout switching and interrupting devices, and all energized electrical conductors and circuit parts enclosed within grounded metal compartments

*Switchgear, metal-enclosed* – a switchgear assembly completely enclosed on all sides and top with sheet metal having either stationary or drawout switching and interrupting devices, and where all energized electrical conductors and circuit parts are not necessarily enclosed within grounded metal compartments

*Switchgear, metal-enclosed power* – a switchgear assembly completely enclosed on all sides and top with sheet metal (except for ventilating openings and inspection windows) containing primary power circuit switching, interrupting devices, or both, with buses and connections. Access to the interior of the enclosure is provided by doors, removable covers or both.

*Testing / Troubleshooting* – tracing voltage with a CSA-approved tester with appropriately protected probes to diagnose an electrical fault condition where it is not practical to do so with the power off and locked out, and is only performed while wearing the required protective equipment as required by this procedure

*Voltage* (of a circuit) – the greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned

*Voltage, nominal* – a nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (e.g.: 120/240 V, 480Y/277 V, or 600 V)

*Voltage-to-ground* – the voltage between an energized ungrounded part and a grounded part (in the case of grounded circuits), or the greatest voltage existing in a circuit (in the case of ungrounded circuits)

*Working on* (energized electrical conductors or circuit parts) – coming into contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, or with tools, probes or test equipment, regardless of the personal protective equipment a person is wearing. There are two categories of working on:

- a) *Diagnostic* (testing) – taking readings or measurements of electrical equipment with approved test equipment that does not require making a physical change to the equipment; and
- b) *Repair* – physical alteration of electrical equipment. e.g.: making or tightening connections or removing or replacing components.

## **4 RESPONSIBILITIES**

### Maintenance Services Management

- Enforce the requirements of this procedure by allowing only Authorized / Qualified persons to undertake work covered by this procedure.
- Provide suitable PPE and devices, ensure regular testing of PPE as required and keep records of testing.
- Provide training to all employees required to do work under this procedure and keep records of training.

### Persons in Charge

- Meet the qualifications of an Authorized / Qualified person as defined in Section 3.
- Provide supervision to Authorized / Qualified persons conducting work under this procedure.
- Monitor compliance with this procedure and report any violations or incidents to management.

### Authorized / Qualified Persons

- Meet the qualifications of an Authorized / Qualified person as defined in Section 3.
- Follow EHS Procedure 2.4.2 Lockout, Tagout and Test instead of working on exposed energized electrical equipment, unless absolutely impossible.
- Follow all requirements of this procedure if absolutely necessary to work on exposed energized electrical equipment.
- Wear and use PPE as required and:
  - inspect voltage-rated rubber gloves prior to every use,
  - do not use defective PPE,
  - report deficiencies to Supervisor or Person In Charge, and
  - obtain PPE in good condition before proceeding with work.
- Use only CSA-approved, minimum Category III testers or meters with fused test leads and portable tools approved by an agency recognized by the ESA.
- Category IV testers or meters must be used for testing on the line side of the main building service disconnect.
- Report to a Supervisor any incidents such as shocks, arcs or flashes that did or could have caused injury or damage to meters, gloves or any other equipment

### Electrical Contractors

- Meet the qualifications of an Authorized / Qualified person as defined in Section 3
- Follow EHS Procedure 2.4.2 Lockout, Tagout and Test instead of working on exposed energized electrical equipment, unless absolutely impossible
- Follow all requirements of this procedure if absolutely necessary to work on exposed energized electrical equipment
- Wear and use PPE as required and:
  - inspect voltage-rated rubber gloves prior to every use,
  - do not use defective PPE,
  - report deficiencies to immediate Supervisor,
  - obtain PPE in good condition before proceeding with work and
  - Notify PDSB Contact Person if work is delayed.
- Use only CSA-approved, minimum Category III meters with fused test leads and portable tools approved by an agency recognized by the ESA

- Report to immediate Supervisor and PDSB Contact Person any incidents such as shocks, arcs or flashes that did or could have caused injury or damage to meters, gloves or any other equipment

## **5 SAFE ELECTRICAL WORK PROCEDURES**

### **General Procedures**

- Only fully Authorized / Qualified persons are permitted to work on electrical systems or components where there is a potential for exposure to energized electrical components. No PDSB staff member will work on any electrical equipment, systems or machines rated above 600 Volts. Contract workers may conduct work on equipment, systems and machines rated above 600 Volts if qualified as High Voltage Electricians.
- Workers who are not involved in work under this procedure are not allowed in the area. They must maintain a minimum distance of 10 feet from any exposed energized electrical equipment.
- Authorized / Qualified persons must place equipment into an electrically safe work condition through the use of lockout and tag (See EHS Procedure 2.4.2) before working on them unless de-energizing introduces additional or increased hazards, or is absolutely impossible.
- Prior to establishing an electrically safe work condition (lockout and tag) all qualified persons working within the presumed arc flash boundary of an exposed energized component must be suitably protected with personal protective equipment for that specific task (See Section 6. Personal Protective Equipment). Once an electrically safe work condition has been established and verified, electrical personal protective equipment can be removed.
- Workers must not endanger themselves or others by attempting to rescue an electrical shock victim as the victim's body may be energized. Call 911 and secure the area.
- Conductive clothing and jewelry (such as watchbands, bracelets, rings, key chains, necklaces, metal frame glasses, etc.) must not be worn within the restricted approach boundary or where they present an electrical contact hazard with exposed energized parts.
- Fiberglass fish tapes must be used when fishing conductors through existing installations where there may be exposure to energized parts.
- Only fiberglass ladders shall be used for work that falls under this procedure.
- Under no circumstances shall an electrical bus be used to support a ladder.
- Adequate lighting is necessary to perform all electrical tasks. Blind reaching into electrical enclosures is prohibited. Employees must ensure they have enough illumination to perform a job safely.
- Only devices designed for the purpose of pulling fuses shall be used to remove and install fuses. The fuse-pullers shall be of the appropriate size and style for the fuse.
- All portable electric tools must be approved by an agency recognized by the ESA and must be visually inspected prior to each use. Any damaged electric tool must be immediately removed from service. Electrically insulated tools must be used whenever working within the restricted approach boundary on energized equipment.
- PPE and other related safety equipment must be stored and used in accordance with manufacturer's recommendations. Regular tests and inspections are required to ensure that any equipment is still fit for purpose and use. Equipment can include voltage-rated gloves, arc-rated clothing, hearing protection, face shields, safety shoes with electrical shock resistance, double layer hoods and eye protection.
- All arc-rated clothing must be laundered and maintained according to manufacturer's instructions. Employees are not permitted to repair or make alterations to any arc-rated apparel. Examples of prohibited alterations include adding patches or name tags, writing on fabric or applying heat-transfer lettering or logos.
- Elevated work on energized electrical systems above 750 Volts must be performed in a lifting device approved for work on energized electrical systems.

## **Testing Equipment and Tools**

All electrical test equipment, special tools, and their accessories must be:

- Rated for the circuits and equipment to which they will be connected.
- Used in accordance with the manufacturer recommendations and used as intended.
- CSA-approved with a minimum 600 V AC rating and a minimum Category 3 Rating.
- Equipped with slip protection on test probes.
- Equipped with self-contained fault protection or limitation devices, such as internal current-limiting fuses or probe current-limiting resistors.
- Wired such that they voltage/current path from the probes is not routed through the selector switching device.
- Inspected prior to each use. Electrical test instruments and all associated test leads, cables, power cords, probes, and connectors must be visually inspected for external defects or damage by the employee before each use. If visible defects or evidence of damage that might expose an employee to injury are evident, the defective or damaged item must not be used until any required repairs and tests have been made.
- Maintained and stored according to the manufacturer's instructions. The employee is responsible to ensure that electrical test equipment and associated probes are stored in a manner that will protect them from moisture and dust, and will prevent damage and deterioration. Protective cases should be purchased with the equipment for storage purposes.
- Any tools or equipment that may be used in the course of testing, troubleshooting or verification must not be capable of conducting electrical current to the employee if they come into contact with an exposed live conductor.

## **Barriers and Guarding**

- The purpose of barriers and guarding are to provide insulation and physical separation. Wherever possible barriers and guards will be permanently installed to reduce and eliminate exposure to live electrical equipment.
- Insulating barriers can be made of voltage-rated rubber products, voltage-rated tape, or certain plastics or composites. The material used depends upon the task. Insulating barriers may be placed directly on energized conductors and parts to prevent inadvertent contact with body parts and tools. The barriers must be rated according to ASTM standards for, or above, the circuit voltage involved. An insulating barrier is normally not adequate to restrain significant physical force or to stop a puncture or cut.
- Where used, rubber matting, commonly referred to as switchboard matting, will comply with ASTM D178 Class 2 specifications by being a minimum of 1/4" thick (6.4 mm) and tested to 20,000 volts. Rubber matting must be inspected prior to each use for damage, cuts or contamination that may reduce effectiveness. Rubber matting found to be damaged or otherwise unsuitable for electrical use will be removed from service.
- Physical guarding shall never be placed directly on an energized part. They are installed to provide a physical restraint to prevent body parts or tools from getting near energized parts.
- Physical guards may only be constructed of approved materials and only at the direction of the Electrical Supervisor. No temporary guard of any material is to be used for any type of insulating or physical barrier without the specific permission of the Electrical Supervisor.

## **6 PERSONAL PROTECTIVE EQUIPMENT (PPE)**

PPE must be selected according to the expected hazards, voltage levels and conditions of work. Additional factors that will be considered include;

- condition and age of the equipment
- the equipment design
- the barriers that exist around the equipment

All PPE used must be inspected in accordance with the manufacturer's instructions and at a minimum at least once before each use. Where specific instructions exist for inspection of PPE in this or other procedures they will be complied with by workers and contractors. Damaged PPE will not be used. Defective PPE must be tagged defective until repaired or destroyed.

### **Hand and Arm Protection**

- Gloves used for flash protection must be long enough to cover body parts such as hands, wrists, and arms that are exposed to the flash hazard. Gloves shall be of sufficient length to cover these parts until they overlap other flash protection, such as the sleeve of a flash-protection garment. The glove must cover any openings in the sleeve, such as the slit for the cuff. Insulated Rubber Gloves with leather protectors provide additional arc flash protection for the hands.
- When flash protection is required for the arms beyond the distances that a glove will provide, a long-sleeve arc-rated shirt, jacket, or coverall is required. The sleeve for the arc-rated shirt must be tucked into the gloves. Short sleeves or rolled up sleeves are not permitted when working where there is a risk of arc flash. In addition, ensure that for tasks where arms are raised the wrist is protected from arc flash.

### **Voltage-Rated Gloves**

- Voltage-rated gloves (Class "0" Insulated Rubber Gloves) must be used for electrical shock prevention. Only Type-II gloves, which are ozone-resistant and made of an elastomer or combination of elastomeric compounds, and with a minimum class of "0", will be used. Class "0" gloves are rated to 1,000 volts and are not to be used on any circuit greater than 600 volts.
- Voltage-rated gloves must be visually inspected prior to each use for cuts, punctures, holes or damage that may affect their rating or effectiveness. Gloves must be removed from their protectors for inspection. Leather protectors must be inspected before each use and determined to be free of holes, tears, and contamination. Insides of the leather protector gloves shall also be inspected for sharp or pointed objects that may damage voltage-rated rubber gloves.
- Cleaning and maintenance of the voltage-rated gloves and leather protectors must be done as instructed by the manufacturer. Only approved powder is recommended for use on voltage-rated rubber products to prevent deterioration of the rubber.
- Voltage-rated rubber gloves must be tested to ensure they are still effective on a regular schedule. Every in-service voltage-rated rubber glove and leather protector combination must be tested every 6 months. The testing will be done by a qualified outside vendor in accordance with ASTM F496 and conducted every 6 months.
- Employees issued voltage-rated gloves will be provided with a second pair while the first pair of gloves is in for testing.
- Voltage-rated gloves must be stored in a dry cool place and not exposed to sunlight or chemicals such as solvents, oils or greases. Voltage-rated gloves must be allowed to take their natural shape and must not be folded, creased, inside out, compressed, or in any manner that will cause stretching or compression while stored. They must be kept inside of protectors or in a bag, box, or container that is designed for and



used exclusively for the gloves and must be inserted into their protective container with the fingers pointed upward (i.e. no pinching, bending, etc.).

#### Voltage-rated Glove Protectors

- Leather protectors for voltage rated-rubber gloves must be worn over voltage-rated rubber gloves for protection from abrasion, cuts or punctures.
- The leather protectors must not be used alone for shock protection at any time. Leather protectors are only used with the voltage-rated rubber gloves and are not to be used as general work glove. As much as possible leather protectors must be kept clean and free of oil, grease or solvent contamination.
- Protectors that have been used for other purposes must not be used to protect voltage-rated rubber gloves.

#### Safety Footwear

- Employees and contractors who conduct work under this procedure must wear safety footwear approved by CSA for impact protection with a minimum rating of Class 1 (green tag or green triangle), and displaying the Ohm symbol ( $\Omega$ ) on a tag indicating they have been tested for electrical shock resistance.

#### Eye Protection

- Safety glasses must be used by all workers to protect the eyes from impact injuries due to flying or falling objects. Safety glasses must be CSA approved. Safety glasses must be worn while performing testing, troubleshooting or verification where there is a possibility of arc flash. Safety glasses worn for work conducted under this procedure must be UV and IR rated and have electrically non-conducted frames.
- Face shields may be used to provide additional protection to the face. Face shields are not a replacement for safety glasses and safety glasses must be worn with the face shield. Face shields must not be cracked or broken.

#### Arc-Rated Clothing

- Arc-rated clothing must cover associated parts of the body as well as all flammable apparel while allowing movement and visibility. Loose-fitting clothing is preferred as it provides additional thermal insulation due to the creation of air spaces beneath the clothing. Work clothing or arc flash suits that are contaminated, or damaged to the extent their protective qualities are impaired, must not be used.
- Arc-rated clothing shall be inspected before each use. Arc-rated clothing and any other protective items that become damaged or contaminated with grease, oil or flammable liquids or combustible materials shall not be used.
- The garments manufacturer's instructions for care and maintenance of the arc-rated clothing must be followed. All arc-rated clothing must be stored in a manner that prevents physical damage; damage from moisture, dust or other deteriorating agents, or contamination from flammable or combustible materials.
- Clothing made from flammable synthetic materials that melt at temperatures below 315°C (600°F), such as acetate, acrylic, nylon, polyester, polyethylene, and spandex, either alone or in blends must not be worn.

## Selection of Personal Protective Equipment for Various Tasks

1. Refer to Appendix C to identify when arc flash PPE is required.
2. When arc flash PPE is required, refer to Appendix D1 (for alternating current equipment) and D2 (for direct current equipment) to determine the arc flash PPE category.
3. Once the arc flash PPE category has been identified from Appendix D1 or D2, refer to Appendix E to determine the required PPE for the task.

## Approach Boundaries to Energize Parts for Shock Protection for AC Systems

Nominal System Voltage Range, Phase to Phase	Limited Approach Boundary (exposed fixed circuit part)	Restricted Approach Boundary
Less than 50	Not specified	Not specified
50 - 150	3 ft. 6 in.	Avoid contact
151 - 600	3 ft. 6 in.	1 ft. 0 in.

## 7 TRAINING

- Training will be provided to every licensed PDSB electrician and controls technician who will be testing, troubleshooting or verifying on exposed energized electrical equipment. In addition all Electrical and Mechanical Supervisors and Assistant Supervisors must receive training. Other staff may be trained on an as-required basis.
- PDSB staff who have successfully completed the training program will be considered qualified to conduct work under this procedure. Only qualified staff who have been trained in their use may use electrical test equipment and special tools.
- Contractors who conduct work under this program for the PDSB must provide proof of licensing as an electrician and proof of training on procedures for safe testing, troubleshooting or verifying on exposed energized electrical equipment. This can be obtained by completion of Appendix B. Electrical Contractor Agreement.

The content of the training will include:

- Applicable legislation and codes
- Hazards likely to be encountered working on energized electrical equipment
- Safe Work Practices
- Use of gloves and other PPE
- Inspection, maintenance and storage of gloves and other PPE
- Common errors and misconceptions
- Correct application and use of meters and tools
- Use of meters and tools for electrical testing
- Inspection of meters and tools
- Proper inspection, maintenance and storage of meters and tools

Successful completion of training requires:

- Full attendance of the course with no interruptions or temporary absences
- Completion and passing of a comprehension test at the end of the course
- That the Instructor is satisfied the participant has learned and understood the procedures

## **APPENDICES**

### **Appendix A. Electrical Test Procedure**

Wherever possible, electrical troubleshooting must be done with the power supply turned off, locked and tagged out as specified in EHS 2.4.2 Lockout, Tagging and Test Procedure. Where absolutely impossible, as a last resort, electrical troubleshooting including testing with a multimeter, may be conducted on energized circuits providing the following is strictly adhered to:

- The multimeter must be a minimum Category 3 (or higher where required);
- The multimeter must be equipped with appropriately rated, fused test leads; and
- The appropriate PPE is worn by the person doing the testing.

#### **Steps to Conduct Electrical Testing**

1. Identify voltage ratings involved and any unusual characteristics of the testing to be done. (Note: Higher than 600 V must be tested by an authorized contractor with High Voltage training.) Ensure multimeter and fused leads are rated as high or higher than the equipment you are working on.
2. Inspect all components of the multimeter and fused leads for any signs of damage. If damaged, DO NOT USE. Inform your Supervisor and obtain another multimeter before testing.
3. Ensure multimeter is set to the proper setting and to the highest voltage possible. If multiple lead ports are infrequently used, cover or block these ports to avoid operator error.
4. Determine the appropriate PPE level for the testing. Inspect your PPE prior to putting it on. In particular:
  - 4.1. Voltage-rated gloves must be visually inspected prior to each use for cuts, punctures, holes or damage that may affect their rating or effectiveness. Gloves must be removed from their protectors for inspection. Leather protectors must be inspected before each use and determined to be free of holes, tears, and contamination. Insides of the leather protector gloves shall also be inspected for sharp or pointed objects that may damage voltage-rated rubber gloves.
5. Conduct the 3-point test:
  - 5.1. Test a circuit known to be live
  - 5.2. Measure the target circuit
  - 5.3. Re-test the live circuit, to ensure all of the multimeter components are functioning, including fuses
6. NEVER switch multimeter functions while the meter is energized. Remove the test probes from any source of energy when changing settings. When switching from different meter functions or test points, ensure that the settings on the meter match the application.

**Appendix B. Electrical Contractor Agreement**

**All PDSB Electrical Contractors must complete this form and submit all requested documentation.**

**Requirements for Contractors Working on Electrical Systems or Equipment:**

- Contractor employees must abide by all requirements of the PDSB Health and Safety Program, including specifically EHS Procedures *Lockout, Tagging and Test Procedure* and *Procedures for Safe Working and Testing of Energized Electrical Equipment*.
- Contractor employees who conduct work on energized electrical equipment must have a current electrical license. If working on equipment or systems above 600 V they must also have high voltage electrical training.
- Contractor employees must also be trained to a level comparable to PDSB's training outlined in the above-mentioned procedures.

**Contractor Information**

Company Name		Phone Number	
Company Address		Fax Number	

**Contractor Employee Information**

NAME (Print)	Electrician's License #		NAME (Print)	Electrician's License #

**Company Representative: I certify that employees working on behalf of \_\_\_\_\_ will meet or exceed the requirements outlined in EHS Procedures *Lockout, Tagging and Test Procedure* and *Procedures for Safe Working and Testing of Energized Electrical Equipment*. Should the list of Employee Information change (i.e. new employees, new information, etc.) I will provide an updated list to the PDSB Representative by mail, facsimile, or electronic mail prior to the employee working at the PDSB.**

**Name \_\_\_\_\_ Title \_\_\_\_\_**

**Signature \_\_\_\_\_ Date \_\_\_\_\_**

PDSB Representative: I certify that I have supplied the contractor listed above with EHS Procedures *Lockout, Tagging and Test Procedure* and *Procedures for Safe Working and Testing of Energized Electrical Equipment*. I will keep the documentation on file and produce it as requested. A new Electrical Contractor Agreement is required to be signed every three years.

**Name \_\_\_\_\_ Title \_\_\_\_\_**

**Signature \_\_\_\_\_ Date \_\_\_\_\_**

**Additional Contractor Employee Information**

<b>NAME (Print)</b>	<b>Electrician's License #</b>		<b>NAME (Print)</b>	<b>Electrician's License #</b>

## Appendix C. Arc Flash Hazard Identification for Alternating Current (AC) and Direct Current (DC) Systems

Task	Equipment condition (2)	Arc flash PPE required (1)
Reading a panel meter while operating a meter switch	Any	No
Normal operation of a circuit breaker (CB), switch, contactor or starter	All of the following: <ul style="list-style-type: none"> <li>the equipment is properly installed;</li> <li>the equipment is properly maintained;</li> <li>all equipment doors are closed and secured;</li> <li>all equipment covers are in place and secured; and</li> <li>there is no evidence of impending failure.</li> </ul>	No
	One or more of the following: <ul style="list-style-type: none"> <li>the equipment is not properly installed;</li> <li>the equipment is not properly maintained;</li> <li>equipment doors are open or not secured;</li> <li>equipment covers are off or not secured; or</li> <li>there is evidence of impending failure.</li> </ul>	Yes
For ac systems: Work on energized electrical conductors and circuit parts, including voltage testing	Any	Yes
For dc systems: Work on energized electrical conductors and circuit parts of series-connected cells, including voltage testing	Any	Yes
Voltage testing on individual battery cells or individual multi-cell units	All of the following: <ul style="list-style-type: none"> <li>the equipment is properly installed;</li> <li>the equipment is properly maintained;</li> <li>covers for all other equipment are in place and secured; and</li> <li>there is no evidence of impending failure.</li> </ul>	No
	One or more of the following: <ul style="list-style-type: none"> <li>the equipment is not properly installed;</li> <li>the equipment is not properly maintained;</li> <li>equipment doors are open or not secured;</li> <li>equipment covers are off or not secured; or</li> <li>there is evidence of impending failure.</li> </ul>	Yes
Removal or installation of CBs or switches	Any	Yes

(Continued)

Task	Equipment condition (2)	Arc flash PPE required (1)
Removal or installation of covers for equipment such as wireways, junction boxes, and cable trays that does not expose bare, energized electrical conductors, and circuit parts	All of the following: <ul style="list-style-type: none"> <li>• the equipment is properly installed;</li> <li>• the equipment is properly maintained; and</li> <li>• there is no evidence of impending failure.</li> </ul>	No
	One or more of the following: <ul style="list-style-type: none"> <li>• the equipment is not properly installed;</li> <li>• the equipment is not properly maintained; or</li> <li>• there is evidence of impending failure.</li> </ul>	Yes
Removal of bolted covers (to expose bare, energized electrical conductors, and circuit parts) For dc systems, this includes bolted covers, such as battery terminal covers	Any	Yes
Removal of battery intercell connector covers	All of the following: <ul style="list-style-type: none"> <li>• the equipment is properly installed;</li> <li>• the equipment is properly maintained;</li> <li>• covers for all other equipment are in place and secured; and</li> <li>• there is no evidence of impending failure.</li> </ul>	No
	One or more of the following: <ul style="list-style-type: none"> <li>• the equipment is not properly installed;</li> <li>• the equipment is not properly maintained;</li> <li>• covers for any other equipment are off or not secured; or</li> <li>• there is evidence of impending failure.</li> </ul>	Yes
Opening hinged door(s) or cover(s) (to expose bare energized electrical conductors and circuit parts)	Any	Yes
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary. This activity does not include opening of doors or covers	Any	No
Application of temporary protective grounding equipment, after voltage test	Any	Yes
Work on control circuits with exposed energized electrical conductors and circuit parts, 120 V or below without any other exposed energized equipment over 120 V including opening of hinged covers to gain access	Any	No

(Continued)

<b>Task</b>	<b>Equipment condition (2)</b>	<b>Arc flash PPE required (1)</b>
Work on control circuits with exposed energized electrical conductors and circuit parts, greater than 120 V	Any	Yes
Insertion or removal of individual starter buckets from motor control centre (MCC)	Any	Yes
Insertion or removal (racking) of CBs or starters from cubicles, doors open or closed	Any	Yes
Insertion or removal of plug-in devices into or from busways	Any	Yes
Insulated cable examination with no manipulation of cable	Any	No
Insulated cable examination with manipulation of cable	Any	Yes
Work on exposed energized electrical conductors and circuit parts of equipment directly supplied by a panelboard or motor control centre	Any	Yes
Insertion or removal of revenue meters (kW-hour, at primary voltage and current)	Any	Yes
For dc systems, insertion or removal of individual cells or multi-cell units of a battery system in an enclosure	Any	Yes
For dc systems, insertion or removal of individual cells or multi-cell units of a battery system in an open rack	Any	No
For dc systems, maintenance on a single cell of a battery system or multi-cell units in an open rack	Any	No
For dc systems: Work on exposed energized electrical conductors and circuit parts of utilization equipment directly supplied by a dc source	Any	Yes

(Continued)



Task	Equipment condition (2)	Arc flash PPE required (1)
Arc-resistant switchgear Type 1 or 2 (for clearing times of < 0.5 s with a prospective 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 C22.2 No. 022 or IEEE C37.20.7: <ul style="list-style-type: none"> <li>• Insertion or removal (racking) of CBs from cubicles;</li> <li>• Insertion or removal (racking) of ground and test device; or</li> <li>• Insertion or removal (racking) of voltage transformers on or off the bus</li> </ul>	All of the following: <ul style="list-style-type: none"> <li>• the equipment is properly installed;</li> <li>• the equipment is properly maintained;</li> <li>• all equipment doors are closed and secured;</li> <li>• all equipment covers are in place and secured; and</li> <li>• there is no evidence of impending failure.</li> </ul>	No
	Any of the following: <ul style="list-style-type: none"> <li>• the equipment is not properly installed;</li> <li>• the equipment is not properly maintained;</li> <li>• equipment doors are open or not secured;</li> <li>• equipment covers are off or not secured; or</li> <li>• there is evidence of impending failure.</li> </ul>	Yes
Opening voltage transformer or control power transformer compartments	Any	Yes
Outdoor disconnect switch operation (hookstick operated) at 1 kV through 15 kV	Any	Yes
Outdoor disconnect switch operation (gang-operated, from grade) at 1 kV through 15 kV	Any	Yes

**Notes:**

- (1) Hazard identification is one component of risk assessment. Risk assessment involves a determination of the likelihood of occurrence of an incident, resulting from a hazard, which could cause injury or damage to health. The assessment of the likelihood of occurrence contained in this Table does not cover every possible condition or situation. Where this Table indicates that arc flash PPE is not required, an arc flash is not likely to occur.
- (2) The phrase “properly installed” as used in this Table means that the equipment is installed in accordance with applicable industry codes and standards and the manufacturer’s recommendations. The phrase “properly maintained” as used in this table means that the equipment has been maintained in accordance with the manufacturer’s recommendations and applicable industry codes and standards. The phrase “evidence of impending failure” as used in this table means that there is evidence such as arcing, overheating, loose or bound equipment parts, visible damage, or deterioration.

**Appendix D1. Arc Flash PPE Categories for Alternating Current (AC) Systems**

Equipment	Arc flash PPE category	Arc flash boundary
Panelboards or other equipment rated 240 V and below Parameters:  Maximum of 25 kA short-circuit current available; maximum of 0.03 s (2 cycles) fault clearing time; working distance 455 mm (18 in)	1	485 mm (19 in)
Panelboards or other equipment rated > 240 V and up to 600 V Parameters:  Maximum of 25 kA short-circuit current available; maximum of 0.03 s (2 cycles) fault clearing time; working distance 455 mm (18 in)	2	900 mm (3 ft)
600 V class motor control centers (MCCs) Parameters:  Maximum of 65 kA short-circuit current available; maximum of 0.03 s (2 cycles) fault clearing time; working distance 455 mm (18 in)	2	1.5 m (5 ft)
600 V class motor control centers (MCCs) Parameters:  Maximum of 42 kA short-circuit current available; maximum of 0.33 s (20 cycles) fault clearing time; working distance 455 mm (18 in)	4	4.3 m (14 ft)
600 V class switchgear (with power circuit breakers or fused switches) and 600 V class switchboards Parameters:  Maximum of 35 kA short-circuit current available; maximum of up to 0.5 s (30 cycles) fault clearing time; working distance 455 mm (18 in)	4	6 m (20 ft)
Other 600 V class (277 V through 600 V, nominal) equipment Parameters:  Maximum of 65 kA short circuit current available; maximum of 0.03 s (2 cycles) fault clearing time; working distance 455 mm (18 in)	2	1.5 m (5 ft)
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV Parameters:  Maximum of 35 kA short-circuit current available; maximum of up to 0.24 s (15 cycles) fault clearing time; working distance 910 mm (36 in)	4	12 m (40 ft)
Metal-clad switchgear, 1 kV through 15 kV Parameters:  Maximum of 35 kA short-circuit current available; maximum of up to 0.24 s (15 cycles) fault clearing time; working distance 910 mm (36 in)	4	12 m (40 ft)

(Continued)

Equipment	Arc flash PPE category	Arc flash boundary
<p>Arc-resistant switchgear Type 1 or 2 (for clearing times of &lt; 0.5 s (30 cycles) with a prospective 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, 1 kV through 15 kV:</p> <p>Parameters:</p> <p style="padding-left: 40px;">Maximum of 35 kA short-circuit current available; maximum of up to 0.24 s (15 cycles) fault clearing time; working distance 910 mm (36 in)</p>	N/A (doors closed)	N/A (doors closed)
	4 (doors open)	12 m (40 ft)
<p>Other equipment 1 kV through 15 kV</p> <p>Parameters:</p> <p style="padding-left: 40px;">Maximum of 35 kA short-circuit current available; maximum of up to 0.24 s (15 cycles) fault clearing time; working distance 910 mm (36 in)</p>	4	12 m (40 ft)

**Notes:**

- (1) See [Appendix E](#) for a list of protective clothing and PPE for each arc flash PPE category.
- (2) For equipment rated 600 V and below and protected by upstream current limiting fuses or current limiting circuit breakers sized at 200 A or less, the arc flash PPE category may be reduced by one number, but not below arc flash PPE category 1.

## Appendix D2. Arc Flash PPE Categories for Direct Current (DC) Systems

Equipment	Arc flash PPE category	Arc flash boundary
<b>Storage batteries, direct current switchboards, and other dc supply sources</b> <b>100 V &lt; Voltage &lt; 250 V</b> Parameters: Voltage: 250 V Maximum arc duration and working distance: 2 s at 455 mm (18 in)		
Short-circuit current < 4 kA	1	900 mm (3 ft)
4 kA ≤ short-circuit current < 7 kA	2	1.2 m (4 ft)
7 kA ≤ short-circuit current < 15 kA	3	1.8 m (6 ft)
<b>Storage batteries, direct current switchboards and other dc supply sources</b> <b>250 V ≤ Voltage ≤ 600 V</b> Parameters: Voltage: 600 V Maximum arc duration and working distance: 2 s at 455 mm (18 in)		
Short-circuit current < 1.5 kA	1	900 mm (3 ft)
1.5 kA ≤ short-circuit current < 3 kA	2	1.2 m (4 ft)
3 kA ≤ short-circuit current < 7 kA	3	1.8 m (6 ft)
7 kA ≤ short-circuit current < 10 kA	4	2.5 m (8 ft)

**Notes:**

- (1) See [Appendix E](#) for a list of protective clothing and PPE for each arc flash PPE category.
- (2) Apparel that can be expected to be exposed to electrolyte shall meet both of the following conditions: (a) be evaluated for electrolyte protection in accordance with ASTM F1296; and (b) be arc-rated in accordance with ASTM F1891, or equivalent.
- (3) “Short-circuit current,” as used in this Table, is determined from the dc power system maximum available short-circuit, including the effects of cables and any other impedances in the circuit. Power system modelling is the best method to determine the available short-circuit current at the point of the arc. Battery cell short-circuit current can be obtained from the battery manufacturer. See [Clause D.5](#) in CSA Z462-15 for the basis for table values and alternative methods to determine dc incident energy. Methods should be used with good engineering judgment.
- (4) The methods for estimating the dc arc flash incident energy that were used to determine the categories for this Table are based on open-air incident energy calculations. Open-air calculations were used because many battery systems and other dc process systems are in open areas or rooms. If the specific task is within in an enclosure, it would be prudent to consider additional PPE protection beyond the value shown in this table. Research with ac arc flash has shown a multiplier of as much as 3x for arc-in-a-box (508 mm [20 in.] cube) versus open air. Engineering judgment is required when reviewing the specific conditions of the equipment and task to be performed, including the dimensions of the enclosure and the working distance involved.

## Appendix E. Personal Protective Equipment (PPE)

Arc flash PPE	
category	PPE
1	<p>Arc-rated clothing, minimum arc rating of 4 cal/cm<sup>2</sup> (Note 3):</p> <p>Arc-rated long-sleeve shirt and pants or arc-rated coverall                      Arc-rated faceshield or arc flash suit hood (Note 2)                      Arc-rated jacket, parka, rainwear, or hard hat liner (AN)</p> <p>Protective equipment:</p> <p>Hard hat                      Safety glasses or safety goggles (SR)                      Hearing protection (ear canal inserts)                      Heavy duty leather gloves (Note 1)                      Leather footwear (AN)</p>
2	<p>Arc-rated clothing, minimum arc rating of 8 cal/cm<sup>2</sup> (Note 3):</p> <p>Arc-rated long-sleeve shirt and pants or arc-rated coverall                      Arc-rated arc flash suit hood; or arc-rated faceshield (Note 2) and arc-rated balaclava                      Arc-rated jacket, parka, rainwear, or hard hat liner (AN)</p> <p>Protective equipment:</p> <p>Hard hat                      Safety glasses or safety goggles (SR)                      Hearing protection (ear canal inserts)                      Heavy duty leather gloves (Note 1)                      Leather footwear</p>
3	<p>Arc-rated clothing, selected so that the system arc rating meets the required minimum arc rating of 25 cal/cm<sup>2</sup> (Note 3):</p> <p>Arc-rated long-sleeve shirt (AR)                      Arc-rated pants (AR)                      Arc-rated coverall (AR)                      Arc-rated arc flash suit jacket (AR)                      Arc-rated arc flash suit pants (AR)                      Arc-rated arc flash suit hood                      Arc-rated gloves (Note 1)                      Arc-rated jacket, parka, rainwear, or hard hat liner (AN)</p> <p>Protective equipment:</p> <p>Hard hat                      Safety glasses or safety goggles (SR)                      Hearing protection (ear canal inserts)                      Leather footwear</p>

(Continued)

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**Arc flash PPE**

category	PPE
4	<p>Arc-rated clothing, selected so that the system arc rating meets the required minimum arc rating of 40 cal/cm<sup>2</sup> (Note 3):</p> <ul style="list-style-type: none"> <li>Arc-rated long-sleeve shirt (AR)</li> <li>Arc-rated pants (AR)</li> <li>Arc-rated coverall (AR)</li> <li>Arc-rated arc flash suit jacket (AR)</li> <li>Arc-rated arc flash suit pants (AR)</li> <li>Arc-rated arc flash suit hood</li> <li>Arc-rated gloves (Note 1)</li> <li>Arc-rated jacket, parka, rainwear, or hard hat liner (AN)</li> </ul> <p>Protective equipment:</p> <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 footwear</li> </ul>

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Legend: AN = as needed (optional); AR = as required; SR = selection required

**Notes:**

- (1) Arc rating is defined in [Definitions](#).
- (2) Faceshields shall meet the following requirements:
  - Face protection:
    - (i) Faceshields shall have an arc rating suitable for the arc flash exposure.
    - (ii) Faceshields shall have a wrap-around guarding to protect the face, chin, forehead, ears, and neck area.
    - (iii) Faceshields without an arc rating shall not be used.
    - (iv) Eye protection (safety glasses or goggles) shall be worn under faceshields or hoods.
  - Note:** Faceshields made with energy-absorbing formulations that can provide higher levels of protection from the radiant energy of an arc flash are available, but these shields are tinted and can reduce visual acuity and colour perception. Additional illumination of the task area can be necessary when these types of arc-protective faceshields are used.
- (3) An arc flash suit hood may be worn in lieu of a face shield.
- (3) If rubber insulating gloves with leather protectors are used, additional leather or arc-rated gloves shall not be required. The combination of rubber insulating gloves with leather protectors satisfies the arc flash protection requirement.