26 ELECTRICAL HAZARDS

An **electrical hazard** can be defined as
- a dangerous condition where a worker could make electrical contact with energized equipment or a conductor, and from which the person may sustain an injury from shock; and/or,
- there is potential for the worker to receive an arc flash burn, thermal burn, or blast injury.

**Note:** An electrical hazard is considered to be removed when protective measures are put in place at the source (remove hazard or de-energize), or along the path (place electrical insulation/barrier between the worker and the electrical hazard). Where PPE is relied upon for worker protection, an electrical hazard is considered to remain and it is still necessary to address safety requirements for other workers in the area.

Injuries resulting from a worker making electrical contact represent a relatively small portion (7.7%) of the lost-time injuries electricians experience, according to 1997–1999 statistics. It is reasonable to assume that the situation is similar today. Other mechanical trades that do some electrical work can probably expect even fewer electrical injuries.

Nevertheless, working on or near electrical hazards is dangerous and can be fatal. Any work on or near energized equipment must be done only when measures are in place to provide protection from electric shock and burn. With adequate safety measures in place, every electrical injury and fatality can be prevented.

The law requires safe work practices. Under the **Occupational Health and Safety Act and Regulations for Construction Projects** (the green book), employers, supervisors, and workers each have legal responsibilities to ensure that work is being carried out in a safe manner.

There are also restrictions in the Construction Projects regulation (O. Reg. 213/91, s. 182) on who can work on electrical equipment:

1. **No worker shall connect, maintain or modify electrical equipment or installations unless,**
   - the worker holds a certificate of qualification issued under the Ontario College of Trades and Apprenticeship Act, 2009, that is not suspended, in the trade of,
   - (i) electrician — construction and maintenance, or
   - (ii) electrician — domestic and rural, if the worker is performing work that is limited to the scope of practice for that trade; or
   - the worker is otherwise permitted to connect, maintain or modify electrical equipment or installations under the Ontario College of Trades and Apprenticeship Act, 2009 or the Technical Standards and Safety Act, 2000. O. Reg. 627/05, s. 4; O. Reg. 88/13, s. 2.

2. **A worker who does not meet the requirements of clause (1) (a) or (b) may insert an attachment plug cap on the cord of electrical equipment or an electrical tool into, or remove it from, a convenience receptacle.**

Guidelines for working on or near electrical equipment and conductors are found in several documents:

- Construction Regulation (O. Reg. 213/91)
- Ontario Electrical Safety Code
- Operating manuals for different tools and equipment.

An important aspect of electrical work involves isolating electrical energy. A reference for detailed information on lockout and control of hazardous energy is the CAN/CSA-Z460: Control of Hazardous Energy—Lockout and Other Methods.

**Electrical Injuries**

There are basically two ways to be injured by electricity. One is by electric shock and the other is by arc flash.

**Electric shock** is the passing of electric current through the body. Electrical contact can cause involuntary physical movements. The electrical current may do the following.

- Prevent you from releasing your grip from a live conductor
- Throw you into contact with a higher voltage conductor
- Cause you to lose your balance and fall
- Cause severe internal and external burns
- Kill you.

A household 125-volt circuit can deliver 15 amps. Current as low as 30/1000 of 1 amp (30 mA) can cause breathing to stop. A 15-amp circuit contains many times the current needed to cause death.
A major cause of accidents involving electricity comes from the failure to identify the hazards associated with live electrical equipment and wiring (Figure 26-1).

An **arc flash** is a release of energy caused by an electric arc (Figure 26-2). The flash causes an explosive expansion of air and metal. The blast produces:

- A dangerous pressure wave
- A dangerous sound wave
- Shrapnel
- Extreme heat
- Extreme light.

These dangers can result in blast injuries, lung injuries, ruptured eardrums, shrapnel wounds, severe burns, and blindness. Arc flash injuries can also result in death (Figure 26-3).

### Safeguards

#### Protective Tools and Equipment

Workers exposed to an electrical hazard must use mats, gloves, shields, flame resistant clothing, and any other protective equipment required to protect themselves from electric shock and burn. As part of everyday work, electrical workers should always do the following:

- Remove watches, rings, neck chains, or other current-conducting apparel.
- Wear electric-shock-resistant footwear.
- Wear a CSA-approved Class E hard hat or equivalent.
- Wear safety glasses with side shields.
- Wear under and outer clothing that has flame-resistance properties.

Tools, devices, and equipment—including personal protective equipment—used for live work must be designed, tested, maintained, and used so as to provide adequate protection for workers.

Where there is the potential for an arc flash, **all** PPE should be chosen with consideration for the kinds of hazards that can result from an arc flash. (See "Flash hazard arc flash protection" below.)

The following information provides guidelines on appropriate and required personal protective equipment. Check the reference documents identified at the beginning of this chapter to determine your job-specific needs. See also the chapters on personal protective equipment in this manual.

#### Clothing

Whether or not the day’s planned work involves working near an electrical hazard, workers that do electrical work should choose everyday clothing that offers some flame-resistance properties. When work must be done in the presence of an electrical hazard, ensure that all clothing is chosen to provide adequate protection from the potential hazards. (See "Flash Hazard (Arc Flash) Protection" section in this chapter.)

#### Head Protection

The following types of hard hats comply with the Construction Projects regulation (213/91):

- **Class E, Type 1 or 2** (CAN/CSA-Z94.1)
- **Type II, Class E** (ANSI Z89.1)
- **Type I, Class E** (ANSI Z89.1).

Type 1 hard hats provide protection to the top of the head, while Type 2 hard hats provide protection to the top and sides of the head. Because it protects against side impact, CSA Type 2 hard hats are recommended for construction work. Class E hard hats are able to withstand an electrical contact equal to 20,000 volts (phase-to-ground).
Foot Protection

Construction workers require Grade 1 toe protection with sole puncture protection in accordance with CAN/CSA Z195-14: Protective Footwear. A green triangular patch on the tongue or the ankle of protective footwear indicates that it meets the requirements of the Construction Projects regulation (213/91).

Construction workers who are exposed to electrical hazards (e.g., mechanical tradespeople) should also wear protective footwear that resists electric shock. This is indicated by a white rectangular label bearing the CSA logo and the Greek letter omega in orange.

Eye Protection

CAN/CSA Z94.3-15: Eye and Face Protectors can assist you in classifying hazards and recommending eye protectors. Appropriate protection chosen according to this standard meets with the intent of the Construction Projects regulation (213/91) regarding eye protection worn on the job.

In any case, eye protection should be of industrial quality eye protection in the form of safety glasses incorporating side-shields or a wrap-around style. Arc flash protection requires a face shield that is rated for arc flash, with safety glasses underneath.

Regular plastic face shields do not provide arc flash protection. They can burn and melt in an arc flash incident. Use a face shield that is designed and rated for arc flash protection.

Hearing Protection

Hearing protection is important at work since continuous exposure to excessive noise can lead to hearing loss and tinnitus. Hearing protection is required for some arc flash hazards. Hearing protection is available in three general types:

1. Disposable ear plugs made of pliable material. One size fits all, but they should only be used once.
2. Reusable custom-fit ear plugs are available to provide protection for specific frequencies of noise. These provide a good seal and can be washed and reused.
3. Earmuffs. They need to be fitted to provide maximum protection.

Shock Protection

The passage of electricity through the body is called shock. Effects can range from a tingling sensation to death. A shock that may not be enough to cause injury can nonetheless startle a worker, causing an involuntary reaction that can result in serious injuries or death.

A household 125-volt circuit can deliver 15 amps. Current as low as 30/1000 of 1 amp (30 mA) can cause breathing to stop. A 15-amp circuit has many times the current needed to cause death.

Rubber gloves and leather protectors are the most common personal protective equipment used for shock protection. These must be adequate to protect the worker from electrical shock or burn. The rubber gloves must have been tested and certified.

Class 0 and Class 00 gloves must be air-tested and visually inspected for damage and adequacy immediately before each use. Class 0 and Class 00 are exempt from regular recertification unless work is carried out under the Electrical Utility Safety Rules (see RB-ELEC available at ihsa.ca). Rubber gloves rated for use with voltages above 5,000 volts AC must be regularly tested and certified to ensure that they can withstand the voltages for which they are rated,

• At least once every three months if they are in service, or
• Once every six months, if they are not in service.

Workers must be trained in the proper use, care, and storage of rubber gloves and leather protectors.

Rubber mats and shields can also be used with standard personal protective equipment to protect the worker from electric shock or burn. The rubber mat must have been tested and certified.

The best shock protection is afforded by turning off or isolating the electrical power from the worker. The Construction Regulation requires all work to be done with the system de-energized unless certain specified conditions are met. (See “Working on Energized Systems” in this chapter.)
Flash Hazard (Arc Flash) Protection

A flash hazard is defined as a dangerous condition associated with the release of energy caused by an electric arc (NFPA 70E 2004). The release of energy is often referred to as an arc flash.

An arc flash produces thermal energy which is measured in calories/cm². Adhering to arc flash protection calculations can still expose a worker to second degree burns, or 1.2 calories/cm².

One calorie is the amount of heat needed to raise the temperature of one gram of water by 1°C.

Second degree burn results from exposure to 1.2 cal/cm² for more than 0.1 second.

1.2 calories/cm² is equivalent to holding your finger in the blue part of a butane lighter flame for one second.

These conditions can lead to arc flash:
• Accidental contact between two conductors
• Wiring errors
• Insulation deterioration or failure
• Corrosion of equipment
• Contamination of the equipment (e.g., dust, moisture)
• Animals, tools, or fallen parts that short-circuit the equipment
• Poor maintenance
• Workers using improper or non-rated tools.

If a worker is close to energized electrical equipment, the worker may be exposed to a flash hazard, even if the source of the arc flash is not being worked on. Employers and supervisors need to ensure these workers are protected from flash hazards, and should educate workers on flash hazard recognition.

It may be possible to eliminate the electrical hazard with equipment designed to offer flash protection. The plugs in Figures 26-4 and 26-5 are designed for flash protection and can be used as a disconnect switch.

Mechanical workers who are potentially exposed to arc flash should always wear clothing that provides for some level of arc-flash protection. Clothing made of synthetic fibres can be readily ignited by arc flash and melt to the workers’ skin. Cotton or wool fabrics are more flame-retardant and are therefore recommended as outer-wear and inner-wear for work clothes. Clothing that is arc-flash rated to provide protection up to a specified hazard category must be worn when there is a flash hazard.

Protection from an arc flash is afforded by protective clothing and equipment such as
• Arc-rated clothing
• Flame-resistant eye protection (arc-rated face shield is often required as well)
• Hand protection
• Hearing protection.

There are a number of levels of arc-rated clothing, ranging from cotton-like clothes to the higher arc-rated suits and face shields (Figure 26-6). The level of protection necessary is determined by a calculation using tables or a computer program.
A hypothetical example:
For voltage testing on an energized part, 240 volts or less, a worker may require the following.
- Arc-rated pants and shirt (each rated to withstand 4 calories/cm²)
- Arc-rated face shield and safety goggles
- 500-Volt-rated class 00 gloves (class 0 gloves protect up to 1000 volts)
- 1000-Volt-rated tools
- Approved hard hat
- Hearing protection.

Actual calculations for this task may yield different results.

Workers who encounter a flash hazard can take additional precautions to reduce exposure.
- Standing as far away as possible from the hazard lowers the calorie intensity of an arc flash.
- Standing to the side when opening electrical-box doors can reduce exposure to the full force of a blast.

Information is available to assist with arc-flash energy calculations. Here are some sources:
- The (US) National Fire Protection Association’s Standard for Electrical Safety in the Workplace (NFPA 70E). Contact the NFPA: www.nfpa.org
- The Institute of Electrical and Electronics Engineers’ standard 1584, Guide for Performing Arc-Flash Hazard Calculations. Contact the IEEE: www.ieee.org
- CSA standard Z462 Workplace Electrical Safety. Contact the CSA: www.csagroup.org

Working on Energized Systems
What if there’s an electrical hazard but work must be done on or near enough to the hazard to make electrical contact, or near enough to be exposed to injury from an arc flash? In such cases, working while the system is energized is permitted only if specific conditions are met.

Work on energized equipment is permitted only in one of the following situations.
- It is not reasonably possible to disconnect the equipment, installation, or conductor from the power supply.
- The equipment is rated at a nominal voltage of 600 volts or less, and disconnecting the equipment would create a greater hazard to workers than proceeding without disconnecting it.
- The work consists only of diagnostic testing.

Note: Testing with a meter is working on energized equipment, and requires appropriate protection including personal protective equipment.

Unless the work consists only of diagnostic testing or involves a nominal voltage under 300 volts, an adequately equipped competent worker who can perform rescue operations, including cardiopulmonary resuscitation (CPR), must be stationed where he or she can see the workers performing the live work.

Work on energized equipment nominally rated greater than 400 amperes and greater than 200 volts, or greater than 200 amperes and greater than 300 volts, can only be done if all of the following conditions are met.

1. The owner of the equipment provides the employer and the constructor with a record showing that it has been maintained according to the manufacturer’s specifications.
2. A copy of the maintenance record is readily available at the project.
3. The employer has determined from the maintenance record that work on the equipment can be performed safely without disconnecting it.
4. Before beginning live work, the worker has verified that requirements 1), 2), and 3) have been met.

Repair or permanently disconnect defective equipment.

Section 2-300 of the Ontario Electrical Safety Code requires operating electrical equipment to be kept in safe and proper working condition.

The constructor must ensure that written procedures for work on or near live equipment are produced and implemented to protect workers from electrical shock and burn. The constructor must have copies of the procedures available for employers on the project.

The employer must provide and explain the written procedures to workers before they start work on or near live equipment. The constructor and the employer both have a general duty to ensure that the health and safety of workers are protected.

Operating Equipment Near Energized Powerlines
Incidental powerline contact happens too often, especially considering the potential severity of the consequences. The Ministry of Labour reported 108 powerline contacts in 1998. That number rose to 196 in 2005. See Table 26-1.

Constructors must be aware of electrical hazards when equipment such as a crane, dump truck, or other vehicle is going to be operated near an energized overhead electrical conductor, or when excavating equipment such as a backhoe will be operated near underground powerlines (Figure 26-7).
When equipment operates within reach of, and could therefore encroach on, the minimum permitted distances from live overhead powerlines (as listed in Table 26-2), the constructor is required to have written procedures in place to prevent it from occurring and to have copies of the procedure available for every employer on the project.

**Note:** The wind can blow powerlines, hoist lines, or your load. This can cause them to cross the minimum distance.

Overhead powerlines are most frequently hit by dump trucks and cranes; however, elevating work platforms and low-tech equipment such as ladders and rolling scaffolds are also involved. Keep in mind that many powerline contacts involve low-voltage service and buried cable.

---

Table 26-1: Summary of Powerline Contacts

<table>
<thead>
<tr>
<th>Year</th>
<th>Crane</th>
<th>Dump truck</th>
<th>Tree felling</th>
<th>Other</th>
<th>Digging</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>19</td>
<td>21</td>
<td>9</td>
<td>87</td>
<td>45</td>
<td>15</td>
<td>196</td>
</tr>
<tr>
<td>2004</td>
<td>11</td>
<td>16</td>
<td>5</td>
<td>57</td>
<td>53</td>
<td>9</td>
<td>151</td>
</tr>
<tr>
<td>2003</td>
<td>16</td>
<td>19</td>
<td>9</td>
<td>63</td>
<td>35</td>
<td>6</td>
<td>148</td>
</tr>
<tr>
<td>2002</td>
<td>16</td>
<td>20</td>
<td>4</td>
<td>50</td>
<td>36</td>
<td>6</td>
<td>148</td>
</tr>
<tr>
<td>2001</td>
<td>16</td>
<td>22</td>
<td>5</td>
<td>43</td>
<td>27</td>
<td>7</td>
<td>132</td>
</tr>
<tr>
<td>2000</td>
<td>15</td>
<td>10</td>
<td>3</td>
<td>59</td>
<td>32</td>
<td>3</td>
<td>122</td>
</tr>
<tr>
<td>1999</td>
<td>11</td>
<td>26</td>
<td>2</td>
<td>48</td>
<td>27</td>
<td>1</td>
<td>115</td>
</tr>
<tr>
<td>1998</td>
<td>10</td>
<td>17</td>
<td>8</td>
<td>39</td>
<td>27</td>
<td>7</td>
<td>108</td>
</tr>
<tr>
<td>TOTALS</td>
<td>114</td>
<td>151</td>
<td>46</td>
<td>446</td>
<td>282</td>
<td>54</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Ontario Ministry of Labour*

Table 26-2: Minimum Distance from Powerlines

<table>
<thead>
<tr>
<th>Voltage Rating of Powerline</th>
<th>Minimum Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>750 to 150,000 volts</td>
<td>3 m (10 ft)</td>
</tr>
<tr>
<td>150,001 to 250,000 volts</td>
<td>4.5 m (15 ft)</td>
</tr>
<tr>
<td>over 250,000 volts</td>
<td>6 m (20 ft)</td>
</tr>
</tbody>
</table>

*Source: O. Reg. 213/91, s. 188*
Safety Measures

Written measures and procedures required by the Construction Projects regulation (213/91) include the following:

• Place enough warning devices in the area of the hazard so that at least one is always visible to the operator. The warning devices must be visible to the operator under any conditions in which the equipment may be operating (night, rain, fog, etc.), and must be specific about the hazard. Provide a sign meeting the requirements of O. Reg. 213/91, s. 44, stating, for example, “Danger! Electrical Powerlines Overhead.” We recommend that you include the voltage (Figure 26-8).

![Figure 26-8: Warning Sign](image)

• Ensure the equipment operator has been provided with written notification of the electrical hazard before beginning the work.
• Ensure there is a sign warning of the hazard that is visible to the operator at the operator’s station. This may come as a sticker with the machine. Check to ensure the sticker is still legible.
• Before the operator starts work, ensure that the employer of the equipment operator provides and explains the procedures to the equipment operator.
• A competent worker must be designated as a signaller to warn the operator when any part of the equipment, load, or hoist line may approach the minimum distance. The signaller must then be in full view of the operator and have a clear view of the equipment and the conductor. Section 106 of the Construction Regulation also applies with respect to the designated signaller.

An exemption to these measures is only allowed if, under the authority of the owner of the electrical conductor (typically the local utility), protective devices and equipment are installed, and written procedures are implemented (e.g., using the Electrical Utilities Safety Rules) that are adequate to protect the equipment operator from electrical shock and burn.

Prevention

Ensure that contractors and workers understand that work should be planned to avoid powerlines. Prepare for work that must be done in close proximity to energized powerlines by developing written procedures ahead of time. Have overhead powerlines moved, insulated, or de-energized where possible. Insulating or “rubberizing” powerlines offers some protection against brush contact in some circumstances. The local utility may provide this service.

![Figure 26-9: Inside the Limit of Approach to the Powerline](image)

Identify the voltage of the service by checking markings on the utility pole and calling the utility. If material must be stored under powerlines, hang warning flags and signs to inform workers about the hazard and the need to obtain written procedures if hoisting (Figure 26-10).

![Figure 26-10: Warning Signs on Utility Poles](image)

Provide instruction as part of site orientation.

• Tell operators of large equipment where overhead and buried powerlines are and where overhead powerlines may be lower than expected.
• Remind workers not to let a ladder, scaffold, or elevated work platform lean or drift toward overhead powerlines. Always maintain minimum allowable clearances.
• Inform all workers how powerline hazards are identified on site and that written procedures are required prior to operating near them.
• Review an appropriate emergency response for equipment operators and workers assisting operators, in case contact should occur.
In the event of contact between equipment and overhead powerlines:

1. **Stay on equipment.** Don’t touch equipment and the ground at the same time. Touching anything in contact with the ground can be fatal. Stay on the equipment unless forced off because of a life-threatening hazard such as fire.

2. **Keep others away.** Warn everyone not to touch the equipment or its load. That includes buckets, outriggers, load lines, and any other part of the machine. Beware of time-delayed relays. After line damage trips a breaker, relays may still try to restore power. They may reset automatically two or three times.

3. **Break contact.** If possible, break contact by moving the equipment clear of the wires. This may not be feasible where contact has welded conductors to equipment, the hoist line, or the load.

4. **Call the local utility.** Get someone to call the local electrical utility for help. Stay on the equipment until the utility shuts down the line and confirms that power is off. Report incidents of powerline contact so that the utility can check for damage that could cause the line to fail later.

5. **Jump clear.** If forced to leave the equipment, jump carefully off the equipment onto the ground landing only on your feet, with your feet together. Touching the equipment and the ground at the same time can be fatal. Touching the ground at different points can also be fatal. Shuffle slowly away from the equipment using very small steps to minimize the contact area with the ground.

6. **Report the contact.** See “Reporting Electrical Incidents” in this chapter.

**Hidden Power Supplies**

Digging into buried cable resulted in 282 powerline contacts between 1998 and 2005 (see Table 26-1). A great many of these resulted from excavating prior to getting a locate on the service (Figure 26-11). If the electrical power cannot be shut off during excavation, the owner (of the service) must be present to supervise the uncovering of the powerline.

**Overvoltage Categories**

Momentary high-voltage transients or spikes can travel through a multimeter at any time and without warning. Motors, capacitors, lightning, and power conversion equipment such as variable speed drives are all possible sources of spikes.

The IEC 1010 standard defines categories I through IV that are abbreviated as CAT I, CAT II, CAT III, etc. The higher-numbered categories represent an electrical environment that is susceptible to higher-energy spikes. For example, multimeters that are designed to the CAT IV standard provide the worker more protection from high transient voltage spikes than do CAT III, CAT II, or CAT I designs. See Figure 26-13 and Table 26-3 for an explanation of each category.

For underground powerlines:

- Before excavating, request that the owner of the service locate and mark underground powerlines.
- Contact the utility through Ontario One Call to locate all underground services.
- Locate and mark underground lines on drawings that will be used for excavating.
- Post warning signs along the route of underground powerlines.
- When operators of excavation equipment arrive on site, tell them where underground services are located and how they are identified.

For powerlines embedded in concrete:

- Ensure various trades provide sleeving when concrete is poured to reduce the need to drill.
- Try to have powerlines laid along dedicated sections of flooring and walls.
- Mark powerline locations on drawings that will be referenced for drilling.
- Use a location service to x-ray the concrete and locate embedded powerlines.

**Multimeters**

In the process of troubleshooting, electrical workers face the risk of injury from improper multimeter selection or use (Figure 26-12). Multimeters that are designed to meet the International Electrotechnical Commission (IEC) 1010 and overvoltage category standards, when properly used, offer the electrician an acceptable level of protection that is recognized by the electrical industry. The use of fused leads provides additional protection for the worker.

![Figure 26-12: A Failed Multimeter](image-url)
Be sure that the multimeter model has been tested. Simply being designed to the CAT III standard, for example, does not mean the multimeter was also tested to that standard. **Look for proof of independent testing by an organization accredited by the Standards Council of Canada—such as the CSA (Canadian Standards Association) International logo—along with the appropriate category rating on the equipment.** Test leads should also be rated at the same or greater voltage than the multimeter.

<table>
<thead>
<tr>
<th>OVERVOLTAGE CATEGORY</th>
<th>IN BRIEF</th>
<th>EXAMPLES</th>
</tr>
</thead>
</table>
| CAT IV               | Three-phase at utility connection, any outdoors conductors | • Refers to the “origin of installation” (i.e., where low-voltage) connection is made to utility power.  
• Electricity meters, primary overcurrent protection equipment.  
• Outside and service entrance, service drop from pole to building, run between meter and panel.  
• Overhead line to detached building, underground line to well pump. |
| CAT III              | Three-phase distribution, including single-phase commercial lighting | • Equipment in fixed installations, such as switchgear and polyphase motors.  
• Bus and feeder in industrial plants.  
• Feeders and short branch circuits, distribution panel devices.  
• Lighting systems in larger buildings.  
• Appliance outlets with short connections to service entrance. |
| CAT II               | Single-phase receptacle connected loads | • Appliance, portable tools, and other household and similar loads.  
• Outlet and long branch circuits.  
• Outlets at more than 10 meters (30 feet) from CAT III source.  
• Outlets at more than 20 meters (60 feet) from CAT IV source. |
| CAT I                | Electronic | • Protected electronic equipment.  
• Equipment connected to (source) circuits in which measures are taken to limit transient overvoltages to an appropriately low level.  
• Any high-voltage, low-energy source derived from a high-winding resistance transformer, such as the high-voltage section of a copier. |

*Parts of this table are reprinted with permission from Fluke Electronics Canada Inc.*
Understanding Overvoltage Installation Categories

The division of a power distribution system into categories is based on the fact that a dangerous high-energy transient such as a lightning strike will be attenuated or dampened as it travels through the impedance (AC resistance) of the system. A higher CAT number refers to an electrical environment with higher power available and higher-energy transients. Therefore, a multimeter designed to the CAT III standard is resistant to much higher-energy transients than one designed to the CAT II standard. Categories I through IV apply to low voltage (less than 1000 V) test equipment.

Safe Use of Multimeters

- Use only multimeters that display both the CSA logo (or equivalent) and the CAT (I, II, III, or IV) designation. Categories I through IV apply to low voltage (less than 1000 V) test equipment.
- Check to ensure that the meter’s voltage rating is appropriate for the work being done. Be aware of multimeters with maximum voltage ratings typical of other countries (550 V for example).
- Use personal protective equipment such as arc flash fire-resistant clothing; eye and face protection; long-sleeved shirts; dielectric safety boots; rubber gloves with leather protectors; and mats, blankets, or shields as required (Figure 26-). Do not wear synthetic inner or outer clothing that can melt if an arc flash occurs.
- Check the manufacturer’s manual for special cautions. Moisture and cold may affect the performance of your meter.
- Wipe the multimeter and test leads clean to remove any surface contamination prior to use.
- Use fused test leads. Ensure fused leads and internal probe fuses are rated as high as or higher than the equipment you are going to work on. A minimum of 30 kA is recommended (200 kA is desirable).
- Ensure that test leads are in the correct input jacks.
- When the values to be measured are uncertain, start testing with high ranges of the multimeter, then move to the lower ranges.

Testing for power with a meter

Set the meter to the power function to be used for validating the zero energy. Test to ensure the meter is functioning correctly by testing on a known power source, then test the locked out circuit to verify that the power has been effectively isolated, and finally re-test on the same known power supply to verify the meter’s fuse has not blown and the meter is still functioning correctly on that power setting.

Portable Tools and Extension Cords

1. Unless they are double-insulated, tools must have:
   a) the casing grounded
   b) a polarized plug connection.
2. Extension cords must be of the outdoor type, rated for 300 volts, and have an insulated grounding conductor.
3. Defective cords must not be used. They should be either destroyed or tagged and removed from the jobsite until they are repaired.
4. Extension cords should be protected during use to prevent damage.
5. Extension cords should be plugged into Class A ground fault circuit interruptors (GFCIs). When built-in GFCI receptacles are not available, protection can be attained with an in-line GFCI plugged directly into the supply receptacle.

To plug-in safely while working outside, follow the directions in Figure 26-14.

Figure 26-: PPE When Using Multimeters

Figure 26-14: Plug-in Safely
Electric tools used outdoors or in wet locations must be protected by a Class A GFCI (Figure 26-15).

Photo courtesy of EGS Electrical Group Canada Ltd.

**Figure 26-15: In-line Class A GFCI**

### Temporary Wiring and Power


2. **Temporary wiring** must be inspected and approved when initially installed and should be checked regularly. (OESC 2015, Rules 2-004, 2-014, 2-016)

3. **Temporary installations** shall be constructed as separate installations and shall not be interconnected with any of the circuits of the permanent installations except by special permission. (OESC 2015, Rule 76-014)

4. **Feeders** supplying fixed distribution centers shall be installed in armoured cable or the equivalent. A feeder supplying a portable distribution center is permitted to be flexible cord or power cable of the outdoor type suitable for extra-hard usage. Feeders shall be protected at all times from mechanical damage. (OESC 2015, Rule 76-010).

5. **A switch and panel board** must meet the following requirements (as per O. Reg. 213/91, s. 194):
   a) Must be securely mounted on a soundly constructed vertical surface
   b) Must have a cover over uninsulated parts carrying current
   c) Must be located in an area where water will not accumulate and be within easy reach of workers and readily accessible to them
   d) Must be kept clear of obstructions in the area in front of the panel board (O. Reg. 213/91, s. 194)

6. **The switch** that controls a service entrance, service feeder, or branch circuit providing temporary power
   - must not be locked in the energized position; and
   - must be housed in an enclosure that can be locked and is provided with a locking device (Figure 26-16). (O. Reg. 213/91, s. 194)

**Figure 26-16: Shelter and Lockouts for Temporary Panels**

7. **When supplying power** to tools that will be used outdoors or in wet locations, the receptacle must be protected by a class A GFCI (Figure 26-17). (O. Reg. 213/91, s. 195.2)

**Figure 26-17: GFCI in Panel Box**

8. **Portable generators** with no connection between the neutral and the case cannot be used as a stand-alone electrical supply for the operation of portable electrical equipment. Typically, generators with no connection between the neutral and the case are intended to be connected through a transfer switch to a distribution system for use as a standby back-up system in a residential home, in case of power outage.

9. "Generators supplied by equipment rental stores for use as a stand-alone supply to portable electrical devices shall be a generator with the neutral bonded to the case to facilitate the operation of the overcurrent protection device(s)" (Electrical Safety Authority Flash notice 03-03-FL).

10. **Labeling on newer portable generators** must indicate the status of the neutral conductor and shall be marked on each machine as follows: NEUTRAL FLOATING or NEUTRAL BONDED TO FRAME (Figure 26-18).
Electromagnetic induction

Electromagnetic induction can create an electric current in a dead circuit. The condition occurs when a magnetic field from another wire, circuit, or device cuts across a wire in its path and produces a charge in that wire. Temporary grounding will prevent electromagnetic induction. The temporary grounding cable must be the same size conductor as the one found within the circuit.

Grounding

A ground conductor provides a direct physical connection to the mass of the earth. It limits the voltage or current to the ground during normal operation, and also prevents excessive voltages due to lightning strikes.

A temporary ground provides a direct physical connection to the mass of the earth. Temporary grounding typically involves the use of a wire or cable that has one end connected to a de-energized circuit, and the other end to a known grounded connection. The known grounded connection can be the equipment frame (note that if the equipment is electrically isolated, the frame may not provide an effective grounded connection), a metal water pipe, a ground electrode, or other acceptable grounding medium.

Ground all phases. Attach a temporary ground cable to the system and keep it in place until work is completed.

Connecting and disconnecting conductors

Any disconnect devices used to isolate electrical equipment must be certified by CSA International or another certification body accredited by the Standards Council of Canada. It is important that the device has the appropriate rating for the available current and load it is serving. Never assume a circuit has been de-energized when the disconnect is in the open position. Check for power in all conductors, then follow prescribed lockout and tagging procedures before beginning work.

Capacitors

Isolate the capacitor by opening the circuit breaker or the isolation device connecting it to the circuit. Drain off the accumulated charge for five to ten minutes with the system device. Short circuit and ground the capacitor using a hot stick and required personal protective equipment.

Electrical fires

Never put water on fires in live electrical equipment or wiring. Water is a conductor and increases the risk of arc flash and electrocution. An electrical fire in a confined space can rapidly deplete oxygen and may release toxic fumes. If possible, switch off power. Avoid inhaling fumes and vacate the area at once. If necessary, breathe through a damp cloth and stay close to the floor. Use a Class C fire extinguisher. Intended for electrical fires, Class C extinguishers employ a non-conductive extinguishing agent. An ABC fire extinguisher may also be used on an electrical fire. Every worker who may be required to use a fire extinguisher must be trained in its use. Report fires immediately. Wiring or equipment involved in a fire must be inspected by the electrical utility inspector before being reactivated.

Want More Information?

More info on electrical safety can be found in IHSA's Electrical Construction and Maintenance Workers' Safety Manual (M010). This pocket-sized manual was written for electrical workers and is a useful tool that apprentices, journeypersons, supervisors, and management can use to help keep safety in mind when planning work. A new 2016 version of “the blue book” is now available.
**Reporting Electrical Incidents**

All incidents, regardless of severity, must be reported promptly to management and the immediate supervisor, and a record should be kept at the jobsite. When a serious or fatal injury involves a union member, the union office and steward must be notified immediately. Labour and management should cooperate fully in conducting an investigation.

Part VII of the OHSA specifies the requirements for notification in the event of fatalities, injuries, and incidents. In the event of an incident that requires reporting and investigation, care should be taken not to disturb the incident scene, nor should equipment or tools involved in the incident be removed.

**Contact with an overhead powerline**

Contact with an overhead powerline must be reported to multiple parties.

If accidental contact occurs with an energized powerline carrying 750 V or more, report the contact to the inspection department of the Electrical Safety Authority (ESA), and provide written notice to the Ministry of Labour, joint health and safety committee or health and safety representative, and trade union.

**Fatality or critical injury**

A written report is required under subsection 51 (1) of the Act, respecting an occurrence in which a person is killed or critically injured. (See box on next page.)

**Section 53 of the Act:** Where a notice or report is not required under section 51 or 52, and an

- accident
- premature or unexpected explosion, fire, flood or inrush of water
- failure of any equipment, machine, device, article, or thing
- cave-in, subsidence, rockburst
- or other incident as prescribed (see box below)

occurs at a project site, mine, or mining plant, notice in writing of the occurrence shall be given to a director, the joint health and safety committee or health and safety representative, and trade union, if any, by the constructor of the project or the owner of the mine or mining plant within two days of the occurrence containing such information and particulars as are prescribed.

**Reporting serious electrical incidents to the ESA**

An owner, contractor, or operator of a facility must report any serious electrical incident to the Inspection Department of the ESA within 48 hours after the occurrence.

**Notice of accident, explosion or fire causing injury**

If a person is disabled from performing his or her usual work or requires medical attention because of an accident, explosion, or fire at a workplace, but no person dies or is critically injured because of that occurrence, the employer shall, within four days of the occurrence, give written notice of the occurrence containing the prescribed information and particulars to the following:

1. The joint health and safety committee or the health and safety representative, and the trade union, if any
2. The Director, if an inspector requires notification of the Director.

For the purpose of the Act, the Regulations, and the Ontario Electrical Safety Code, “critically injured” means an injury of a serious nature that,

- places life in jeopardy;
- produces unconsciousness;
- results in substantial loss of blood;
- involves the fracture of a leg or arm but not a finger or toe;
- involves the amputation of a leg, arm, hand, or foot but not a finger or toe;
- consists of burns to a major portion of the body; or,
- causes the loss of sight in an eye.


For the purpose of section 53 of the Act, a “prescribed incident” includes:

- accidental contact by a worker or by a worker’s tool or equipment with energized electrical equipment, installations or conductors. (s.11 O. Reg. 213/91)
- Accidental contact by a crane, similar hoisting device, backhoe, power shovel or other vehicle or equipment or its load with an energized electrical conductor rated at more than 750 volts. (s.11 O. Reg. 213/91)

"Serious electrical incident" means,

a) Any electrical contact which causes death or critical* injury to a person, or
b) Any fire or any explosion or any condition suspected of being electrical in origin which might have caused a fire, explosion, loss of life, critical* injury to a person, or damage to property, or
c) Any electrical contact with electrical equipment operating at over 750 volts, or
d) Any explosion or fire of electrical equipment operating at over 750 volts.

OESC 2015

* see definition of “critically injured” under "Fatality or critical injury” above.