

26 ELECTRICAL HAZARDS

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INTRODUCTION

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 electric 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*, 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 Regulation (Ontario Regulation 213/91 Section 182) on who can work on electrical equipment:

- (1) *No worker shall connect, maintain, or modify electrical equipment or installations unless,*
- (a) *the worker is an electrician certified under the Trades Qualification and Apprenticeship Act; or*
- (b) *the worker is otherwise permitted to connect, maintain or modify electrical equipment or installations under the Trades Qualification and Apprenticeship Act, the Apprenticeship and Certification Act, 1998 or the Technical Standards and Safety Act, 2000.*
- (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.
- NFPA 70E *Standard for Electrical Safety in the Workplace*
- CSA Z462 *Workplace Electrical Safety**.
 - * CSA Z462, tentatively called *Workplace Electrical Safety*, is under development. It is a Canadian version of the US electrical safety standard NFPA 70E *Standard for Electrical Safety in the Workplace* and is anticipated to be available in 2008.

An important aspect of electrical work involves isolating electrical energy. A reference for detailed information on lockout and control of hazardous energy is the Canadian standard CSA Z460-05, *Control of Hazardous Energy—Lockout and Other Methods*.

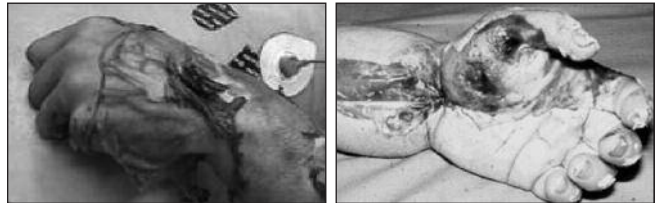
ELECTRICAL INJURIES

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

- 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.

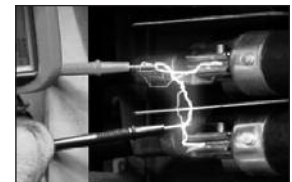
A household 125-volt circuit can deliver 15 amps. Current as low as 30/1000 of 1 amp (30 mA) can cause breathing to stop. A 15-Amp circuit contains many times the current needed to cause death.



A major cause of accidents involving electricity comes from the failure to identify the hazards associated with live electrical equipment and wiring.



An **arc flash** is a release of energy caused by an electric arc. The flash causes an explosive expansion of air and metal. The blast produces



Electric arc

- 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.



Arc flash

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

- 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, and
- 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. As well, see the chapters on personal protective equipment in the Equipment section of 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 below.

Head protection

The following hard hats comply with the Construction Regulation:

- CSA Z94.1-1992 Class E (Canadian)
- ANSI Z89.1-1997 Type II Class E (US)
- ANSI Z89.1-1997 Type I Class E. (US)

Note that under the latest ANSI standard, there are two types of Class E hard hats: Type I and Type II. Type I hats are similar to the old CSA Class B hard hats which provide limited lateral impact protection. The Type II hats have enhanced lateral protection like the CSA Class E. ANSI Type II Class E hard hats are clearly labelled "Type II." If your hard hat just says "ANSI Class E," assume it's a Type I.

Foot protection

Construction workers require Grade 1 toe protection with sole protection in accordance with the Canadian Standards Association standard (CSA) Z195-02. Protective footwear compliant with the intent of the Construction Regulation is identified by a green triangular patch on the tongue or the ankle of the footwear.

Mechanical trades people exposed to electrical hazards should also wear electric-shock-resistant footwear identified by a white rectangular label bearing the CSA logo and the Greek letter omega in orange.



CSA logo



omega

Eye protection

The Canadian Standards Association (CSA) standard CAN/CSA Z94.3-99 *Industrial Eye and*

Face Protectors can assist you in classifying hazards and recommending protectors. Appropriate protection chosen according to this standard meets with the intent of the Construction Regulation 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 to 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 re-certification unless work is carried out under the Electrical Utility Safety Rules.* 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 plug in the picture at right and below is designed for flash protection and can be used as a disconnect switch.



Flash protection is designed into this disconnect switch/plug



Mechanical workers that 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 flame resistant (FR) and 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

- wearing flame-resistant clothing
- flame-resistant eye protection (flame-resistant face shield is often required as well)
- hand protection
- hearing protection.

There are a number of levels of flame-resistant (FR) clothing, ranging from cotton clothes to the flash suits and face shields shown in the accompanying image. 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

- FR-rated pants and shirt (each rated to withstand 4 calories/cm²)
- FR-rated safety goggles
- 500-volt-rated class 00 gloves (class 0 gloves protect up to 1000 volts)
- 1000-volt-rated tools
- approved hard hat.

Actual calculations for this task may yield different results.

Workers that 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: 1-800-344-3555, www.nfpa.org.



A flash suit and face shield are required for the more powerful flash hazards.

- The Institute of Electrical and Electronics Engineers' standard 1584, Guide for Performing Arc-Flash Hazard Calculations. Contact the IEEE: 1-800-678- 4333, www.ieee.org.
- CSA standard Z462 *Workplace Electrical Safety* is currently being developed. Upon completion in 2008, CSA Z462 will be another resource of information dealing with electrical safety concerns such as arc flash. Contact the CSA: 1-800-463-6727, 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, work while the system is energized is permitted only if specific conditions are met.

Work on energized equipment is permitted only if

- 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, or
- 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

- 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, and
- 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

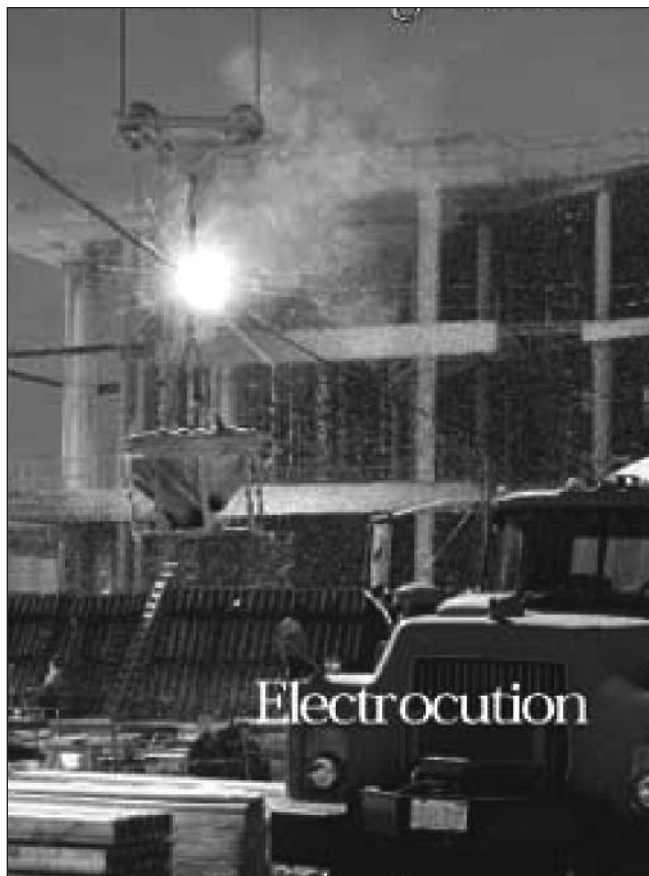
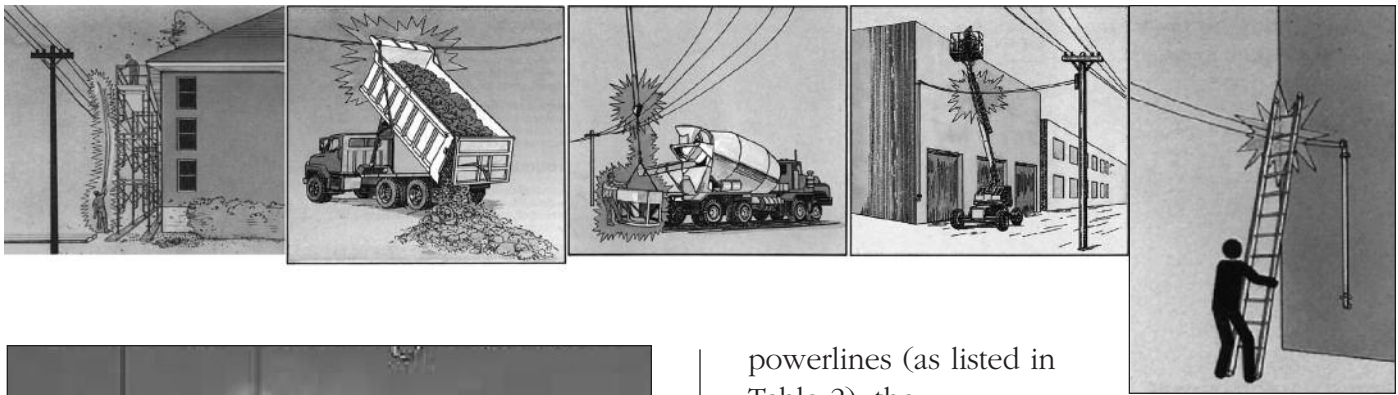
Incidental powerline contact happens too often, especially considering the potential severity of the consequences. The Ministry of Labour reported 108 powerline contacts in 1998. That number rose to 196 in 2005. See Table 1.

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.

Table 1: Summary of Powerline Contacts

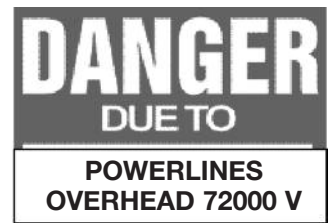
Overhead Lines					Buried Cables		
Year	Crane	Dump truck	Tree felling	Other	Digging	Other	Total
2005	19	21	9	87	45	15	196
2004	11	16	5	57	53	9	151
2003	16	19	9	63	35	6	148
2002	16	20	4	50	36	6	132
2001	16	22	5	43	27	7	120
2000	15	10	3	59	32	3	122
1999	11	26	2	48	27	1	115
1998	10	17	8	39	27	7	108
TOTALS	114	151	46	446	282	54	

(Source: Ontario Ministry of Labour)



When equipment operates within reach of, and could therefore encroach on, the minimum permitted distances from live overhead

powerlines (as listed in Table 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.



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.

Safety measures

Written measures and procedures required by the Construction Regulation include the following:

- Place enough warning devices in the area of the hazard so at least one is always visible to the operator. The warning devices must be visible to the operator under any conditions in which the

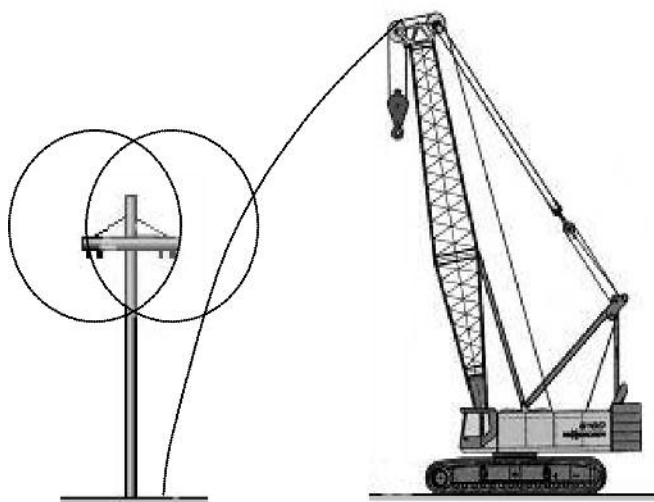
Table 2

Normal phase-to-phase voltage rating	Minimum distance
750 or more volts, but no more than 150,000 volts	3 metres
More than 150,000 volts, but no more than 250,000 volts	4.5 metres
More than 250,000 volts	6 metres

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

equipment may be operating (night, rain, fog, etc.), and must be specific about the hazard. Provide a sign meeting the requirements of the Construction Regulation's section 44, stating, for example, "Danger! Electrical power lines overhead." We recommend that you include the voltage.

- 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



Inside the limit of approach to the powerline.

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 (for example, using the Electrical & Utilities Safety Association (E&USA)'s *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.



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.

Provide instruction as part of site orientation:

- Advise 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 Accidents/Incidents" in this chapter.

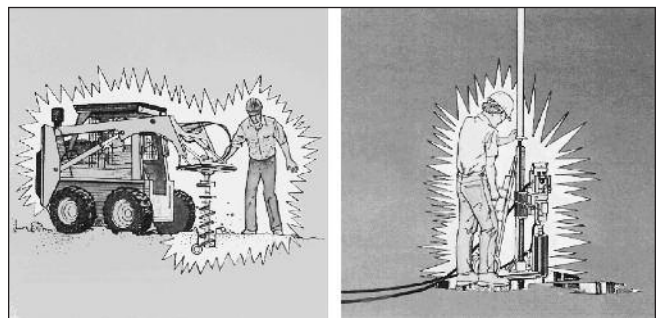
Hidden power supplies

Digging into buried cable resulted in 282 powerline contacts between 1998 and 2005 (see Table 1). A great many of these resulted from excavating prior to getting a locate on the service. 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.

The following are some prevention measures for hidden powerlines.

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, advise 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 ex-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. 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.

Why use overvoltage category rated multimeters?

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.



A failed multimeter

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 the diagram on the next page and Table 3 below for an explanation of each category.

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



Table 3

OVERVOLTAGE CATEGORY	IN BRIEF	EXAMPLES
CAT IV	Three-phase at utility connection, any outdoors conductors	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Appliance, portable tools, and other household and similar loads. • Outlet and long branch circuits. <ul style="list-style-type: none"> • Outlets at more than 10 meters (30 feet) from CAT III source. • Outlets at more that 20 meters (60 feet) from CAT IV source.
CAT I	Electronic	<ul style="list-style-type: none"> • 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.

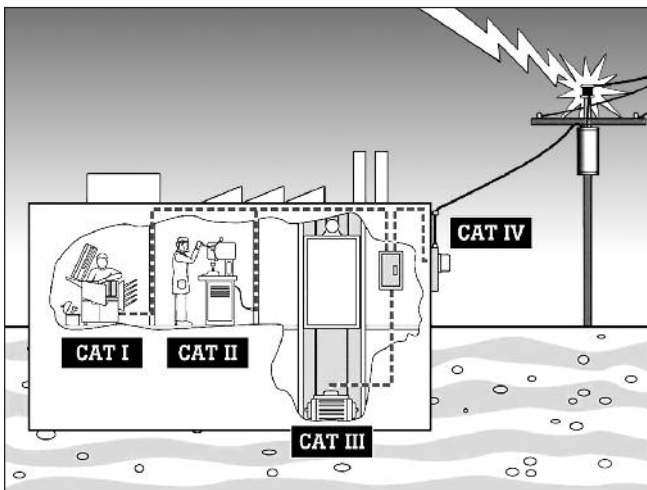
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leads should also be rated at the same or greater voltage than the multimeter.

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 sleeve shirts; dielectric safety boots; rubber gloves with leather protectors; and mats, blankets, or shields as required. **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.
- Connect to the ground first, and disconnect from ground last.
- Test the multimeter on a known power source to verify that the meter is functioning properly before and after testing the suspect circuit, using the same power function for all three tests.

Using a meter to confirm zero energy for a lockout

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 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 either be 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 GFCIs. When built-in GFCI receptacles are not available, protection can be attained with an in-line GFCI plugged directly into the supply receptacle. **Electric tools used outdoors or in wet locations must be protected by a Class A GFCI.**



In-line Class A GFCI.

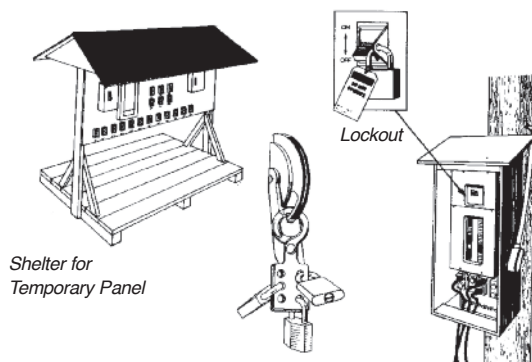
TEMPORARY WIRING AND POWER

1. **Temporary wiring** for construction or demolition projects must be installed in accordance with the Ontario Electrical Safety Code 23rd Edition/2002 (as amended by O. Reg. 62/07). Copies

available from Orderline at 1-888-361-0003 or www.orderline.com.

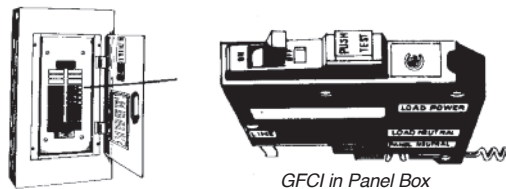
2. A switch and panel board,

- a) must be securely mounted on a soundly constructed vertical surface;
- b) must have a cover over uninsulated parts carrying current;

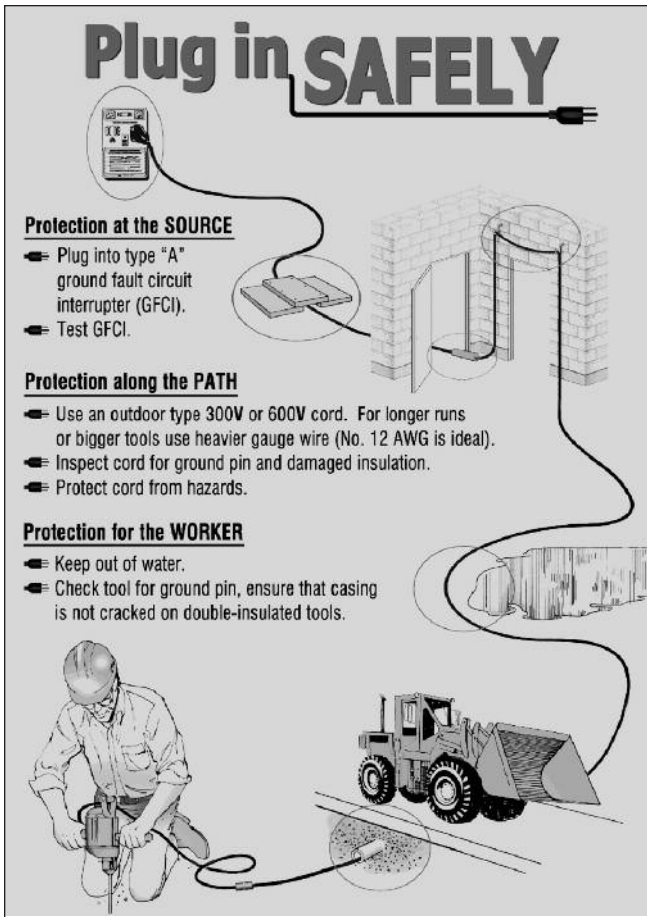


Shelter for Temporary Panel

- c) be located,
 - in an area where water will not accumulate; **and**
 - 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;
- e) 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.
- f) When supplying power to tools that will be used outdoors or in wet locations, the receptacle must be protected by a class A ground fault circuit interrupter (GFCI).



GFCI in Panel Box



3. **Portable generators** for use as a stand-alone supply for portable electrical devices must be labelled "**Neutral Bonded To Frame.**"

"Portable Generators for portable electrical devices shall be a generator with the neutral bonded to the case to facilitate the operation of the overcurrent protection device(s)." Labelling on newer portable generators must indicate the status of the neutral conductor and shall be marked on



Labelled "Neutral Floating"

each machine as follows: NEUTRAL BONDED TO FRAME or NEUTRAL FLOATING.

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Portable generators with no connection between the neutral and the case cannot be used for a stand-alone electrical supply for the operation of portable electrical equipment. Generators with no connection between the neutral and the case are intended to be connected to a distribution system through a transfer switch. An example of this is a standby backup system in a residential home which kicks in upon failure of the utility supply. These generators will be labelled "**Neutral Floating**".

OTHER ELECTRICAL ISSUES

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.

A grounding conductor 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

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.

REPORTING ELECTRICAL ACCIDENTS/INCIDENTS

All accidents, 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 *Occupational Health and Safety Act* specifies the requirements for notification in the event of fatalities, injuries, and accidents. In the event of an accident that requires reporting and investigation, care should be taken not to disturb the accident scene, nor should equipment or tools involved in the accident 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.

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.

Note: *O. Reg. 834* and *Ontario Electrical Safety Code* (OESC) (twenty third edition 2002) use virtually identical wording for the definition of “critically injured.”

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

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.

“Serious electrical incident” means,

- Any electrical contact which causes death or critical* injury to a person, or
- 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
- Any electrical contact with electrical equipment operating at over 750 volts, or
- Any explosion or fire of electrical equipment operating at over 750 volts.

OESC 2002

* see definition of “critically injured” under “Fatality or Critical Injury” above.

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.