Working Safely Around Electricity

WorkSafeBC

About WorkSafeBC

At WorkSafeBC, we're dedicated to promoting safe and healthy workplaces across B.C. We partner with workers and employers to save lives and prevent injury, disease, and disability. When work-related injuries or diseases occur, we provide compensation and support injured workers in their recovery, rehabilitation, and safe return to work. We also provide no-fault insurance and work diligently to sustain our workers' compensation system for today and future generations. We're honoured to serve the workers and employers in our province.

Prevention Information Line and contact information

We provide information and assistance with health and safety issues in the workplace.

Call the information line 24 hours a day, 7 days a week to report unsafe working conditions, a serious incident, or a major chemical release. Your call can be made anonymously. We can provide assistance in almost any language.

If you have questions about workplace health and safety or the Occupational Health and Safety Regulation, call during our office hours (Monday to Friday, 8:05 a.m. to 4:30 p.m.) to speak to a WorkSafeBC officer.

If you're in the Lower Mainland, call 604.276.3100, or if you're anywhere else in Canada, call toll-free at 1.888.621.7233 (621.SAFE).

Health and safety resources

You can find our health and safety resources at worksafebc.com/forms-resources. Printed copies are available for some resources and can be ordered from worksafebcstore.com.

BC Hydro public safety information

bchydro.com/safety

For information on overhead power line voltage or to complete the Assurance of Compliance with Occupational Health and Safety Regulation, Part 19 (Form 30M33), contact the utility owner. For BC Hydro, call the Electric Service Coordination Centre at 1.877.520.1355.

Before you dig, contact BC 1 Call by submitting an online ticket at bc1c.ca or by calling 1.800.474.6886, or *6886 on your cellphone.

In case of electrical contact

Is there a fire or an immediate threat to life?

- **Yes.** Call 911. They will contact the utility owner to shut off the power.
- **No.** Contact the utility owner to have the power shut off. For BC Hydro, call 1.888.POWERON (769.3766), or *49376 on your cellphone.

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Acknowledgments

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- Electrical Industry Training Institute Ltd. (EITI)
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About this guide

Electricity can be our best friend — or our worst enemy. Injuries can range from shock to severe burns. Injuries and fatalities can occur from incidents involving low voltages or high voltages. They usually occur from contact with high-voltage power lines.

This book explains the dangers of working around and on energized low-voltage equipment and near high-voltage conductors. It is written for supervisors and workers who work around and with electrical equipment and near power lines. It is intended for those who are familiar with the basic hazards of electrical contact.

If you are a painter or equipment operator, you may work around electrical equipment and conductors. However, you may not be familiar with all the hazards of electrical contact. **If so, you should know that this book is not a training manual.** You should follow up with your supervisor or WorkSafeBC for more information on how the hazards and safety steps outlined in this book apply to your work conditions. All workers must be informed of potential electrical hazards before being allowed to work near energized electrical conductors or equipment.

This book has three parts:

- Part 1 describes the dangers of contact with low-voltage electricity, common problem areas, and safe work practices.
- Part 2 describes the dangers of contact with high-voltage electricity. It also provides guidelines for working safely near power lines.
- Part 3 describes electrical injuries.

This book provides an overview of key electrical hazards. It is not intended as a guide to performing electrical work. Electrical workers must be familiar with the codes and regulations that cover power lines, electrical equipment, and installation in more detail. **If you install, alter, or maintain electrical equipment, you must be qualified to carry out the work, as required by the *Safety Standards Act* and the regulations made under it.**

This book does not replace the Occupational Health and Safety Regulation. Refer to the Regulation, especially Part 19: Electrical Safety and Part 10: De-energization and Lockout, for specific requirements.

Contents

Part 1:
Low-voltage electrical safety

Low-voltage systems

What does *low voltage* mean?

According to the Regulation, *low voltage* means "a potential difference (voltage) from 31 to 750 volts inclusive, between conductors or between a conductor and ground."

Low-voltage electrical systems serve most homes and commercial buildings. Every day, hundreds of workers in British Columbia work safely on and around low-voltage electricity. Small or large, the job is usually handled without incident. Occasionally, however, something goes horribly wrong. A hazard is overlooked, and a worker is injured in an electrical incident.

This part of the book explains why energized low-voltage systems are dangerous. It then outlines the basic steps to de-energize and lock out equipment. This part also describes the hazards that are often overlooked when working on or around low-voltage systems. It tells you what to look for and how to avoid incidents.

Qualified person

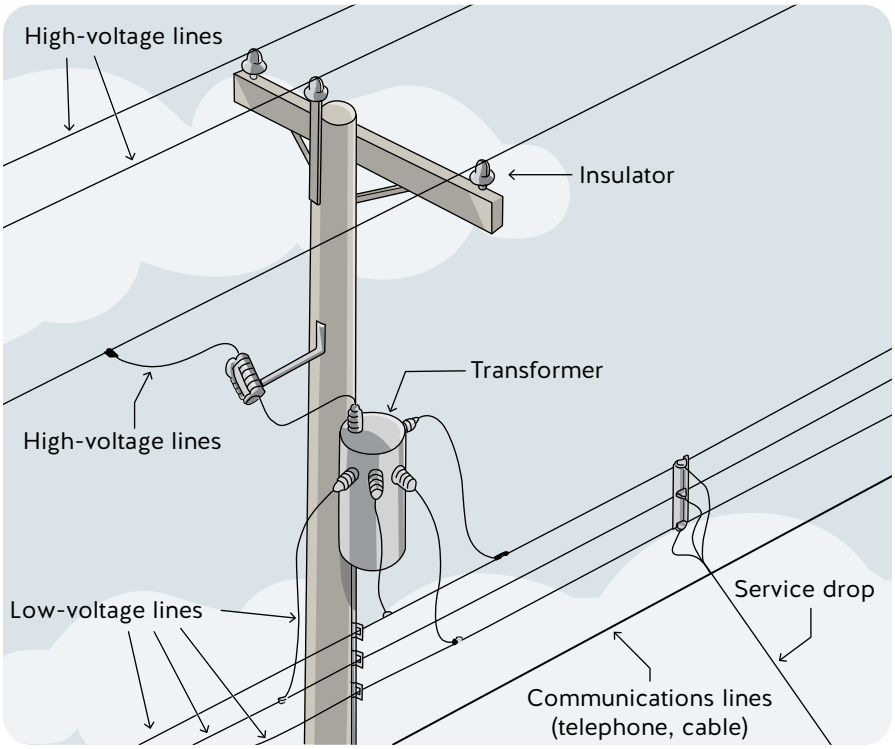
The BC Electrical Code, as adopted under the Electrical Safety Regulation, defines a qualified person as "one familiar with the construction and operation of the apparatus and the hazards involved." For more specific information on who is qualified to do or supervise electrical work and testing, consult the Electrical Safety Regulation or contact Technical Safety BC.

Identifying low-voltage overhead conductors

Utility poles generally carry both low-voltage and high-voltage conductors (power lines). They also carry communications lines, such as cable television and telephone lines. High-voltage conductors are always installed at or near the top of the utility pole. Low-voltage conductors are usually installed below the high-voltage conductors (see illustration on page 3).

If there is a transformer on the pole, lines from the high-voltage conductors feed the transformer. The transformer reduces the voltage for distribution through low-voltage lines to homes (120/240 V) and commercial and light industrial buildings (typically 347/600 V). Electricity travels through the low-voltage distribution lines to the service drop (located on the building), taking power to individual customers.

Employers are responsible for accurately determining the voltage of all power lines in the work area. Contact the utility owner and review the procedures on Form 30M33 to determine the correct voltage and limits of approach.



You can often identify overhead electrical conductors by their placement on the pole.

Abbreviations

This book uses the following abbreviations:

A	ampere
mA	milliampere
V	volt
kV	kilovolt (1 kV = 1000 volts)
kVA	kilovolt ampere

Why energized low-voltage systems are dangerous

You may think that low-voltage contact is much less dangerous than high-voltage contact. People often believe that a mistake made while working on a low-voltage system means only a quick flash and the tripping of a circuit breaker. This is a common misunderstanding.

There are more injuries from low-voltage systems (especially 347 V systems) than there are from high-voltage systems. An electric current through your heart can cause an irregular heartbeat or a heart attack.

Electric shock can also cause your muscles to contract. This may prevent you from releasing your grip, thus extending your exposure to the current. In some instances, low-voltage contact can cause serious shock and burn injuries and even death. See "Types of electrical injuries," pages 48–51.

Almost all voltages are potentially dangerous because of the shock hazard. With low voltages fed by high-capacity transformers, the potential for arc flashes is an additional hazard that can cause serious injuries.

Arc flashes

You don't have to be physically touching energized equipment or a power line to be seriously injured or killed. An arc flash can occur when energized electrical equipment or circuits are exposed and a worker interacts with the equipment in a manner that could cause an electrical fault, or when energized conductors are short-circuited or grounded. Arc flash burns are the most common electrical injury. Fatal arc flash burns can occur from a distance of 3 m (10 ft.).

Two factors can make energized low-voltage equipment extremely hazardous:

- The small working clearances between low-voltage components leave little room for error when using tools.
- Low-voltage equipment in some industrial services may be supplied by an electrical system that can feed incredible amounts of energy into a fault (caused by a short-circuit, for

example). In such cases, a fault can cause an intense, persistent, and rapidly expanding arc of radiant energy to build in a split second. This energy is released suddenly in a restricted space. The flames can reach up to 3 m (10 ft.) and can cause terrible burns on anyone exposed to them. Arc flash incidents often leave the electrical structure a charred and melted wreck. The intense heat generated can be several thousand degrees.

As well as causing fire, the heat from an arc flash can melt solids, vaporize liquids, and expand gases. This results in a huge buildup of pressure, which is called an arc blast. The blast can result in physical trauma, cause thermal burn, destroy equipment, and hurl objects and pieces of metal onto nearby workers. In some tests, the noise from an arc blast reached 140 decibels, which could cause hearing damage. Arc blast pressure injuries can usually be prevented by standing to the side of the equipment while operating the switch disconnect.

Working near energized equipment

Uninsulated energized parts of low-voltage electrical equipment and conductors must be guarded by approved cabinets or enclosures. If not, the energized parts must be in a suitable room or enclosed area that is accessible only to qualified and authorized persons.

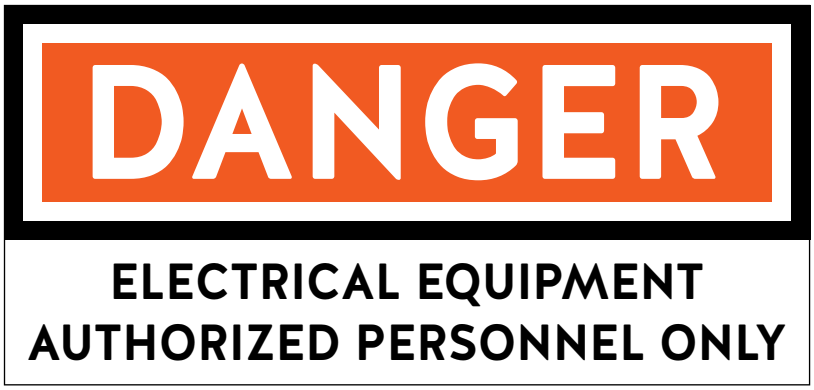
Warning signs limiting entry must mark each entrance to a guarded location containing uninsulated and exposed energized parts.

If uninsulated energized parts are not guarded with approved cabinets or enclosures:

- Suitable barriers or covers must be provided if a worker unfamiliar with the hazards is working within 1 m (3.3 ft.) of those parts.

  or

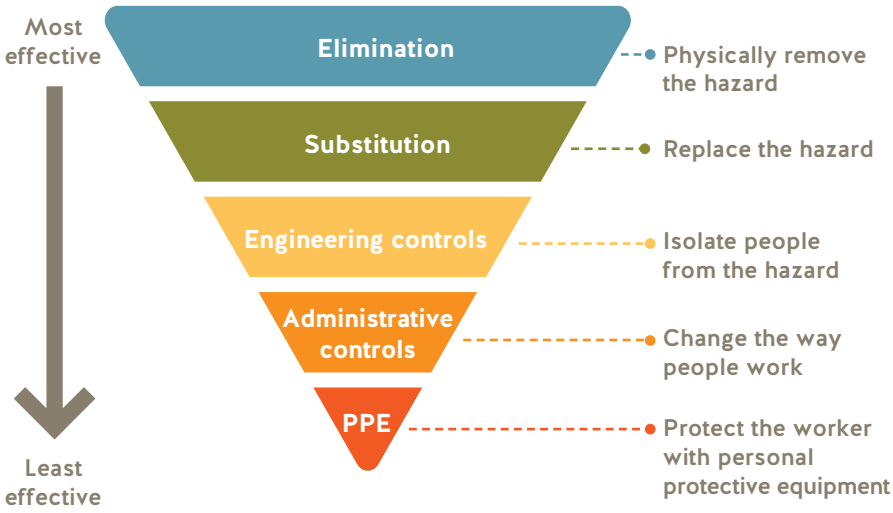
- The worker must be informed of the potential hazards and must follow written safe work procedures.



The hierarchy of controls

When considering how to reduce risk, there's a certain order you should follow. This is called the hierarchy of controls. It's important to follow the hierarchy rather than start with the easiest control measures.

While the controls are listed in order of effectiveness, you should consider all five types of controls. They often work best in combination.



1. **Elimination.** Eliminating the hazard completely is always the first choice.
2. **Substitution:** Substitution involves replacing the material or process with a less hazardous one.
3. **Engineering controls.** If you can't eliminate the hazard or substitute a safer alternative, engineering controls are the next-best options. These involve using work equipment or other means to prevent workers from being exposed to a hazard. Engineering controls are physical changes to the workplace and include equipment guarding, de-energization and lockout (see "De-energization and lockout" on page 8), and many other options.
4. **Administrative controls.** Administrative controls involve identifying and implementing safe work procedures so your workers can perform their job duties safely. An example

of an administrative control is implementing person-check procedures for a worker doing electrical work alone or in isolation.

5. **Personal protective equipment and clothing.** Using personal protective equipment is another important control to protect workers. When working on energized equipment, workers need insulated tools and special clothing. See “Personal protective equipment and clothing” on page 11.

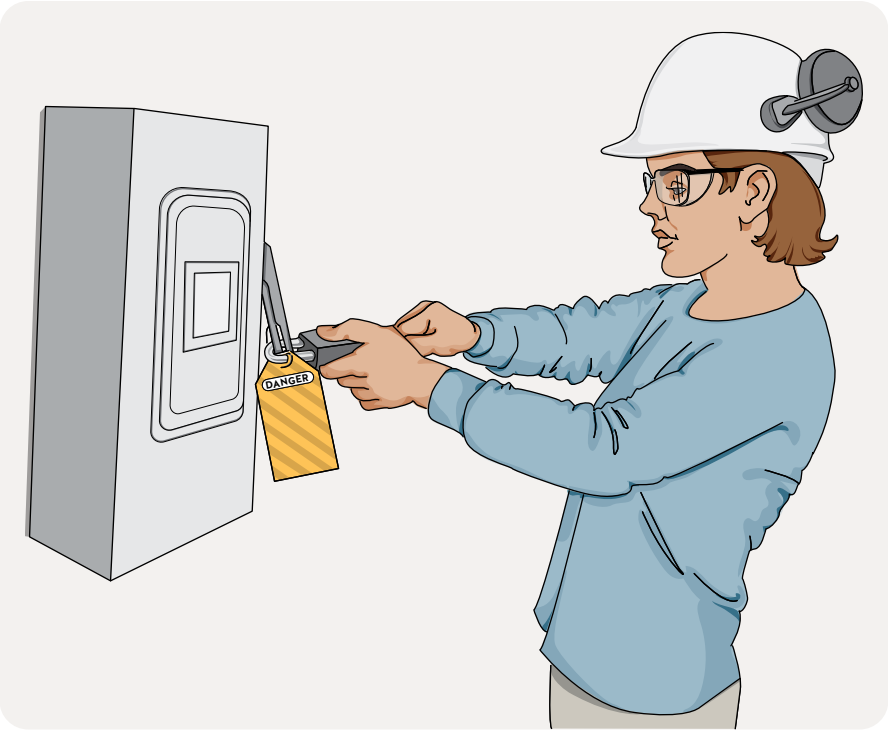
De-energization and lockout

Because of the hazards of working on energized low-voltage equipment, if maintenance work is required, the first choice is to de-energize and lock out the equipment. De-energization and lockout prevents the release of energy that could cause injury or death. Locks are used to make sure no one accidentally turns on equipment while workers are performing maintenance on it.

Maintenance is any work that keeps machinery or equipment in a safe operating condition. This includes installing, repairing, cleaning, and lubricating equipment, as well as clearing obstructions to the normal flow of material.

As a worker, you must follow your employer's safe work procedures to de-energize and lock out equipment. At a minimum, a procedure should include the following five steps:

1. Identify the machinery or equipment that needs to be locked out.
2. Shut off the machinery or equipment. Make sure that all moving parts have come to a complete stop or safe state. Also make sure that the act of shutting off equipment does not cause a hazard for other workers.
3. Identify and de-energize the main energy-isolating device (for example, a switch or valve) for each energy source. There may be more than one source of power, such as control voltage from a separate source.
4. Apply a personal lock to the energy-isolating device for each hazardous energy source, and keep the keys to the lock in your possession. Ensure that all parts and attachments are secured against inadvertent movement. Each worker must apply a personal lock.
5. Test the lockout to make sure it's effective and to verify that all live components have been de-energized. Before testing, ensure that all workers are clear of the hazard and that no hazard will be created if the process is not effective. You can test de-energization and lockout after each energy-isolating device is locked out or after a group of nearby devices is locked out.



Apply a lock to the electrical disconnect switches before working on the equipment.

Safe work procedures for work on electrical equipment should also include the following:

- Steps to ensure that all work has been completed on a circuit before it is connected to the power source
- Who is qualified to test electrical circuits
- What types of testing devices are acceptable

Lockout requirements

For more information on lockout, see the following:

- Occupational Health and Safety Regulation, Part 10: De-energization and Lockout
- *Controlling Hazardous Energy: De-Energization and Lockout* (WorkSafeBC publication)

Working on energized equipment

For most work, you must de-energize electrical equipment because there is a high risk of injury when working on energized equipment. It may be possible to schedule such work outside of normal work hours to limit the inconvenience.

Sometimes it is not practicable to completely disconnect low-voltage equipment before working on it. For example, it may be necessary to have equipment running in order to test it or fine-tune it. In such cases, the work must be performed by workers who are qualified and authorized to do the work. They must follow written safe work procedures.

You should observe the following general precautions when working on energized equipment (but note that these are not a substitute for proper training and written safe work procedures):

- **Think ahead.** Assess all the risks associated with the task. Plan the whole job in advance so you can take every precaution, including arranging for help in case of paralyzing shock. Consider holding a pre-job safety meeting to discuss the job with all workers before starting the work.
- **Know the system.** Make sure accurate, up-to-date information is available to everyone working on the system.
- **Limit the exposure.** Expose live parts for as little time as necessary. This does not mean you should work hastily. Be organized so you can do the job efficiently.
- **Cover exposed live metal.** Use insulating barriers or shields to cover live parts.
- **Cover grounded metalwork.** Cover grounded metal parts with insulating material as much as possible.
- **Limit the energy to reduce the risk.** Take all practical steps to ensure the fault current at the point of work is kept as low as possible while the work is in progress. For example, when measuring voltage, do it on the load side of the circuit-protective devices with the smallest current rating. Current-limiting devices can be used to reduce the risk of an arc flash.

- **Remove metal rings, bracelets, and wristwatches.** These could cause a short-circuit if there are small clearances. If it is necessary to wear MedicAlert bracelets, secure them with transparent surgical tape, adhesive tape, or rubber bands.
- **When operating a safety switch, use one hand and turn your face and body to the side.** Limit possible injuries by not placing body parts directly in front of energized equipment when there is danger of an arc flash.
- **Avoid electrical contact when working in awkward positions.** If you must work in an awkward or unbalanced position and reach with your tools, use insulating cover-up material on the tools to avoid contact with live conductors.
- **Use the correct equipment and clothing.** See "Personal protective equipment and clothing" below.

Personal protective equipment and clothing

Employers are responsible for providing any specialized personal protective equipment and clothing necessary for work on energized equipment. Supervisors must ensure that workers use the clothing and equipment. Workers are responsible for inspecting the equipment before use and for using it properly.

When working on energized equipment, you need the following protective equipment and clothing:

- Insulated tools to avoid shocks and prevent accidental short-circuits
- Rubber gloves (or leather gloves for testing equipment)
- Cover-up blankets to avoid accidental contact with live equipment
- Shock-resistant safety boots or shoes (with the appropriate CSA symbol)
- Safety glasses, goggles, or a face shield to protect against molten metal or ultraviolet light
- Arc-rated clothing if there is a risk of an electric arc that could cause a fire

Regulation requirements

If you must work on energized low-voltage equipment, see the following requirements in the Regulation:

- Sections 8.14–8.17, Eye and Face Protection
- Section 8.22, Footwear
- Section 8.31, Flame Resistant Clothing
- Sections 10.2 and 10.3, De-energization and Lockout

Safety glasses normally used on construction projects to protect against debris are not designed to prevent injuries from the ultraviolet light of electric arc radiation. If the risk is high, de-energizing must be the first choice. If work has to be done on live equipment, polycarbonate safety glasses are required. However, you should consider using a complete polycarbonate face shield. Polycarbonate glasses will filter out most of the ultraviolet light. Yellow-tinted glasses will filter out more blue-spectrum light without making it too dark to work. However, even the best safety glasses cannot protect against an electric arc or a fireball.

When working on energized low-voltage equipment, workers need protective equipment, including insulated tools, safety eyewear, rubber gloves, and shock-resistant footwear.

Flame-resistant clothing

If there is a fire hazard, workers must wear flame-resistant clothing. Consider wearing clothing made of flame-resistant cotton or wool blends. The fabric should have a smooth, tightly woven finish.

Avoid clothing made of nylon, polyester acetate, or acrylic fibres. These fabrics are moderately flammable and will melt while burning, causing deep and extensive burns to the skin. Also avoid laminated fabric containing polyurethane sponge because it ignites and burns quickly. Many synthetic materials don't char or turn to ash when they reach ignition temperatures. Instead, they melt and form a hot, tacky residue that sticks to skin and burns the flesh.

Common problem areas

This section highlights common problem areas and gives examples of actual incidents where workers have suffered injury while working on electrical equipment. It also offers suggestions to help you work safely.

Lighting circuits (347 V)

When testing lighting circuits, you do not require prior written permission from WorkSafeBC as long as you follow established safe work procedures and use CSA-approved testing equipment and tools.

347/600 V systems are usually used in commercial and industrial buildings, and lighting at 347 V is common. De-energize and lock out the power supply before working on electrical components. Then test all conductors to ensure de-energization.

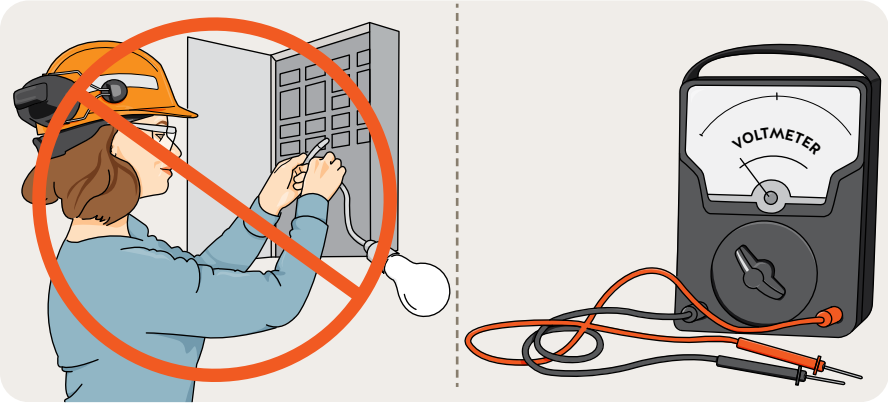
Written permission from WorkSafeBC is required to work on energized parts of electrical equipment connected with lighting circuits operating at more than 250 volts-to-ground.

Lockout is required at the electrical panel before replacing any part associated with the lighting circuit.

Checking voltages with a meter

To check voltages with a meter, you must be qualified and know the hazards. Testing can be dangerous, particularly if someone is unqualified, with little or no electrical experience. For example, you must never use an improvised test lamp, which can cause an electric arc. If you incorrectly connect a meter to measure current rather than voltage, the low resistance of the ammeter could allow an abnormally high current to flow when voltage is checked.

Workers often lean close to equipment to see where to put the test probes. If an electric arc occurs, your face will bear the brunt of the intense heat. You must wear goggles or safety glasses. If there is a high risk, you must use a full-face shield. See page 12 for more information on safety glasses.



Use approved portable meters and leads, not improvised test lamps.

An electric arc may occur in one of the following ways:

- An improvised test probe (for example, a screwdriver blade or bare alligator clips) with more than the necessary exposed metal may create a phase-to-phase or phase-to-ground short-circuit on the closely spaced fuse clips or bus bars of a 600 V panel.
- A screwdriver being used on energized equipment may slip and ground out the live parts.
- A multimeter that is not switched from the ammeter or ohmmeter mode may create a short-circuit across phases when the probes are placed on the conductors to measure voltage. The multimeter may disintegrate if the internal fuse is not designed to protect against this kind of misuse. This, however, is not the worst that can happen. The arcing caused at the test probes can ionize the air, resulting in a fireball. This problem should not occur if testing equipment meets the requirements listed below.

The testing equipment must meet CSA standards or another standard acceptable to WorkSafeBC. Alternatively, acceptable testing equipment must have the following characteristics:

- It has high rupturing capacity fuses or alternative protective circuitry to protect you in case of a fault.
- Measurement ranges are clearly and unambiguously marked.
- The insulation on the instrument leads is in good condition and is rated to the maximum voltage reading of the meter.
- The lead wires are not cracked or broken. They have a current-carrying capacity (ampacity) that meets or exceeds the maximum current measurement of the meter.
- There is only a minimum amount of exposed metal at the probe tips to avoid short-circuiting closely spaced live parts.

When checking voltages with a meter, you must use an approved meter and should follow safe work practices, which include the following:

- Set the meter to the correct mode and voltage range. If possible, check its operation on a 120 V convenience outlet (for example, a system with a low available fault current). Multi-range instruments should always be turned off or set to their maximum AC voltage range when not in use.
- Use a single-function meter (voltmeter) rather than a multimeter if possible.
- Where possible, test on the load side of the fuse or circuit breaker that has the smallest rating.
- Make sure meter leads are connected to the appropriate terminals of the meter for the measurement involved.
- Set the meter at the highest range that will allow for the expected reading to be achieved.

Working alone

Electrical work is often done by someone working alone or in isolation. For example, it may be done on a rooftop, or it may take place after regular hours so de-energization does not inconvenience as many workers.

The employer must develop and implement a written procedure for checking the well-being of a worker doing electrical work alone or in isolation. The procedure must include the following:

- The time interval between checks
- The procedure to follow in case the worker cannot be contacted, including provisions for emergency rescue
- The person designated to establish contact with the worker at predetermined intervals and at the end of the work shift

Consult the worker assigned to work alone or in isolation when determining the time intervals.

Storage batteries

Some batteries may have a high level of stored energy (for example, batteries in battery-powered vehicles or large banks of storage batteries). The voltage of some battery banks may be high enough to be a shock hazard. However, short-circuiting by a ring or wristwatch bracelet can severely burn you, even if no shock hazard exists.

You must use proper protective equipment for testing, connecting, or disconnecting batteries. To protect against battery acid, use a face shield, plastic apron, and plastic gloves. There must be an eyewash station nearby in case of splashes to the eye. You must use insulated tools (for example, wrenches or screwdrivers).

Ladders and other long tools or equipment

When working on or near energized electrical equipment, use fibreglass ladders and nonconductive tools. Do not use metal ladders, wire-reinforced wooden ladders, and other long tools or equipment, such as gutters or scaffolding, if there is a possibility of contacting bare energized components.

Low-voltage sections of unit substations

Workers have been injured while replacing components on low-voltage sections of unit substations. Unfortunately, this type of low-voltage section of the switch gear is often close to the supply transformer terminals — a place where there is very little impedance to limit the flow of fault current. If there are a number

of loads on a bus bar, the supply transformer may be quite large. The larger the transformer, the larger the current that will pour into a fault. Working on live installations of this kind can be extremely dangerous. De-energizing must be your first approach in such cases.

Some electrical equipment is designed to electrically isolate sections of the unit substations. You can maintain this equipment safely without de-energizing all of it. Consult the manufacturer's instructions and refer to written safe work procedures.

Working near low-voltage overhead lines

Individual buildings such as houses often receive low-voltage electricity from overhead distribution lines and service drops. These lines are usually out of reach. However, workers using a ladder may come close to low-voltage lines. These lines are not insulated well enough for a person to touch them safely. Consider them energized and dangerous.

Sometimes a work process, such as window washing or painting, results in a temporary encroachment by a worker into the area of low-voltage lines. In that case, one of the following must occur:

- Barriers or covers must be provided if a worker unfamiliar with the hazards is working within 1 m (3.3 ft.) of those parts.
- The worker must be informed of the potential hazards and must follow written safe work procedures.

Sometimes there may be a permanent change in the building, such as a new stairway or work platform, that allows workers to get near the low-voltage lines. In this case, qualified and authorized workers must reposition or cover the lines with conduit or other approved cover to protect workers from contact.

Portable electrical equipment and extension cords

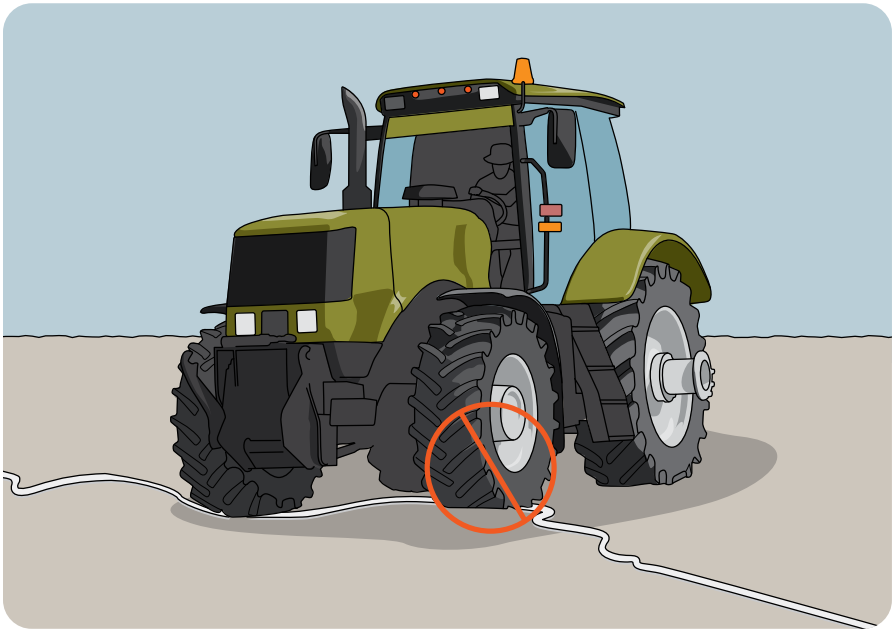
Portable electrical equipment includes extension cords and power tools that are used on 120 V systems at 20 A or less and are not hard-wired to a permanent electrical system. Maintain portable equipment in good repair and make sure it is suitable

for the conditions where it is being used. For example, the outer jacket of an extension cord may appear undamaged but may conceal a broken ground conductor. Portable electrical equipment must be effectively grounded unless it has double insulation or equivalent protection.

Additional precautions are needed when using portable electrical equipment outdoors or in wet or damp locations. This equipment, including temporary lighting, requires a class A–type ground fault circuit interrupter (GFCI) installed at the receptacle or on the circuit panel unless another means of protection is provided that is acceptable to WorkSafeBC, such as the Assured Grounding Program.

Workers have received an electric shock or been badly burned as a result of contact with damaged extension cords. Electrical cords are often left unprotected, stretched across the ground in the path of machinery. Over time, these cords become frayed, cut, and damaged from constant use and the pressure of vehicle traffic running over them.

Sometimes workers leave wires exposed or repair a cut cord only with electrical tape. These cords are particularly hazardous when the ground is wet.



Damaged cords can result in serious electrical injuries.

GFCIs and Assured Grounding Programs

A GFCI is a device that detects any leakage current in an electrical circuit and trips (turns off) the circuit whenever the leakage current is greater than 5 mA. GFCIs are required whenever portable electrical equipment is used outdoors or in wet or damp locations.

WorkSafeBC allows use of an Assured Grounding Program as an alternative to using GFCIs in such conditions. However, the use of an Assured Grounding Program requires permission from the electrical authority that has jurisdiction in the area.

Using GFCIs

To prevent nuisance tripping of GFCIs, the following safe work practices are recommended:

- Mount GFCI receptacles and GFCI circuit breakers in dry locations. If this is not possible, use portable GFCIs that are rated rainproof.
- Connect only one power tool to each GFCI.
- Cover power tools to protect them from the rain when they are not in use.
- Store power tools and extension cords in a dry location.
- Maintain extension cords and power tools in good condition.
- Use extension cords that are rated for hard usage or better.
- Don't use extension cords longer than 45 m (150 ft.).

Assured Grounding Program

Before an Assured Grounding Program can be used instead of GFCIs, a variance must be obtained from the electrical authority having jurisdiction. The purpose of an Assured Grounding Program is to ensure that the black wires (hot), white wires (neutral), and, in particular, green wires (ground) of extension cords and power tool cords are properly connected. This is done by testing every extension cord and power tool when it is first put into service, following repairs, and every three months.

An Assured Grounding Program has four parts:

1. **Worker training.** All workers using extension cords and power tools under an Assured Grounding Program must be trained on the program.
2. **Daily visual inspection.** The workers using the extension cords and power tools must check them for damage daily. Any damage found must be repaired before the workers use the cord or tool. Don't splice damaged extension cords and power cords of tools. Either replace the cords or shorten them to remove the damaged portion.

3. **Continuity and polarity testing every three months.** A qualified worker must test every extension cord and power tool for circuit continuity and correct polarity before they are used for the first time, following repairs, and during the months of January, April, July, and October. A qualified worker is a person who has been authorized by a supervisor to perform the task and who has received appropriate training.
4. **Colour-coding extension cords and power tools.** Extension cords and power tools that have been tested must be tagged with a coloured band about 10 cm (4 in.) from the plug. Coloured electrical tape is suitable for this purpose. A different colour is required for each quarter of the year. The following colours are standard for all worksites using an Assured Grounding Program in B.C.:

Red	January, February, March
White	April, May, June
Blue	July, August, September
Green	October, November, December

For example, a new extension cord tested on February 8 will have a red tag at the plug. The extension cord must be retested and marked with a white tag during April.

Part 2:
High-voltage electrical safety

High-voltage systems

What does *high voltage* mean?

According to the Regulation, *high voltage* means "a potential difference (voltage) of more than 750 volts between conductors or between a conductor and ground."

Working safely around high-voltage conductors is a challenge for many workers in B.C. High-voltage systems are generally associated with utility services and heavy industry, such as pulp mills, sawmills, and mining operations. With care and precise planning, you can operate equipment and tools safely around these potentially lethal power lines.

This part of the book is designed for workers who must work close to high-voltage equipment and conductors. It explains why high-voltage systems are dangerous. It lists the minimum distances you must keep away from live power lines and explains what you should do if you can't maintain these limits of approach. It also describes common problem areas. Finally, it gives safe work practices for working close to overhead lines around construction sites and for operating equipment around power lines.

When this book mentions the owner of a power system, keep in mind that B.C. has a number of electrical utilities. BC Hydro is the largest, but there is also FortisBC. Power is also provided by several municipalities, universities, and other corporations.

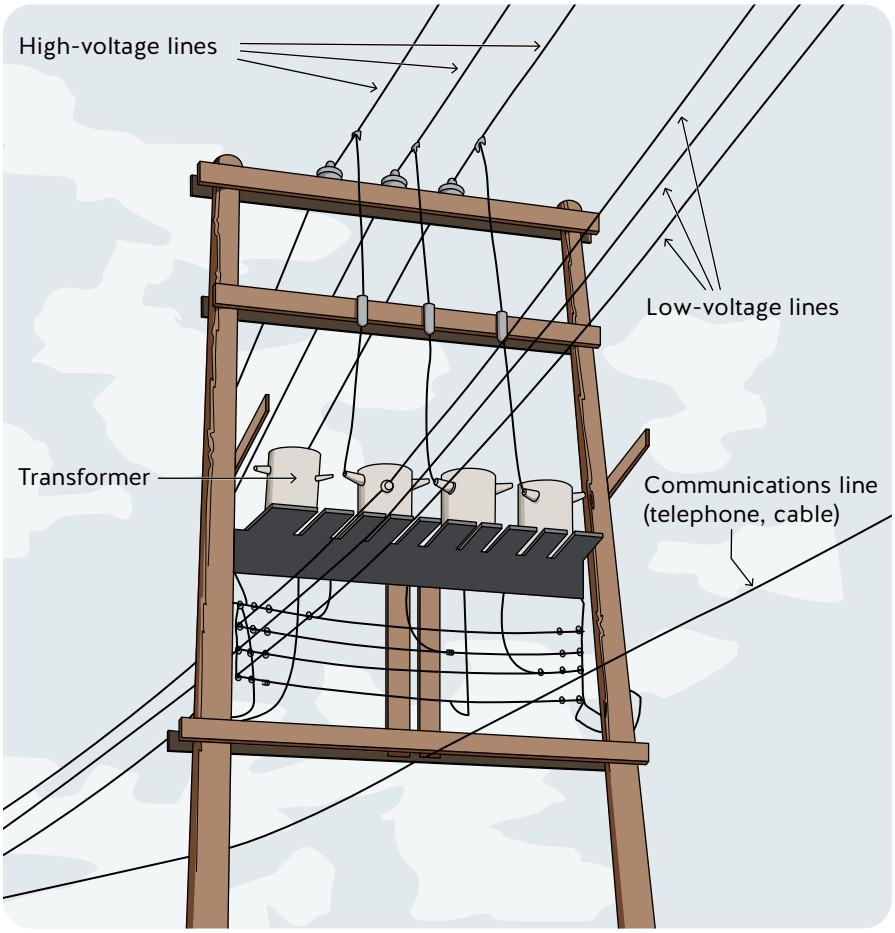
Work on high-voltage systems

This book is not a manual for work on high-voltage systems. Any work on high-voltage equipment and power systems must be performed by qualified and authorized workers in accordance with written safe work procedures acceptable to WorkSafeBC. Requirements for working on these systems are specified in Part 19 of the Regulation. For de-energization and lockout, workers must follow the safe work procedures set out by the employer or owner of the power system.

Identifying high-voltage overhead conductors

Overhead high-voltage conductors are usually installed at the top of utility poles. If there is more than one conductor, they are usually placed side by side on a cross-arm. If there is a transformer on the pole, the high-voltage conductors are

mounted above it. These are general guidelines. Employers are responsible for accurately determining the voltage of all conductors on the pole or in the work area.



On older systems, transformer bank platforms may be installed using an H-frame configuration. They are most often seen in alleys. The illustration on page 3 shows a common single-pole configuration.

Electrical distribution system

Generating stations and substations send electricity via high-voltage transmission lines at 69–500 kV (69 000–500 000 V). These lines are located on top of large towers or poles in transmission rights-of-way. Substations in urban areas reduce the voltage and distribute electricity via overhead or underground distribution lines. The high-voltage lines on utility poles on our streets are typically at 12.5–25 kV (12 500–25 000 V).

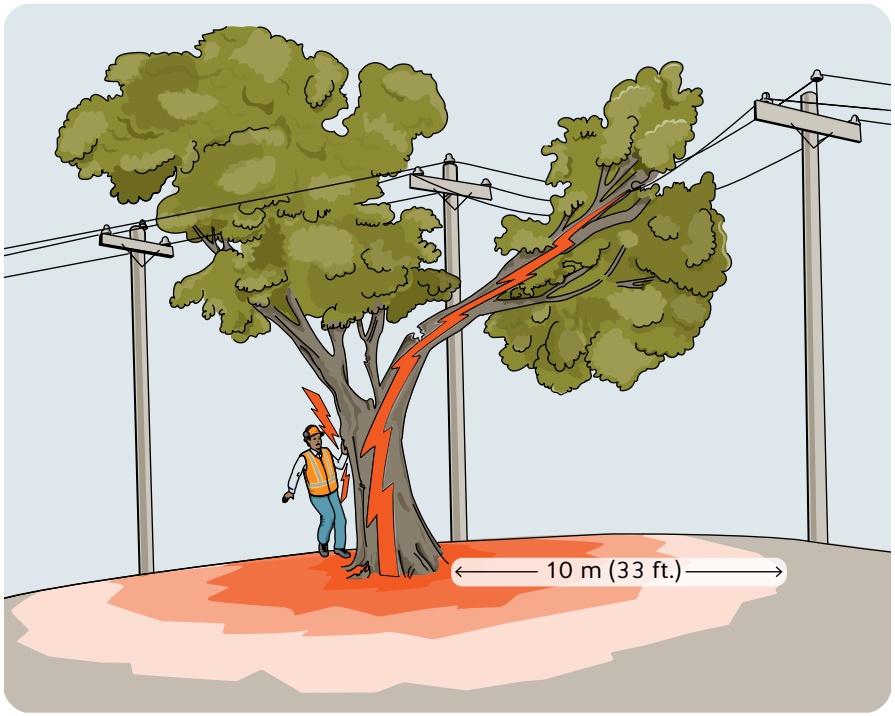
Why energized high-voltage systems are dangerous

Incidents involving high voltages can result in severe injuries and death. When an electric current passes through the body, it generates heat and can extensively damage internal tissues. In some cases, the entry and exit wounds are so severe that a foot or hand has to be amputated. The electric current can also stop the heart. See “Types of electrical injuries,” pages 48–51.

Electricity seeks all paths to the ground. These paths might include a tree, mobile equipment, or the human body. If a part of the equipment you are operating contacts a live power line, then anything in contact with your equipment will also become energized. The earth itself could become energized for some distance around your unit. Similarly, the ground could become energized if a tree makes contact with a power line or if a broken power line falls to the ground.

When the electrical flow reaches the ground, it spreads out like ripples in a pool of water. The voltage is very high where electrical contact is made with the ground. Farther away from this point, the voltage gradually drops off. Wet ground will extend the distance and the danger.

The voltage at the contact point is approximately the same as the line voltage. With power lines up to and including 69 kV (69 000 V), the voltage drops to zero about 10 m (33 ft.) away from the contact point with the ground. With higher voltages, such as those carried by the lines along transmission rights-of-way, the voltage might not drop to zero until you are as far away as 32 m (105 ft.).



The safe distance shown here — 10 m (33 ft.) — is for line voltages up to and including 69 kV (69 000 V).

If anything, such as a tree or equipment, touches a high-voltage power line or if a power line falls to the ground, electricity will flow to the ground. This will energize the tree or equipment and anything in contact with it. The surrounding ground may be extremely hazardous. The voltage gradually decreases from the point of contact until it reaches zero.

Whenever there is a voltage difference between one point and another, a current will flow. It is this flow of electricity (the current) that can cause serious injury or death.

Step potential

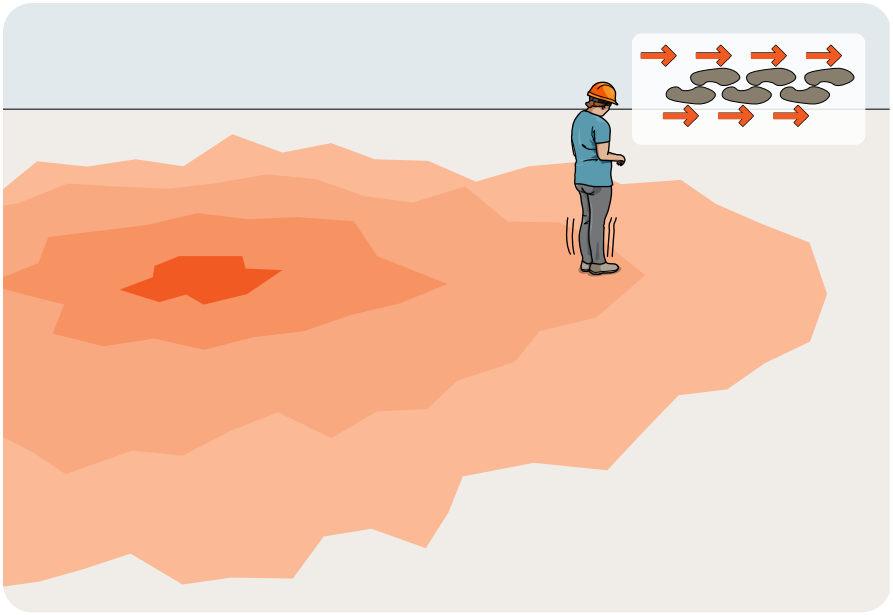
Step potential is the voltage difference between two places that are a step apart on energized ground. For example, if you are standing on energized ground, there could be a significant difference in voltage between where one foot and the other are placed. An electric current could flow up one leg and down the other.

Step potential: If your feet are spread apart on energized ground, electricity can flow through your body from the area of higher voltage to the area of lower voltage.

If your feet are close together and touching, you are fairly safe. Since there is almost no voltage difference between the places where your feet stand, electricity is unlikely to seek a path through your body.

If you find yourself on energized ground and need to move away, you can avoid electric shock because of step potential by making sure there is no space between your feet. Shuffle your feet while moving out of the energized area. When shuffling, keep your feet touching at all times to maintain the same voltage in both feet.

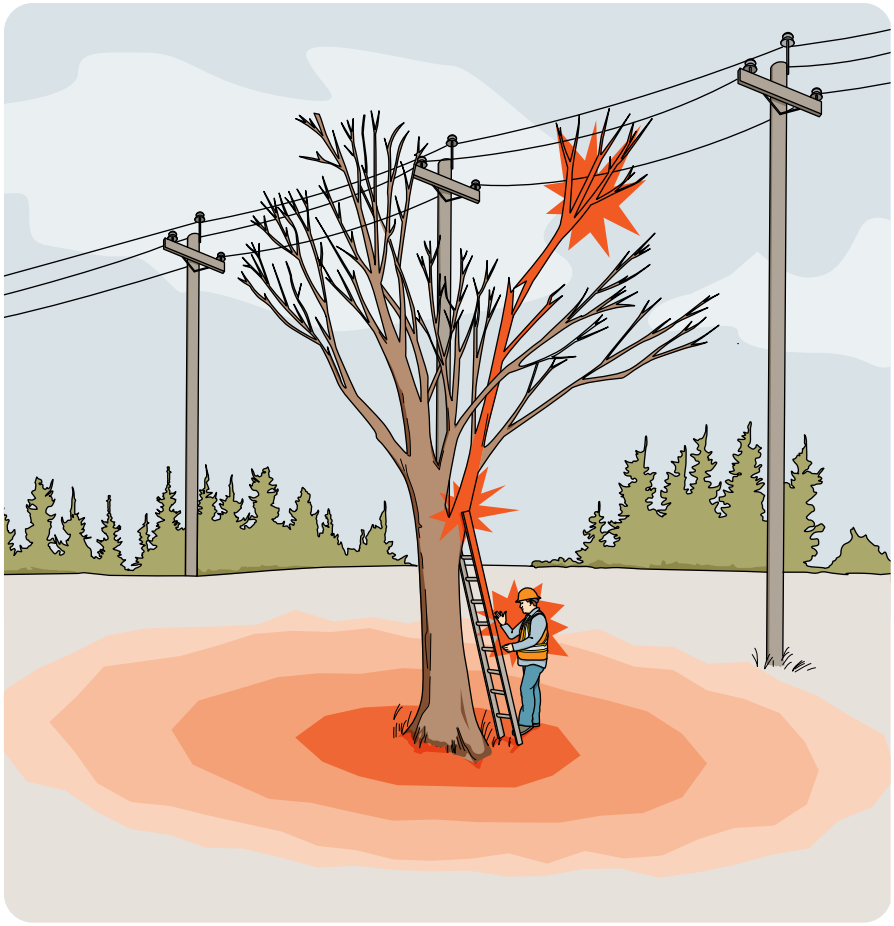
Rescue workers must not enter an area that might be energized. Anyone trying to reach an injured worker in an energized area would be exposed to the same danger of step potential. The power lines must be de-energized and grounded before rescue workers or first aid attendants approach.



If you must move on energized ground, shuffle (heels do not pass toes) while keeping your feet together and touching each other. Don't take steps.

Touch potential

Touch potential is another danger that comes from the difference in voltage. It occurs when you touch something that is energized while standing on lower-voltage ground. For example, if a tree or equipment is in contact with a power line, it will be energized to the same voltage as the power line. The surrounding ground will be energized to a lower voltage. If you touch the energized tree or equipment at the same time as you touch the ground with your feet, electricity will flow through your body from the higher-voltage tree or equipment to the lower-voltage ground.



Touch potential: Trees and equipment become energized when they contact a power line. Electricity can flow through anyone who touches the energized tree or equipment, often causing serious injury or death.

Safety in the event of power line contact

Power lines can be brought down by storms, trees, ice, motor vehicle accidents, and other events. Even if the power line does not come down, if it is in contact with a tree, vehicle, or mobile equipment, the tree, vehicle, or equipment will be energized and so will the ground.

Workers in a vehicle or mobile equipment

If you are in a vehicle or mobile equipment that makes electrical contact, stay in the vehicle or mobile equipment if it is safe to do so.

You are relatively safe inside your vehicle as long as you don't touch or step onto anything outside the vehicle that will provide a path for the current to flow to ground. Wait until the owner of the power system has verified that the power lines have been de-energized and grounded. In one incident, for example, the raised box of a dump truck hit a 69 kV (69 000 V) power line. The driver stayed in the truck and was not injured even though all 18 tires were damaged by the electric current.

If the vehicle is not damaged and is not entangled with the power line, it is safe to drive slowly out of the energized area, at least 10 m (33 ft.) clear of the wires and any wet ground. Because of the danger of exploding tires, isolate large mobile equipment with inflated rubber tires and keep workers and other equipment clear of the trajectory zone. There is a danger of exploding tires for up to 24 hours.

If you must abandon your vehicle because of an emergency such as a fire, be aware that the ground below your machine may be energized and use extreme caution.

To make a safe escape, keep both feet together and hands by your sides, and make a short jump from your vehicle. The goal is to ensure that your entire body clears the vehicle and that you land on your feet without stumbling. Don't allow any part of your body to touch the vehicle while you are touching the ground.

Don't take steps away from the vehicle. It is safest to shuffle away without moving your feet more than a few centimetres (a couple of inches) at a time. Keeping your feet together will ensure that you don't straddle two zones with different voltages.

Rescue work around power lines

The main role for rescue workers near downed power lines or energized equipment is to stop people from getting hurt. Here are some safe work practices:

1. **Treat downed lines and anything in contact with a power line as energized.** Energized wires seldom leap about and give off sparks, so you have no way of knowing whether or not they are energized. Even if the line is not energized, automatic switching equipment may restore power to the line without warning.
2. **Park well clear.** When you arrive at the scene, park your vehicle well away from any downed lines. At night, shine a flashlight through the window to make sure you are not parked anywhere near a downed power line.
3. **Stop traffic and keep people clear.** Workers on foot or in vehicles may not see lines that are lying on the ground. The ground surrounding a downed line will be energized. If a live wire comes in contact with a vehicle, or anything else, that object becomes energized. Secure the area and keep everyone back at least 10 m (33 ft.) — more if the voltage is over 69 kV (69 000 V).
4. **Don't become injured yourself.** Regardless of how badly someone is injured, you cannot help if you are injured. Never touch anything that is in contact with a downed power line, including injured or trapped people, puddles, vehicles, or trees. Don't use a dry stick or piece of rope or hose to reach someone, as they will not offer any protection. Don't enter an area that might be energized.
5. **Call the owner of the power system and 911 (or other local emergency number) immediately.** A crew with proper training and equipment will arrive as soon as possible.
6. **Accept confirmation that the system has been de-energized and is safe only from a representative of the power system who is on site.**

General limits of approach

The key to safety is to keep a safe distance from overhead and underground power lines. Part 19 of the Regulation lists the distances that workers must keep away from exposed energized conductors. Table 19-1A in the Regulation gives the general limits of approach. This is the minimum distance from overhead energized high-voltage lines that non-qualified workers and their materials, equipment, and machinery must maintain. Table 19-1B gives the minimum clearance distance required when passing under exposed electrical equipment and conductors (rather than working close to them).

The limits of approach vary with the voltage. The tools and equipment that you hold or operate are an extension of your reach. You must ensure that you have enough room for movement with your tools without violating these limits.

Table 19-1A: Minimum approach distance for working close to exposed electrical equipment or conductors

Voltage, phase to phase	Minimum distance	
	Metres	Feet
Over 750 V to 75 kV	3	10
Over 75 kV to 250 kV	4.5	15
Over 250 kV to 550 kV	6	20

Table 19-1B: Minimum clearance distance for passing under exposed electrical equipment or conductors

Voltage, phase to phase	Minimum distance	
	Metres	Feet
Over 750 V to 75 kV	2	6.5
Over 75 kV to 250 kV	3	10
Over 250 kV to 550 kV	4	13

Table 19-2 in the Regulation gives adjusted limits of approach for specially trained workers. Table 19-3 gives the limits of approach for utility arborists.

Carefully plan the movement of equipment and tools to avoid entering within the general limits of approach. Employers must accurately determine the voltage and minimum limits of approach. To do so, contact the owner of the power system and review the procedures on Form 30M33.

Employers must also ensure the following:

- Supervisors and workers know the location of all electrical power sources in the work area before starting work.
- Supervisors review the general limits of approach with all workers who work near energized high-voltage equipment or power lines.
- Supervisors hold pre-job safety meetings (tailgate meetings) and document the meetings.

Supervisors and workers must maintain the minimum distance from electrical conductors at all times. The minimum distance is measured from the extreme outside dimension of mobile equipment, tools, or materials being handled. The outside dimension may be the tip of an extended equipment boom, a paint roller, or a long pipe that you are lifting. The electrical conductor may be a wire, a transformer, or any other energized component that conducts electricity. All workers need to know the safe limits of approach to electrical conductors and must not get any closer.

Working inside the limits of approach

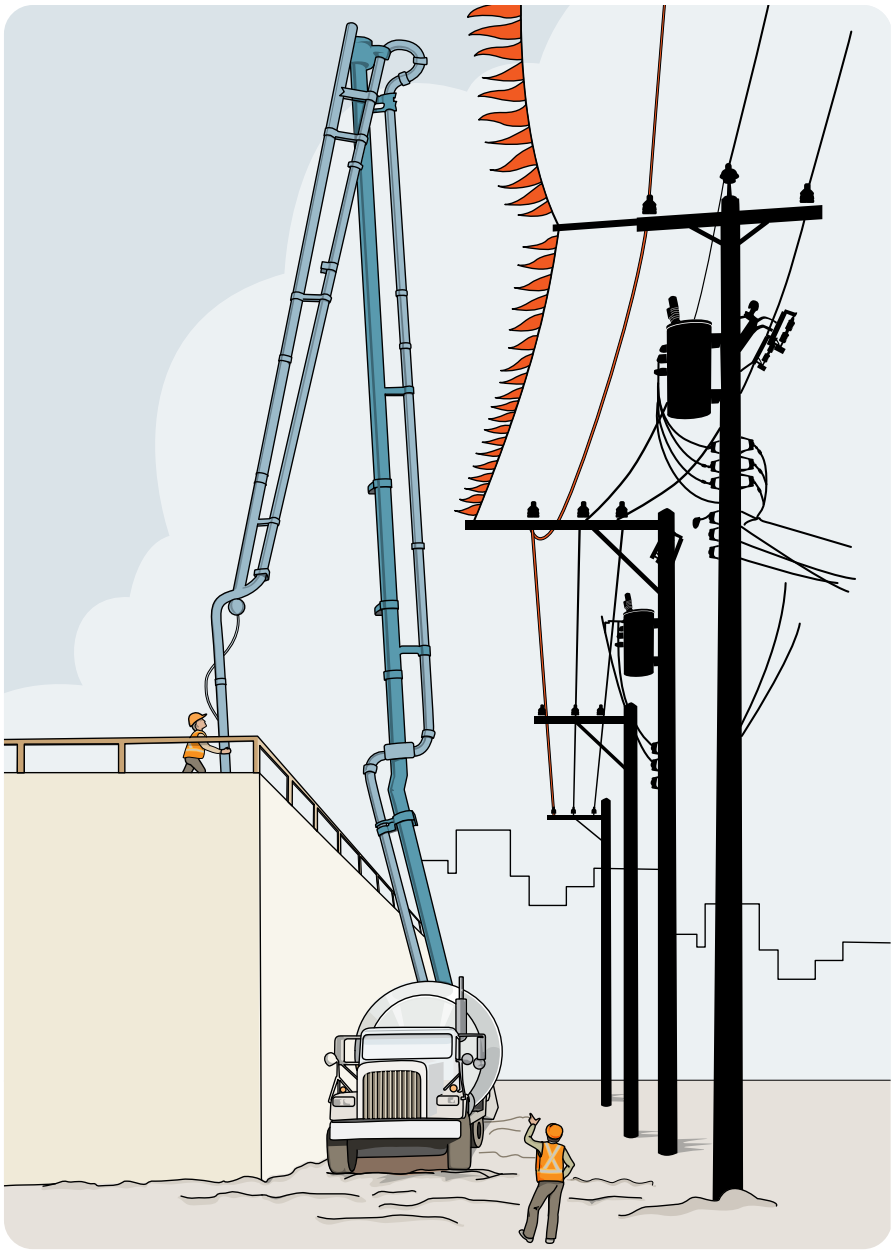
After checking the worksite, you may find that the minimum distance from the electrical conductor cannot be maintained. If inadvertent movement by a worker or equipment may result in either coming closer than the minimum distance, you must follow these steps before proceeding with work:

1. Contact the owner of the power system to decide which of the following options will be taken:
   - Electrical equipment and conductors will be displaced or rerouted.

- If that is not practicable, the equipment will be de-energized (isolated and grounded).
- If neither of the previous options are practicable, the equipment will be visually identified and effectively guarded.

2. Get assurance in writing from the owner of the power system indicating which of the three actions will be taken and when this will be done. The owner of the power system will do this on Form 30M33, available from any WorkSafeBC office or the owner of the power system. No work can be done within the limits of approach until one of the conditions in step 1 has been met and the completed Form 30M33 is on site. It takes time to complete the Form 30M33 process, so it's important to plan ahead.
3. Inform all workers near the power lines of the information in Form 30M33. Make sure they are trained in appropriate safe work procedures.
4. Designate a qualified safety watcher who can monitor equipment and material movement. The watcher gives an instant "stop" signal to the equipment operator when the equipment or load is too close to the electrical conductor. Workers, equipment, tools, and loads must not contact the guarding under any circumstances.

When working within the limits of approach, employers are expected to identify the potential risk. Following the hierarchy of controls, they should do everything that is reasonably practicable to prevent contact with the high-voltage electrical equipment. This includes considering the location of the high-voltage electrical equipment, duration of the job, number of workers exposed, type and amount of equipment being used, collision avoidance devices installed on equipment, and worker training.



Guarding is a visual warning only. The grounded guard wire (with flags) gives warning of approach. The overhead line cover-up, installed by the owner of the power system, has no insulated rating for the purposes of Form 30M33. Workers and equipment must not contact the guard wire or overhead line under any circumstances.

Common problem areas

The rest of Part 2 of this book highlights areas where workers have been injured while working near high-voltage conductors. It also offers suggestions to help you prevent similar incidents and to keep you and your co-workers safe near power lines.

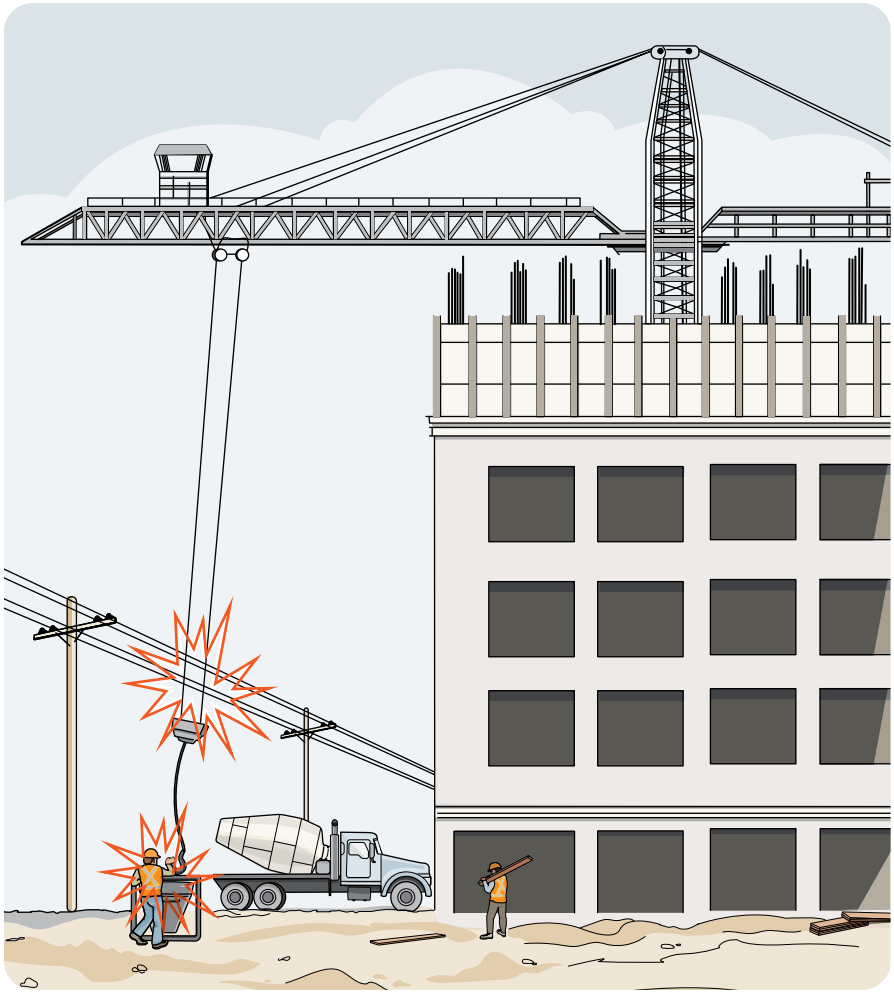
Construction sites near power lines

Each year, workers in B.C. die or are seriously burned as a result of unsafe work practices around energized conductors. The following are reminders to operators of construction equipment and to construction and maintenance workers who must work near power lines:

- Most power lines are found overhead. However, some are buried just a short distance below the surface of the ground.
- The normal operating range of your machine or equipment can often reach either the overhead or the underground power lines above or below you.
- Supervisors and operators of equipment can prevent electrical incidents through knowledge of electrical systems and safe work practices.

Recertifying equipment after electrical contact

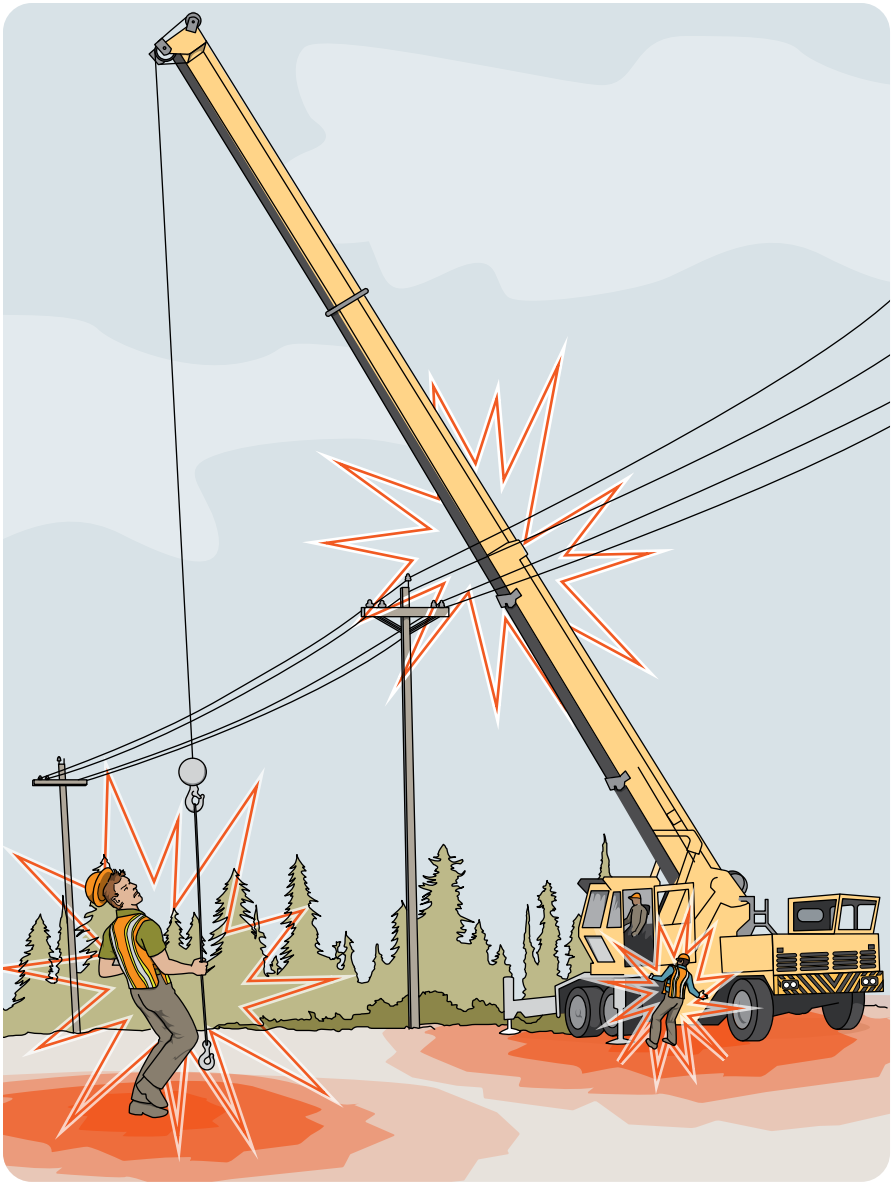
When a machine contacts a power line, the passage of current through the machine can impair the strength of some of its parts. A professional engineer must recertify any hoisting or aerial device that has contacted an energized conductor before it is returned to service. It is recommended that a licensed mechanic check other mobile equipment that has contacted a power line.



Serious injuries or death can result if any part of a crane touches a power line.

Mobile equipment near power lines

Operators of mobile equipment such as cranes, hoists, and backhoes must make sure that no part of the equipment makes contact with an overhead power line. If any part of the equipment contacts an overhead power line, remember that the operator is safer inside the machine than on the ground (see page 31).



If mobile equipment touches a power line, electricity can travel from the power line to a worker touching any part of the equipment, including a pendant control.

If you operate mobile equipment near power lines, take the following precautions:

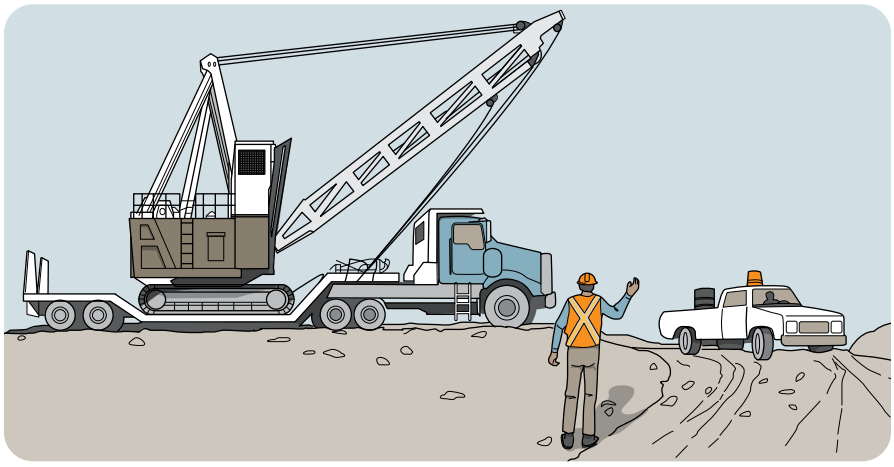
- Keep your mobile equipment, work materials, and tools a safe distance from power lines. This is your first line of defence when operating mobile equipment near overhead power lines.
- If it is necessary to operate equipment close to a power line, consult the table on page 33 to find the minimum distance away from the line you are allowed to work. If it is not possible to keep this distance, the owner of the power system may

need to de-energize or reroute the power line, or provide guarding. Don't proceed until the owner of the power system has given written assurance (on Form 30M33) defining proper safeguards.

- Stand away from your machine when operating the remote controls for the equipment, not beside it. If a power line contact occurs, current will flow through the machine to the ground. If your feet are on the ground and you touch the electrified machine, current will pass through your body to the ground. An electrical contact will also energize the ground around the machine for some distance, up to at least 10 m (33 ft.) — more if the lines carry voltages higher than 69 kV (69 000 V).
- If you must operate controls from the ground, the remote control signal should be carried by radio. In addition, you should stand well clear when operating equipment with a remote control. You must be at least 10 m (33 ft.) away from your machine and the power lines (or farther, depending on the voltage).

Travelling under power lines

Know the height of your load and the height of the power lines you will be travelling under. Always make sure there is sufficient clearance for your load to travel safely under the power lines.



The boom of the grapple yarder has been lowered for transport under power lines.

Pruning or falling trees near power lines

Workers have been killed or injured when doing tree care work or falling trees near power lines. Before workers prune or fall trees close to a power line, a qualified person must inspect the worksite to identify any hazards. This includes situations where any part of a tree is within the general limits of approach or could fall within that distance. The owner of the power system must authorize the person doing the inspection and ensure that the person is qualified.

If tree pruning or falling will come within the general limits of approach, workers must be authorized by the owner of the power system to do the work. Normally the only worker authorized to do this work will be a qualified electrical worker, a certified utility arborist, or an apprentice utility arborist working under the direct supervision of a certified utility arborist or a qualified electrical worker.

Tree pruning or falling is not allowed within the general limits of approach unless both of the following are true:

- A certified utility arborist or qualified electrical worker is present at the site and directing the work.
- At least one additional qualified person, trained in appropriate emergency rescue, is present.

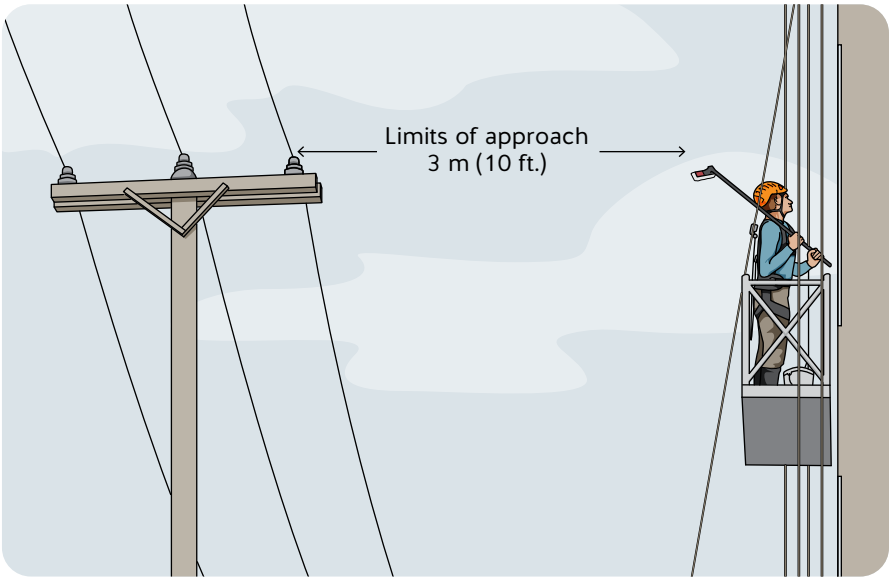
For more information on tree pruning and falling near power lines, see the following:

- Sections 19.30–19.35 of the Regulation
- *Safe Work Practices and Responsibilities for Power Producers* (WorkSafeBC publication)

Scaffolds and other equipment near power lines

The limits of approach must be maintained for all scaffolds and equipment near power lines. For example, when working on scaffolds or window-washing platforms, do not let any tools, such as pipes or rollers, come within the limits of approach. Scaffolds must be positioned and secured in a way that prevents them from coming into contact with adjacent power lines.

Farm equipment can cause incidents if it contacts power lines. Farm workers have received an electric shock when they have lifted metal irrigation pipes, which have then touched overhead power lines. When possible, store metal irrigation pipes at least 30 m (100 ft.) away from overhead power lines.



A tool is an extension of your reach and must not come within the limits of approach.

Utility poles

Don't work close to utility poles if the work could cause a pole to become unstable or if you can't maintain the limits of approach. If any poles are unstable, ask the owner of the power system to support or remove them. Only workers who are qualified and authorized by the owner of the utility may climb poles supporting power lines.

Underground utilities

Low-voltage and high-voltage underground wiring supplies power to schools, commercial buildings, homes, and many other sites. Drilling, excavating, or probing can be dangerous near buried electrical lines. Check with the owner of the power system for the existence and location of underground lines before you start digging.

Workers have died because their shovel blade penetrated a live high-voltage electrical cable. A treated-wood plank buried on top of the cable may be the only protection for the cable. Modern installations often have a bright yellow plastic ribbon buried below the surface to warn that a cable lies beneath it. “Danger — High Voltage” signs warn that high-voltage equipment is enclosed inside and buried underground. Don’t take chances — contact the owner of the power system before you start digging. You must accurately identify the location of underground utilities before you dig.

Besides electricity, there are other kinds of underground utilities, including telephone, gas, cable, water, fibre optic lines, and pipeline services. Some of these service providers belong to BC 1 Call. To find out which utilities are members and the location of their underground cables and pipes, you can submit an online ticket at bc1c.ca or call 1.800.474.6886, or *6886 on your cellphone. If a utility owner is not a member of BC 1 Call, you will need to contact the owner directly to determine the location of underground utilities.

Find out the locations of any underground cables before you begin work.

The following activities are potentially hazardous because workers may contact buried power lines:

- Driving ground rods or any other long metal objects into the ground
- Digging holes for fence posts
- Digging near “Danger — High Voltage” signs
- Trenching

Three keys of electrical safety

1. Look up and down.

All workers who operate machinery or equipment that could come in contact with power lines should look up and check for overhead power lines before beginning work or identify underground power lines in the vicinity. Plan your work to prevent electrical contact.

2. Keep back — know your limits.

When operating machinery or equipment in close proximity to power lines, always maintain the limits of approach: 3–6 m (10–20 ft.), depending on the voltage. Use a spotter to make sure you keep equipment away from power lines.

For proper safe working distances, see the tables on page 33, or contact the owner of the power system or WorkSafeBC. If any portion of a machine or equipment may come closer than the minimum distance, Form 30M33 must be completed before work begins. This allows the owner of the power system to provide some form of protection.

On the ground stay at least 10 m (33 ft.) away from operating equipment, because if it contacts an energized line the electricity will go to ground. The operator should be in the vehicle with everyone else clear of the vehicle when the boom is in motion. If you must approach, ensure the equipment is not operating.

3. Stay back, and call for help.

Stay back at least 10 m (33 ft.) from a fallen power line, exposed underground power line, or any object in contact with the line. If the machinery you are operating contacts an energized line, move it away from the line to break contact. If you can't do this, stay seated in the machine until help arrives.

If it's a life-threatening situation such as a fire, jump clear of the machine, keeping your feet together. Never contact the machine and the ground at the same time. Once clear of the machine,

shuffle away, never allowing the heel of one foot to move beyond the toe of the other. Keep shuffling until you are at least 10 m (33 ft.) away from the machine; this is the safe distance for voltages up to and including 69 kV (69 000 V). Depending on the voltage, you may need to be as much as 32 m (105 ft.) away from the machine.

Always call 911 or your local emergency services when someone is injured in an electrical incident. Don't attempt a rescue until directed by the utility owner. If you touch an injured person who is still in contact with an electrical source, you could be seriously injured or killed. Keep everyone back at least 10 m (33 ft.), and have someone call for help immediately.

In case of electrical contact

Is there a fire or an immediate threat to life?

- **Yes.** Call 911. They will contact the utility owner to shut off the power.
- **No.** Contact the utility owner to have the power shut off. For BC Hydro, call 1.888.POWERON (769.3766), or *49376 on your cellphone.

Plan ahead to prevent an incident

Take electrical safety training. For more information, visit bchydro.com/safety.

For information on overhead power line voltage or to complete Form 30M33, contact the utility owner. For BC Hydro, call the Electric Service Coordination Centre at 1.877.520.1355.

Before digging or drilling, you must accurately determine the location of all underground services in the area. Contact BC 1 Call by submitting an online ticket at bc1c.ca or by calling 1.800.474.6886, or *6886 on your cellphone. Note that some utility owners are not members of BC 1 Call and you must contact them directly for further information.

If a cable is accidentally dug up, call the power utility immediately. Move the digger bucket clear of the cable and stay out of the trench. If the machine can't be moved, keep workers 10 m (33 ft.) away, and make sure the operator remains in the vehicle. If the operator must leave the vehicle because of fire, make sure the operator shuffles and doesn't step away from the vehicle.

Part 3:
Electrical injuries

Types of electrical injuries

Electrical injury is a term for any injury caused by electric shock or electrical burns. Electrical burns can be caused by an arc flash, thermal burns can be caused by expulsion of hot gases and molten materials due to an arc blast, and conduction burns can be caused by conduction of electric current through body parts.

As well as getting an injury directly related to the electrical incident, a worker could be thrown or fall if working at a height. As a result, the worker may also have fractures, spinal injuries, or internal injuries.

A worker with an electrical injury may have a number of signs and symptoms.

First aid

Electric shock and electrical burns are serious injuries and should receive immediate medical attention. As part of their health and safety responsibilities, employers must ensure that adequate first aid equipment, supplies, and trained attendants are on site to handle injuries.

For more information on first aid responsibilities, see the following:

- Sections 3.14–3.21 of the Regulation
- First aid requirements at worksafebc.com/en/health-safety/create-manage/first-aid-requirements

Burns

Burns are the most common electrical injury. An injured worker may have one or more types of burns:

- **Arc flash burns** are caused by radiant heat released when an arc forms between the electrical source and a ground or between two electrical conductors. In this case, the arc does not pass through the body. However, electric arcs can produce intense heat (several thousand degrees) — more than enough to melt steel. This heat can cause first-degree through third-degree burns to any part of the worker exposed to the heat. Electric arcs can also generate intense ultraviolet radiation and cause serious eye injury, even at a distance.
- **Thermal burns** caused by the ignition of clothing are common, particularly with high-voltage exposure. Contact burns occur when skin touches hot surfaces of overheated electrical conductors or other equipment.
- **Conduction burns** are the result of an electric current flowing through tissues or bone. The burn is often only visible at entrance and exit wounds, with the major damage inside the body. Extensive damage to nerves, blood vessels, muscles, and organs may take place as the current passes through the body and generates intense heat (up to 3000 °C).

Electric shock

Electric shock is caused by electric current passing through the body. Electric shock symptoms can range from a barely perceptible tingle to immediate heart stoppage. In addition to the electrical burn injuries discussed on page 49, there may be internal bleeding, unconsciousness, respiratory paralysis, and cardiac disorders.

Electric current can cause involuntary muscle contractions. These may prevent an injured worker from letting go of the live conductor. Sometimes involuntary movements lead to bruises or bone fractures — or even death from collisions or falls.

In some cases, electric shock can cause injuries that are not evident, and symptoms may be delayed. For this reason, all electric shock victims should be taken to hospital for observation.

The damage that electricity does to the body is determined by three major factors:

- The rate of current flow (measured in amperes, and determined by voltage and resistance)
- The path of the current through the body
- The duration the current is flowing through the body

Other factors may also affect the severity of injuries from electric shock:

- The frequency of current (for example, 60 cycles)
- The type of current (AC or DC)
- The phase of the heart cycle when the shock occurs
- The general health of the person receiving the shock

It is not possible to say exactly what injuries will occur from any given amperage. The table on page 51 shows the general relationship between the degree of injury and the amount of current flowing through a person in a hand-to-foot path for just a few seconds. Current that is strong enough to run a 5- or 10-watt light bulb can be fatal. Low voltages can be extremely dangerous.

As shown on page 51, a difference of less than 50 mA exists between a current that is barely perceptible and a fatal one. The degree of injury is proportional to the length of time the body

is in the electrical circuit. The longer someone is exposed to the current, the more serious the shock. **Low voltage does not mean low hazard.**

Range of body tolerance

Electric current (in mA)	Reaction
1–5	Can feel it
5–10	Can't let go
10–50	Increasing pain; breathing may become difficult
50–100	Probably fatal

A 100-watt light bulb uses 833 mA of current. It takes only 5 mA to trip a GFCI. A small amount of current running through the body for a few seconds can give the effects shown in the table.

In case of electrical injury, keep yourself and the injured worker safe:

With **low voltage**, carefully remove the source of contact from the injured worker without endangering yourself. Turn off the power or use insulated material to remove the source of contact (low voltage only).

With **high voltage**, stay back at least 10 m (33 ft.) until the owner of the power system says it is safe to approach. If the voltage is over 69 kV (69 000 V), you may need to keep as far away as 32 m (105 ft.). See page 32 for more information on rescue work around power lines.

Eye injuries

Like any other part of your body, your eyes can be burned. Regular safety glasses will not protect against arc flash burns and arc blasts from electric arcs. Direct or reflected light from an arc flash may cause a surface burn to the cornea. With longer flashes (lasting a couple of seconds), the ultraviolet light may cause permanent retinal damage.

If there is an arc flash, the eyelids are frequently burned. The treatment of burned eyelids requires specialized medical care. The eyes should not be examined as this may injure the burned tissue. Both eyes should be covered with sterile dressings.

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