Working Safely Around Electricity

WorkSafe BC

WORKING TO MAKE A DIFFERENCE

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Workers' Compensation Board of B.C.

About WorkSafeBC

WorkSafeBC (the Workers' Compensation Board) is an independent provincial statutory agency governed by a Board of Directors. It is funded by insurance premiums paid by registered employers and by investment returns. In administering the *Workers Compensation Act,* WorkSafeBC remains separate and distinct from government; however, it is accountable to the public through government in its role of protecting and maintaining the overall well-being of the workers' compensation system.

WorkSafeBC was born out of a compromise between B.C.'s workers and employers in 1917 where workers gave up the right to sue their employers or fellow workers for injuries on the job in return for a no-fault insurance program fully paid for by employers. WorkSafeBC is committed to a safe and healthy workplace, and to providing return-to-work rehabilitation and legislated compensation benefits to workers injured as a result of their employment.

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The WorkSafeBC Prevention Information Line can answer your questions about workplace health and safety, worker and employer responsibilities, and reporting a workplace accident or incident. The Prevention Information Line accepts anonymous calls.

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Many publications are available on the WorkSafeBC web site. The Occupational Health and Safety Regulation and associated policies and guidelines, as well as excerpts and summaries of the *Workers Compensation Act,* are also available on the web site: <www.worksafebc.com>

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About this guide

Electricity can be our best friend—or our worst enemy. When handled improperly, electricity can injure or kill. In British Columbia alone, approximately 90 workers suffer electrical injuries every year. These injuries range from shock to severe burns. On average, three B.C. workers a year die from accidents involving electrical contact. Injuries and fatalities occur from accidents involving low voltages (750 V and below) as well as high voltages, usually from contact with high-voltage power lines.

This booklet 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 as part of their job and who are familiar with the basic hazards of electrical contact.

Some workers—for example, painters and equipment operators—may work around electrical equipment and conductors but may not be familiar with all the hazards of electrical contact. **This booklet is not a training manual for such workers.** They should follow up with their supervisors or with WorkSafeBC for more information on how the hazards and safety steps outlined in this booklet apply to their work conditions. All workers must be informed of the potential electrical hazards before being permitted to work near energized electrical conductors or equipment.

This booklet has three parts:

- Part 1 covers the dangers of contact with low-voltage electricity (750 V and below), common problem areas, and safe work practices.
- Part 2 covers the dangers of contact with high-voltage electricity (over 750 V) and provides guidelines for working safely near power lines.
- Part 3 describes electrical injuries and first aid.

This booklet 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. **Workers who install, alter, or maintain electrical equipment must be qualified to carry out the work, as required by the *Electrical Safety Act* and the regulations made under it.**

This booklet does not replace the Occupational Health and Safety Regulation. Refer to the Regulation, especially Part 19: Electrical Safety, for specific requirements.

Acknowledgments

This booklet was made possible with the generous assistance of many people and organizations who are concerned about electrical safety. WorkSafeBC thanks the following organizations and their representatives who helped compile the information in the first edition of this booklet or reviewed this new edition:

BC Hydro, Corporate Safety

British Columbia Institute of Technology, School of Electrical and Electronics Trades

Electrical Contractors Association of B.C.

Electrical Industry Training Institute Ltd. (EITI)

Electrical Safety Branch, Safety Engineering Services, Ministry of Municipal Affairs

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Low-Voltage Electrical Safety

Low-voltage systems

Low-voltage electrical systems (750 V and below) serve most homes and commercial buildings. Every day, hundreds of B.C. workers work safely on and around low-voltage electricity. Small or large, the job is usually handled without incident. Occasionally, however, something goes horribly wrong—an unexpected hazard has been overlooked and a worker becomes the victim of a sudden explosion or a serious shock.

Part 1 explains why energized low-voltage systems are dangerous and outlines the basic steps to de-energize and lock out equipment. This part also describes the hazards that are often overlooked when someone is working on or around low-voltage systems. It tells you what to look for and how to avoid accidents.

Qualified workers

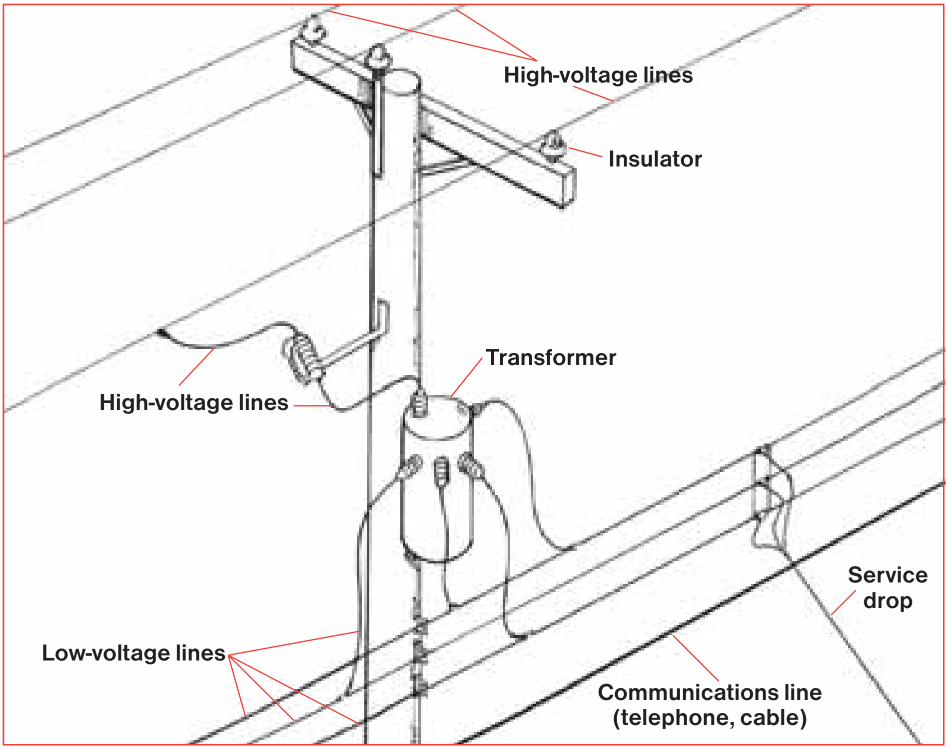
The Electrical Safety Regulation made under the *Electrical Safety Act* defines a qualified person as "an individual who has knowledge of the electrical system and equipment being installed or altered and who is aware of the hazards involved." For more information on who is qualified to do or supervise electrical work and testing, see B.C. Regulation 487/95 or contact the Electrical Safety Branch of the Ministry of Municipal Affairs.

Identifying low-voltage overhead conductors

Utility poles generally carry both low-voltage and high-voltage conductors (power lines) as well as communications lines (such as cable television and telephone). High-voltage conductors are always installed at or near the top of the utility pole. Low-voltage conductors are usually installed as single conductors mounted one above the other (see illustration on page 4).

If there is a transformer on the pole, lines from the high-voltage conductors feed the transformer, which 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.

It is the employer's responsibility to accurately determine the voltage of all power lines in the work area.



Overhead electrical conductors can often be identified by their placement on the pole.

Abbreviations

The following abbreviations are used in this booklet:

A	ampere
mA	milliampere
V	volt
kV	kilovolt (1 kV = 1,000 volts)
kVA	kilovolt ampere

Why energized low-voltage systems are dangerous

People often think that low-voltage contact is much less dangerous than high-voltage contact. They may believe that a mistake made in 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 electrical current through the heart can cause an irregular heartbeat or a heart attack. Electric shock can also cause the muscles to contract and may prevent the worker from releasing his or her grip, thus extending 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 49–53.)

Two factors can make energized low-voltage equipment extremely hazardous. The first is that the small working clearances between low-voltage components leave little room for error when using tools.

Second, 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 electrical energy to build in a split second. This energy is released suddenly in a restricted space. The flames can result in terrible burns on anyone within the arc's range, which may reach up to 3 metres (10 ft.). Arcs of this kind often leave the electrical structure a charred and melted wreck—stark evidence of the intense heat generated (several thousands of degrees).

Almost all voltages are potentially dangerous because of the shock hazard. With low voltages fed by high-capacity transformers, the danger of arc flash burns is an additional hazard that can result in serious injuries.

As well as causing fire, the heat from the arc can melt solids, vaporize liquids, and expand gases. This results in a huge build-up of pressure causing an arc blast. The blast can throw workers across a room, destroy equipment, and hurl objects and pieces of metal onto nearby workers. In some tests, the noise from an arc blast reached 140 decibels.

Working close to energized equipment

Uninsulated, energized parts of low-voltage electrical equipment and conductors must be guarded by approved cabinets or enclosures unless the energized parts are in a suitable room or enclosed area that is accessible only to qualified and authorized persons.

Each entrance to a room or other guarded location containing uninsulated and exposed energized parts must be marked with warning signs limiting entry.

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 metre (3.3 ft.) of those parts, **or**
- The worker must be informed of the potential hazards and must follow written safe work procedures

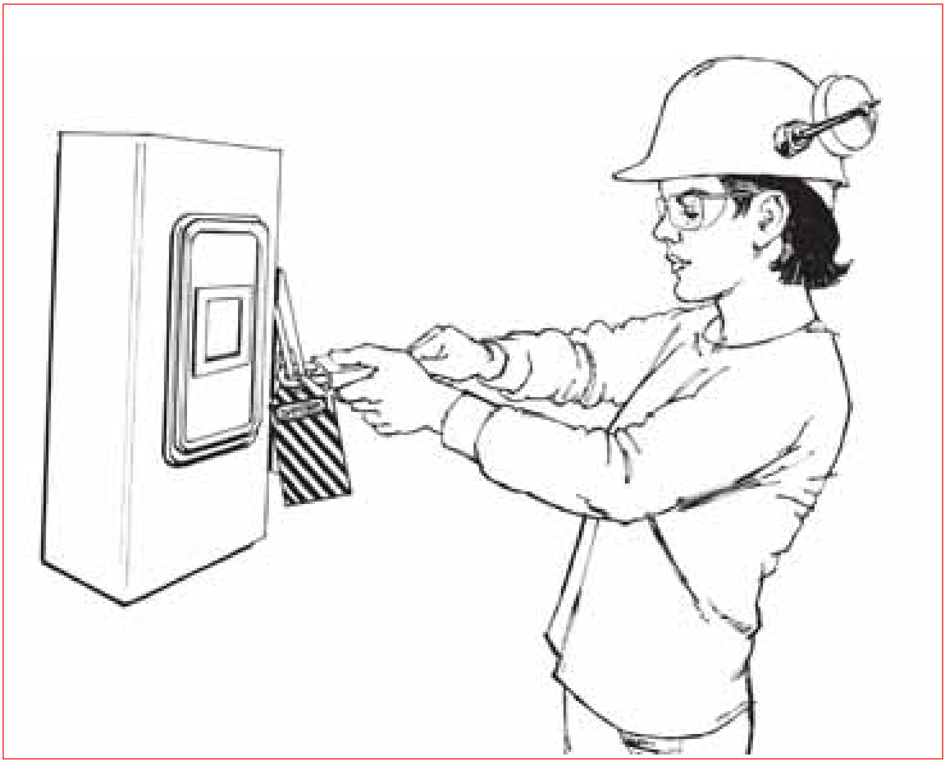
De-energization and lockout

Because of the hazards of working on energized low-voltage equipment, the first choice is to disconnect ("de-energize") and lock out the equipment before maintenance work is done on it. The purpose of de-energization and lockout is to prevent the release of energy that could cause injury or death. A lock or locks are used to make sure that equipment is not accidentally or inadvertently turned on while workers are performing maintenance on it.

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

Workers must follow their employer's safe work procedures to de-energize and lock out equipment. At a minimum, any 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. Also ensure that the act of shutting off equipment does not cause a hazard to other workers.
3. Identify and de-activate the main energy-isolating device (such as a switch or valve) for each energy source. There may be more than one source of power, such as backfeed from the load side or control voltage from a separate source.
4. Apply a personal lock to the energy-isolating device for each energy source, and ensure that all parts and attachments are secured against inadvertent movement. (Each worker must apply a personal lock unless group lockout procedures are followed.)
5. Test the lockout to make sure it's effective and to verify that all live components have been de-energized. First ensure that all workers are in the clear and that no hazard will be created if the lockout is not effective. Lockout can be tested 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 include:

- Steps to ensure that all work has been completed on a circuit before the circuit 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
- *Lockout*, a booklet available from WorkSafeBC (see page ii)

Working on energized equipment

For most work, the electrical equipment must be de-energized because there is a high risk of injury to workers if they work 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 of the risks associated with the task. Plan the whole job in advance so that you can take every precaution, including arranging for help in case of paralyzing shock. Consider the use of a pre-job safety meeting to discuss the job with all workers before starting the work.
- **Know the system.** Accurate, up-to-date information should be available to those who work on the system.
- **Limit the exposure.** Have live parts exposed for as little time as necessary. *This does not mean that you should work hastily.* Be organized so that the job can be done efficiently.
- **Cover exposed live metal.** Use insulating barriers or shields to cover live parts.
- **Cover grounded metalwork.** Grounded metal parts should be covered with insulating material as much as possible.
- **Limit the energy to reduce the risk.** All practical steps should be taken to ensure that 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 wristwatch bands.** These could cause a short-circuit where small clearances are involved. (If it is necessary to wear medic-alert bracelets, secure them with transparent surgical or adhesive tape or rubber bands.)

- **Use one hand with your face and body turned to the side when operating a safety switch.** 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.)

Regulation requirements

If you must work on energized low-voltage equipment, see the requirements in the Occupational Health and Safety Regulation:

• Part 8, sections 8.14–8.17	Safety eyewear
• Part 8, section 8.22	Safety footwear
• Part 8, section 8.31	Flame-resistant clothing
• Part 19, section 19.10(2)	Working on energized low-voltage equipment
• Part 19, section 19.10(3)	Working on energized lighting circuits

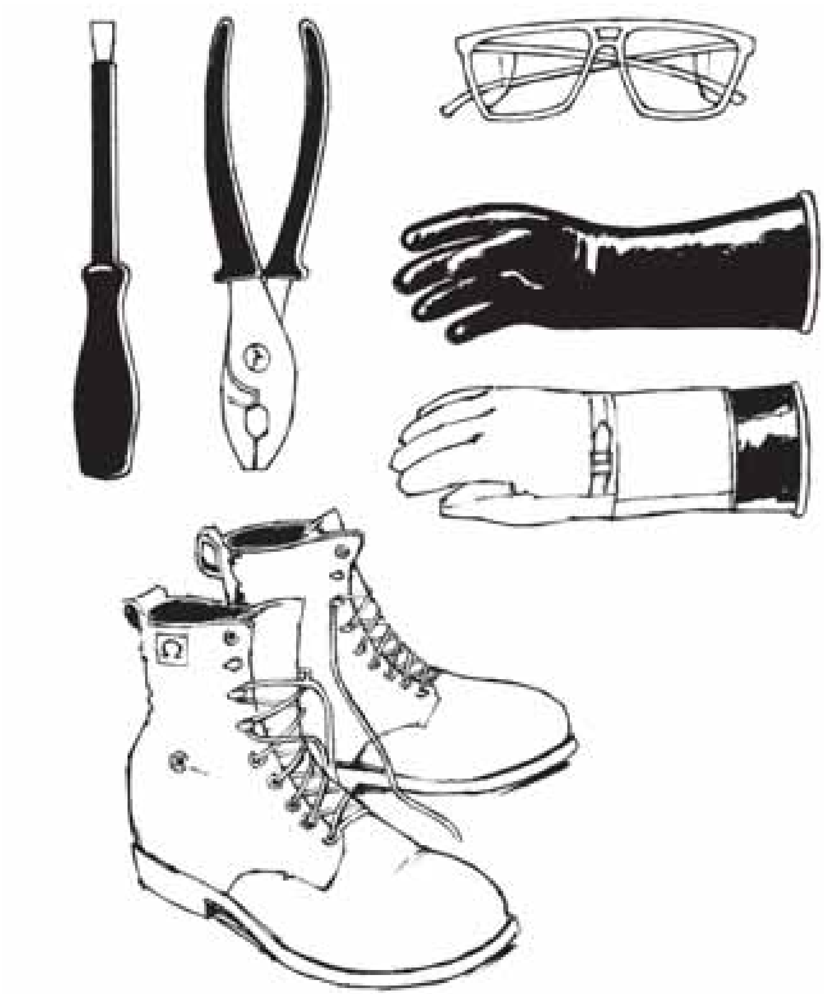
Personal protective equipment and clothing

It is the employer's responsibility to provide the specialized personal protective equipment and clothing needed for work on energized equipment. The supervisor 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, qualified and authorized workers need the following protective equipment and clothing:

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

Safety glasses normally used on construction projects to protect eyes from debris are not designed to prevent injuries from the ultraviolet light of an electric arc. If the risk is high, de-energizing must be the first choice. If work must be done on live equipment, polycarbonate safety glasses are required; however, the use of a complete polycarbonate face shield should be considered. Polycarbonate glasses will filter out most of the ultraviolet light, and 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. Workers should also avoid laminated fabric containing polyurethane sponge, as this ignites and burns quickly. Many synthetic materials do not char or ash when they reach ignition temperatures. Rather, they melt and form a hot, tacky residue that sticks to the skin and burns the flesh.

HAZARD ALERT

A journeyman electrician was burned when there was an explosion caused by an electric arc. He was installing a 600 V temporary service to a construction site. The high-visibility vest he was wearing caught fire, and the plastic on the vest melted, increasing the severity of his burns.

Although flame-resistant vests are available, most high-visibility vests are not flame-resistant. If there is any danger of a fire or explosion when working with energized equipment, the worker should remove a vest that is not flame-resistant or should wear a flame-resistant vest.

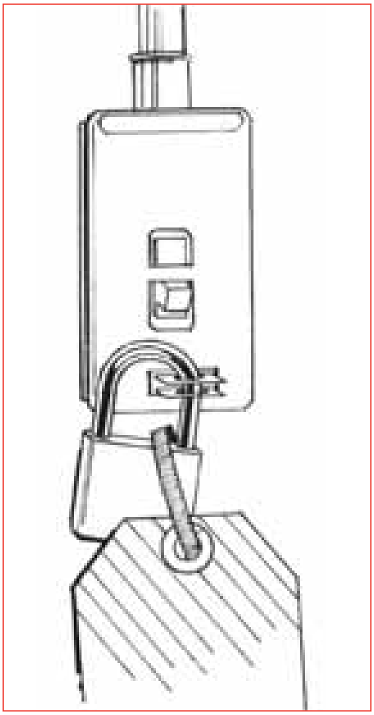
Common problem areas

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

Lighting circuits (347 volts)

With the increasing use of 347/600 V systems in commercial and industrial buildings, 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.

Work must not be done on energized parts of electrical equipment that is connected with lighting circuits operating at more than 250 volts-to-ground without the prior written permission of WorkSafeBC.



If only the ballast is being changed, a lock on the wall switch will protect the worker. However, this is not acceptable for three-way, four-way, or low-voltage lighting controls.

HAZARD ALERT

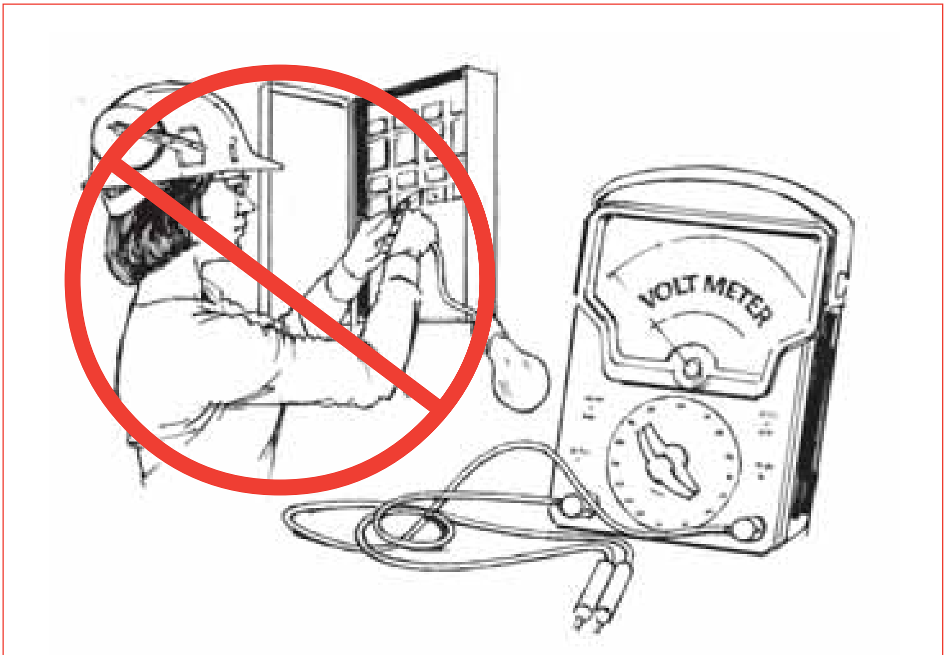
A worker contacted an energized wire while working on an energized 347 V ballast box above the suspended ceiling. Using safe work procedures, a co-worker pulled him away from the paralyzing contact. Subsequently, one finger had to be amputated.

In another, similar incident, a worker suffered electric shock and died.

Checking voltages with a meter

Checking voltages with a meter must be performed by workers who are qualified and know the hazards. Testing can be dangerous, particularly if it is done by unqualified workers who have little or no electrical experience. For example, workers must never use an improvised test lamp, which can cause an electric arc. If a worker incorrectly connects 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 the equipment to see where the test probes must be put. In the event of an electric arc, the worker's face will bear the brunt of the intense heat. Goggles or safety glasses must be worn; if there is a high risk, a full face shield must be used (see page 11 for more information on safety glasses).



Use approved portable meters and leads, not an improvised test lamp.

An electric arc may be started in one of the following ways:

- An improvised test probe (possibly a screwdriver blade or bare aligator 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 busbars of a 600 V panel.

- A screwdriver that is 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 because the internal fuse may not be 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 other standard acceptable to WorkSafeBC. Alternatively, acceptable testing equipment must have the following characteristics:

- It has high rupturing capacity (HRC) fuses or alternative protective circuitry to protect the worker 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, qualified workers 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 having 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, such as on a rooftop or after regular hours so that de-energization does not inconvenience as many workers.

The employer must develop and implement a written procedure for checking the well-being of someone doing electrical work alone or in isolation. The procedure must include the time interval between checks and the procedure to follow in case the worker cannot be contacted (including provisions for emergency rescue). Someone must be designated to establish contact with the worker at predetermined intervals and at the end of the work shift. The time intervals must be determined in consultation with the worker assigned to work alone or in isolation.

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). Short-circuiting by a ring or wristwatch bracelet can severely burn a worker, even if no shock hazard exists. The voltage of some battery banks, however, may be high enough to be a shock hazard.

Proper protective equipment must be used for testing, connecting, or disconnecting batteries. For protection from the battery acid, a face shield, plastic apron, and plastic gloves are needed. There must be an eye wash station nearby in case of splashes to the eye. Insulated tools (wrenches, screwdrivers, etc.) must be used.

HAZARD ALERT

A technician was installing a storage battery when his wristwatch came in contact with the battery terminal. The wristwatch caused the battery to short-circuit and the worker suffered severe burns to his hands.

Ladders

Metal ladders or wire-reinforced wooden ladders must not be used by workers working on energized electrical equipment or by workers working near energized electrical equipment if there is a possibility of contacting bare energized components.

Low-voltage sections of unit substations

Workers have been injured while they were 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 busbar, 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 so that sections of the unit substations are electrically isolated. This equipment can be maintained safely without de-energizing all of the electrical equipment. Consult the manufacturer's instructions and provide workers with written safe work procedures.

HAZARD ALERT

Two workers were attempting to add a new 400 A switch to the energized 600 V section of a 1,500 kVA power centre. A number of important loads were fed from the low-voltage busbars where the workers were going to install a new fused switch. They didn't want to inconvenience other operations by de-energizing the other loads connected to the busbars. Instead of planning a shutdown, they decided that they could install the switch live because it was "only" low voltage. The workers were severely burned during the installation.

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 the area of low-voltage lines—for example, when washing windows or painting. These lines are not insulated well enough that a person can safely touch them. They should be considered energized and dangerous.

When a work process (such as window washing or painting) results in a *temporary* encroachment by a worker into the area of low-voltage lines, either:

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

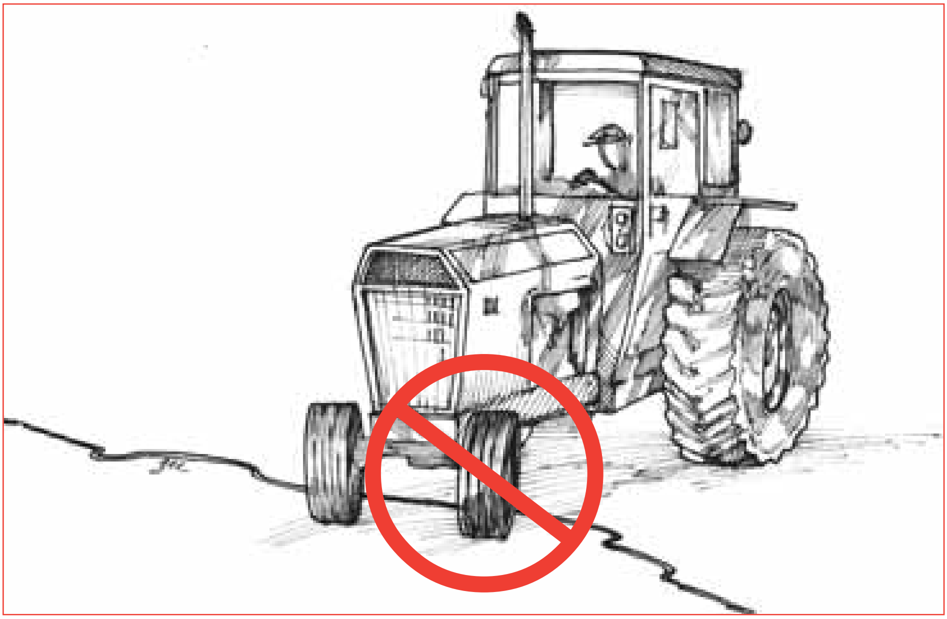
Sometimes there may be a *permanent* change in the building (such as a new stairway or work platform) that allows workers to move close to the low-voltage lines. In this case, qualified and authorized workers must reposition or cover the lines with conduit or other approved cover to protect workers from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

Portable electrical equipment and extension cords

Portable electrical equipment must be checked to ensure it is approved. Portable power tools and extension cords must be maintained in good repair and be suitable for the conditions where they are 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 if approved portable electrical equipment is used 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 been electrocuted or badly burned as a result of contact with damaged extension cords. Electrical cords are often left unprotected, stretched across 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 wires are left exposed or a cut cord is repaired 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 Program

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 milliamperes. The Assured Grounding Program is an acceptable alternative to using GFCIs.

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 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.
- Do not use extension cords longer than 45 metres (150 ft.).

Assured Grounding Program

An Assured Grounding Program may be used as an alternative to GFCIs for portable electrical equipment used outdoors or in a wet or damp location. The purpose of this program 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

   Extension cords and power tools must be checked for damage daily by the persons who will be using them. Any damage found must be repaired before the cord or tool is used. Damaged extension cords and power cords of tools must not be spliced. The cords can either be replaced or be shortened 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 inches) from the male plug. Coloured electrical tape is suitable for this purpose. A different colour is required for each quarter of the year. These colours are standard for all worksites using an Assured Grounding Program in British Columbia:

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

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

2 High-Voltage Electrical Safety

High-voltage systems

Working safely around high-voltage conductors (over 750 V) is a challenge for many workers in British Columbia. 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, workers can operate equipment and tools safely around these potentially lethal power lines.

Part 2 of this booklet 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 workers 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 and gives safe work practices for working close to overhead lines around construction sites and for operating equipment around power lines.

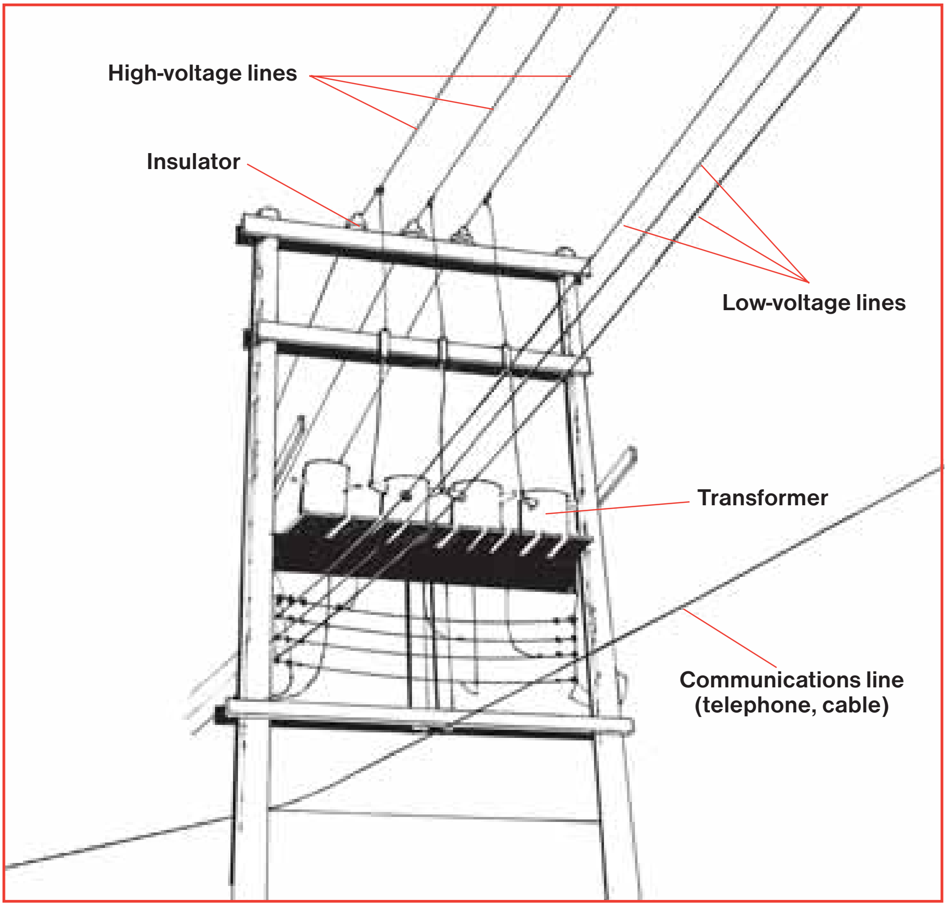
When this manual mentions contacting the owner of the power system, keep in mind that there are a number of electrical utilities in British Columbia. BC Hydro is the largest, but there is also UtiliCorp Networks Canada, and power is provided by several municipalities, universities, and other corporations.

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 set out in the Occupational Health and Safety Regulation, Part 19. For isolation and lockout, workers must follow the safe work procedures set out by the employer and/or the 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 crossarm. If there is a transformer on the pole, the high-voltage conductors are mounted above it. These are general guidelines. It is the employer's responsibility to accurately determine the voltage of all conductors on the pole or in the work area.



An H-frame configuration may be used to facilitate the installation of transformer bank platforms on older systems. They are most often seen in alleys. The illustration on page 4 shows a common single-pole configuration.

Electrical distribution system

Electricity is transmitted from generating stations and substations via high-voltage transmission lines at 60–500 kV (60,000–500,000 V). These lines are located on top of large towers or poles in transmission rights-of-way. The voltage is reduced at substations in urban areas and distributed by overhead or underground distribution lines. The high-voltage lines on utility poles on our streets are typically at 4–25 kV (4,000–25,000 V).

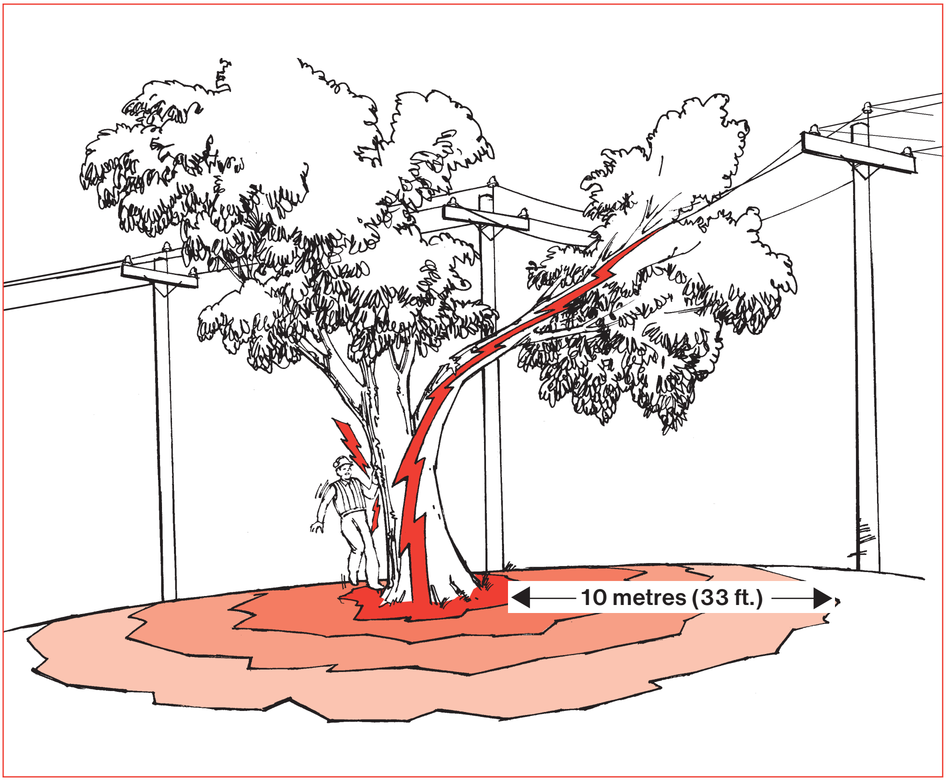
Why energized high-voltage systems are dangerous

Accidents 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 49–53.)

Electricity seeks all paths to the ground. That path 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 60 kV (60,000 V), the voltage drops to zero about 10 metres (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 metres (105 ft.).

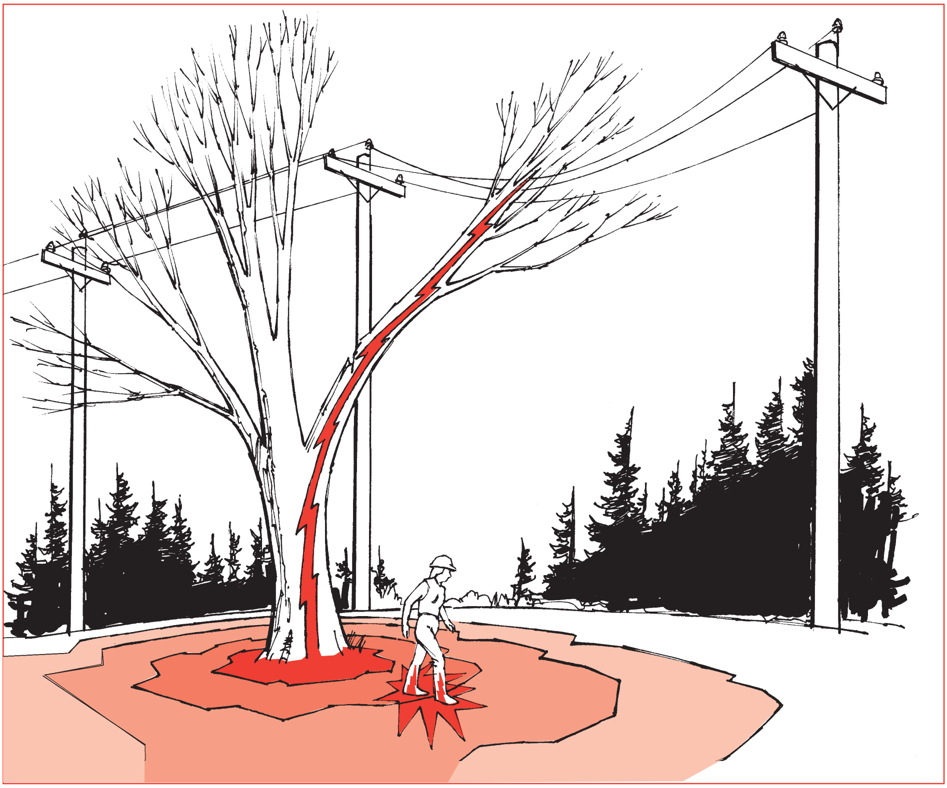


If anything touches a high-voltage power line or if a power line falls to the ground, electricity will flow to the ground, energizing the tree or equipment and anything in contact with it. The surrounding ground may be extremely hazardous. The voltage gradually decreases from the point of contact until it reaches zero. The safe distance shown here—10 metres (33 ft.)— is for line voltages up to and including 60 kV (60,000 V).

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, and an electric current could flow up one leg and down the other.

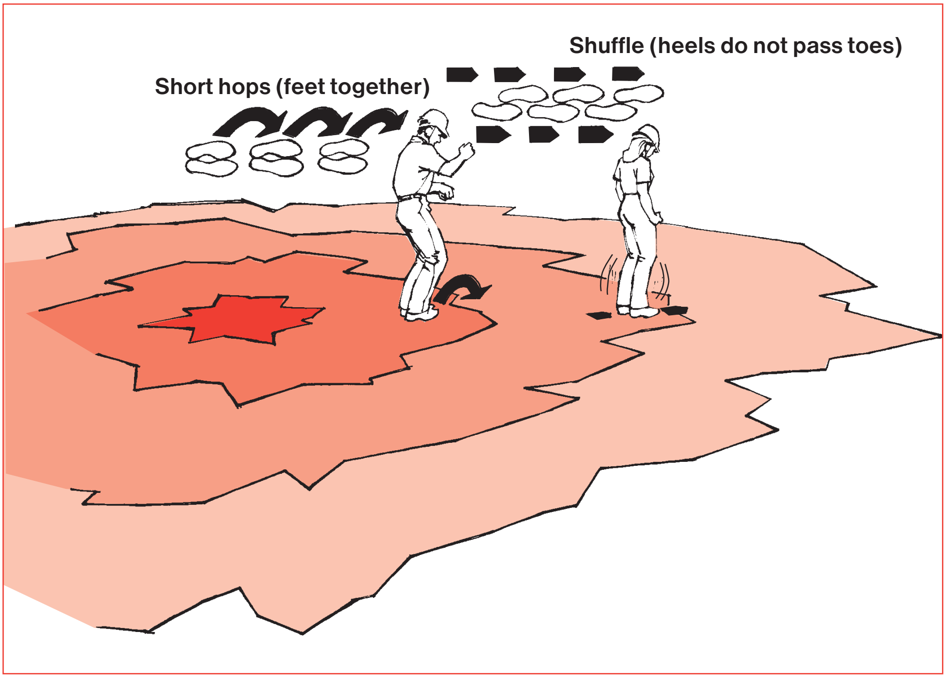


Step potential: If your feet are spread apart on energized ground, electricity can flow through your body from the area of higher voltage to the area of lower voltage.

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

If you do find yourself on energized ground and need to move away, you can avoid electric shock or electrocution due to 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.

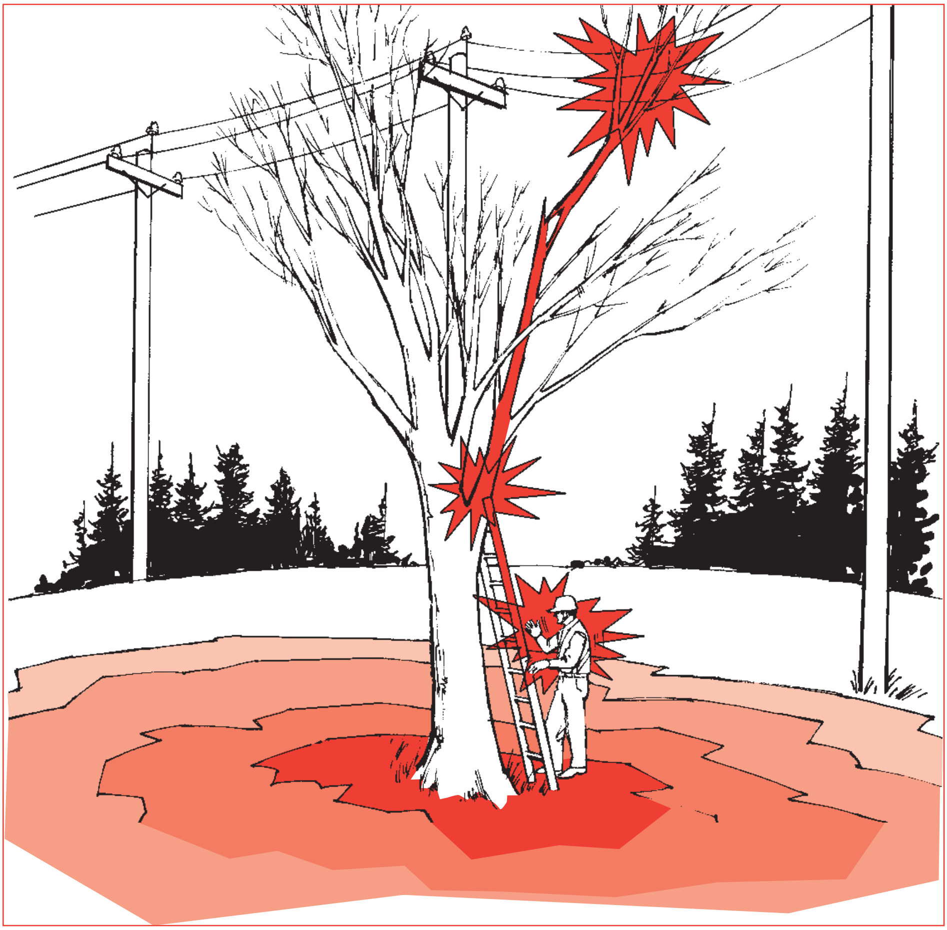
Similarly, rescue workers must not enter an area that might be energized. Anyone trying to reach an injured worker in an energized area would be exposed to the same danger of step potential. The power lines must be de-energized and grounded before rescue workers or first aid attendants approach.



If you must move on energized ground, shuffle or hop while keeping your feet together and touching each other. Do not 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 the lower-voltage ground. For example, if a tree or some 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 equipment or tree 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 a worker 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 in a number of situations, including storms, trees, ice, and motor vehicle accidents. Even if the power line does not come down, if it is in contact with a tree, vehicle, or mobile equipment, the ground will be energized and so will the tree, vehicle, or equipment.

Workers in a vehicle or mobile equipment

If electrical contact is made, *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 do not 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 60 kV (60,000 V) power line. The driver stayed in the truck and was not injured, although all 18 tires were damaged by the electrical current.

If the vehicle is not damaged and is not entangled with the power line, it is safe to slowly drive out of the energized area, at least 10 metres (33 ft.) clear of the wires and any wet ground. Because of the danger of exploding tires, large mobile equipment with inflated rubber tires should be moved to an open space away from workers and other equipment. 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 of the possibility that the ground below your machine is energized and use *extreme caution.*

To make a safe escape, keep both feet together and hands by your side 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. Do not allow any part of your body to touch the vehicle while you are touching the ground.

Do not 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 do not 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 metres (33 ft.)—more if the voltage is over 60 kV (60,000 V).
4. **Don't let yourself become a victim.** Regardless of how badly someone is injured, you cannot help if you are electrocuted. Never touch *anything* that is in contact with a downed power line, including injured or trapped victims, puddles, vehicles, or trees. Do not use a dry stick or piece of rope or hose as they will not offer any protection. Do not 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.**

HAZARD ALERT

A vehicle made contact with a high-voltage power line. When a police officer arrived at the scene, the vehicle was still energized. The police officer walked toward the vehicle. The officer's legs started tingling about 2 metres (6 ft.) away from the vehicle. The officer was fortunate not to be seriously injured or electrocuted.

General limits of approach

The key to safety is to keep a safe distance from overhead or underground power lines so that the dangers described in pages 25–31 do not arise. The Occupational Health and Safety Regulation, Part 19, lists the distances that various workers must keep away from exposed energized conductors. Table 19-1 in the Regulation gives the general limits of approach (see table below). This is the *minimum* distance from overhead energized high-voltage lines that non-qualified workers and their materials, equipment, and machinery must maintain.

The limits of approach vary with the voltage. Tools and equipment that a worker holds or operates are an extension of the worker's reach. Workers must ensure that they have enough room for movement with their tools without violating these limits.

General limits of approach (Table 19-1)

Voltage, phase to phase		Minimum distance	
Kilovolts	***Volts***	***Metres***	***Feet***
Over 750 V to 75 kV	Over 750 V to 75,000 V	3	10
Over 75 kV to 250 kV	Over 75,000 V to 250,000 V	4.5	15
Over 250 kV to 550 kV	Over 250,000 V to 550,000 V	6	20

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

The movement of equipment and tools must be carefully planned to avoid entering within the general limits of approach:

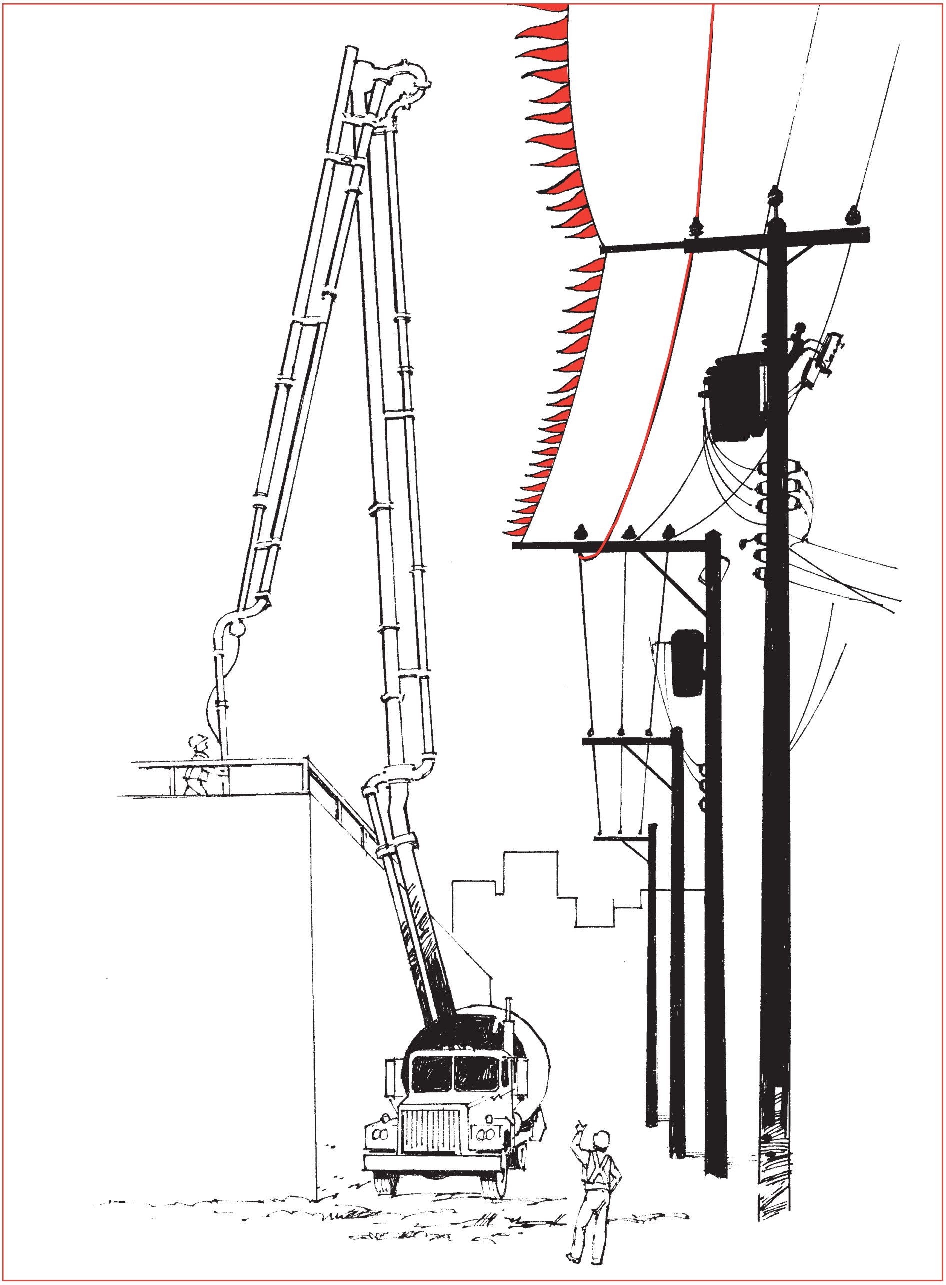
- Supervisors and workers must know the location of all electrical power sources in the work area before starting work.
- The employer must accurately determine the voltage and minimum limits of approach. This can be done by contacting the owner of the power system.
- Supervisors must review the general limits of approach with all workers who work near energized high-voltage equipment or power lines. A pre-job safety meeting (often called a tailboard meeting) is required, and written records of the meeting must be kept.

- Supervisors and workers must ensure that the minimum distance from electrical conductors is maintained 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 must know the safe limits of approach to electrical conductors and not get any closer.

Working inside the limits of approach

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

1. Call the owner of the power system and arrange for a worksite meeting to decide whether the energized electrical conductors can be:
   - Displaced or rerouted, **or**
   - De-energized (isolated and grounded), **or**
   - 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. There can be no work 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.
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 and give 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.



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 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 information is a reminder 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 accidents through knowledge of electrical systems and safe work practices.

HAZARD ALERT

A tower crane operator working from the top of a high-rise building was hoisting material to different floors. The operator had completed a lift and returned the bucket to the ground loading area. While the operator was repositioning the bucket, the hoist cable slackened excessively and crossed over a 12 kV (12,000 V) power line, energizing the hoist cable.

Fortunately, no one was injured in this near-miss incident.

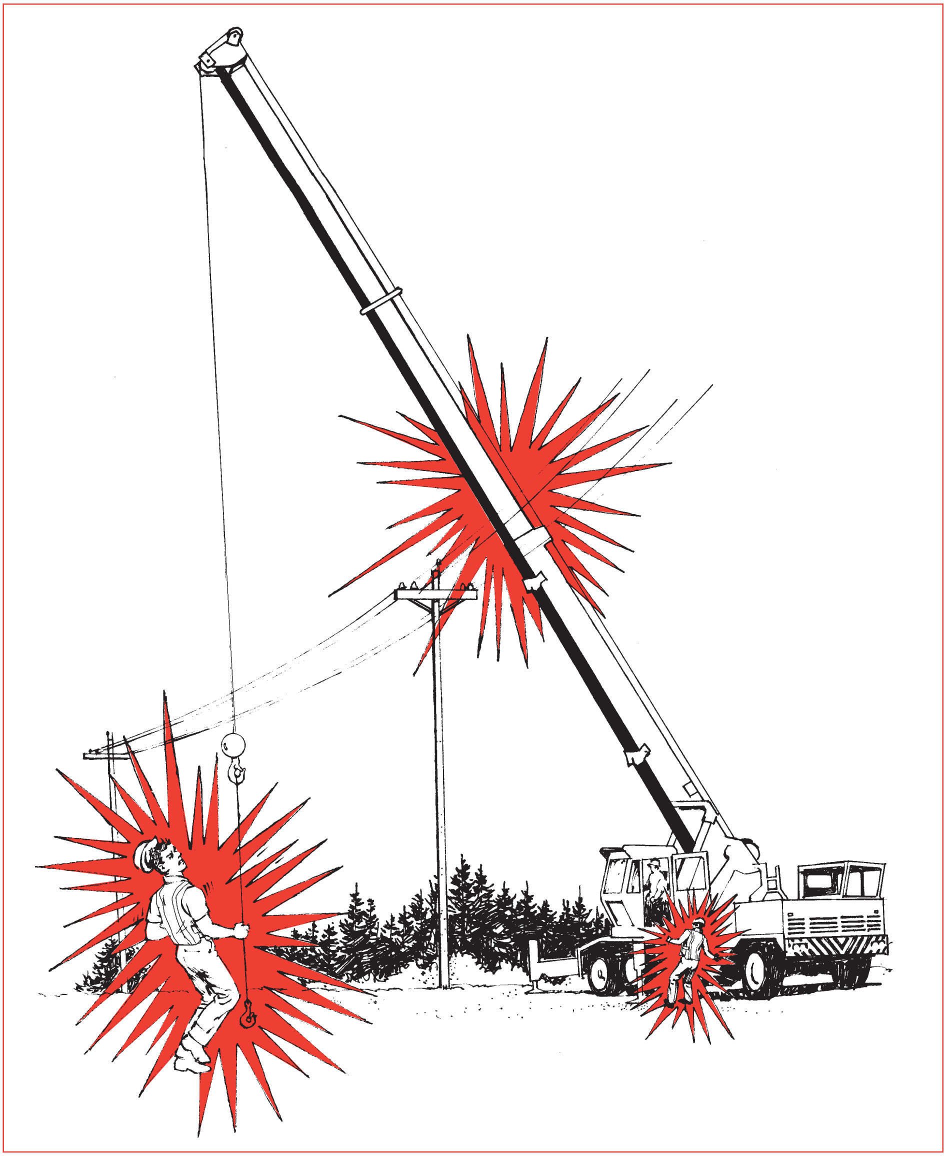
Recertifying equipment after electrical contact

When a machine makes contact with a power line, the passage of current through the machine can impair the strength of some of its parts. Any hoisting or aerial device that has been in contact with an energized conductor must be recertified by a professional engineer before it is returned to service. It is recommended that a licensed mechanic check other mobile equipment that has been in contact with 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 take care that no part of the equipment makes contact with an overhead power line. If any part of the equipment does make contact with an overhead power line, remember that the operator is safer inside the machine than on the ground (see page 30).



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.

HAZARD ALERT

A worker was on the ground guiding a mobile crane onto a truck deck when the crane's boom made contact with a power line. The electrical current passed through the crane jib that the worker was holding and then passed through the worker to the ground. The worker was electrocuted.

In another accident, a pumper truck operator was lowering the truck's boom after pouring concrete. He was standing away from the truck using the pendant control. The boom contacted the high-voltage line and power came through the pendant line to the operator. The operator was electrocuted.

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 closer than 6 metres (20 ft.) to a power line, contact the owner of the power system to find out the voltage of the line. Then consult the table on page 32 to find the minimum distance away from the line you are permitted 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 circuit or provide guarding (see pages 33–34). Do not proceed until the owner of the power system has given written assurance defining proper safeguards.
- Do not stand on the ground beside your machine to operate the remote controls for the equipment. 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 unit, current will pass through your body to the ground. An electrical contact will also energize the ground around your equipment for some distance, up to at least 10 metres (33 ft.)—more if the lines carry voltages higher than 60 kV (60,000 V).
- If you must operate controls from the ground, the remote control signal should be carried by radio or by non-conductive cable such as fibre optics. (If the fibre optic cable has armouring with metal bands, it will be conductive.) In addition, you should stand well clear—depending on the voltage, at least 10 metres (33 ft.) away from your machine and from the power lines—when operating equipment with a remote control.

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.

HAZARD ALERT

A skidder was towing a line log loader down a road alongside a power line. While the skidder operator was manoeuvring out of a small turnout, the snorkel guyline contacted the power line. Both machines were energized. Although two workers tried to signal to the skidder operator to stay in the vehicle, he jumped to the ground while still touching the energized skidder and was electrocuted.

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

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, including 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 permitted within the general limits of approach unless:

- A certified utility arborist or qualified electrical worker is present at the site and directing the work, **and**
- 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:

- Occupational Health and Safety Regulation, Part 19, Tree Pruning and Falling near Energized Conductors
- *Safe Work Practices for Certified Utility Arborists,* a booklet available from WorkSafeBC (see page ii)

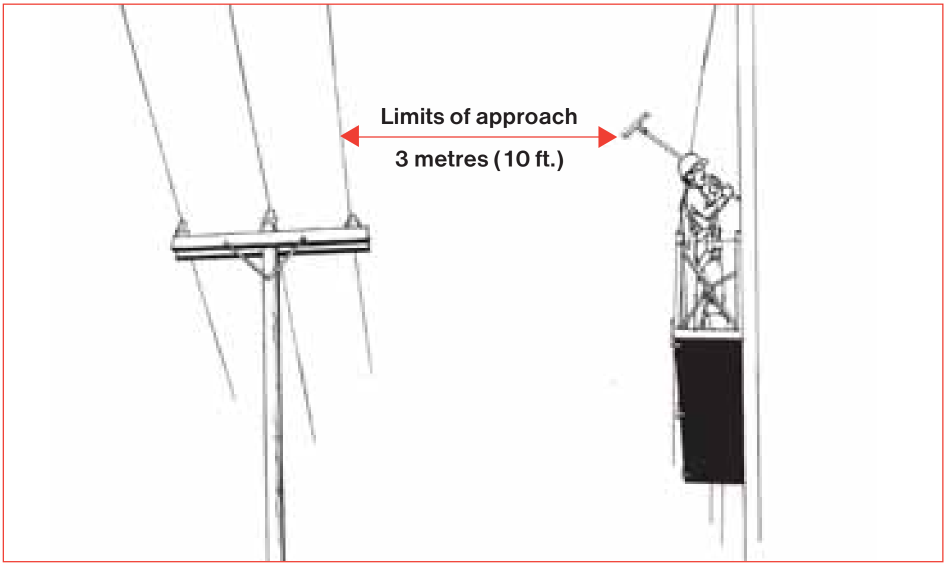
HAZARD ALERT

A tree trimmer was up in a tree trimming branches about 2.5 metres (8 ft.) away from a power line. When a tree branch was cut, it fell onto the power line and the other end hung against the trunk of the tree. The worker received a fatal shock when he tried to free the branch from the tree.

Scaffolds and other equipment near power lines

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

Farm equipment can cause accidents when it contacts power lines. Farm workers have been electrocuted when metal irrigation pipes have been lifted up, touching overhead power lines. Where practicable, store metal irrigation pipes at least 30 metres (100 ft.) away from overhead power lines.



The tool is an extension of the worker's reach and must not come within the limits of approach.

HAZARD ALERT

A construction worker was erecting tubular scaffolding 3 metres (10 ft.) from an energized 25 kV (25,000 V) conductor. The worker was handling a long section of bracing, which accidentally made contact with the power line. The worker was electrocuted.

Utility poles

Do not work close to utility poles if the work could cause a pole to become unstable or if the limits of approach cannot be maintained. If any poles are unstable, ask the owner of the power system to support or remove them. Workers must not climb poles supporting power lines unless they are qualified and authorized by the owner of the utility.

HAZARD ALERT

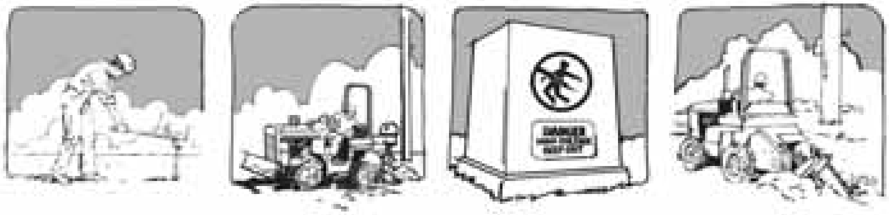
A worker was excavating a trench beside a utility pole. The pole was undermined when too much soil was removed next to the pole. The pole fell over, causing high-voltage lines to fall near the worker. Fortunately, the worker was not injured.

Underground utilities

Today, low-voltage and high-voltage underground wiring is used for supplying power to schools, commercial buildings, homes, and numerous 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, and pipeline services. Some of these service providers belong to BC One Call. By calling 1 800 474-6886, you can find out which utilities are members and the location of their underground cables and pipes. Only a few power systems are members, but more are joining. If a utility is not a member of BC One Call, you will need to contact the owner directly to obtain the location of underground utilities.



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

The following activities are potentially hazardous because workers may come in contact with 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

HAZARD ALERT

A worker was breaking concrete when his jackhammer broke through a conduit. The tool made contact with an energized 15 kV (15,000 V) underground cable. The worker was electrocuted.

7 steps to electrical safety

1. 10 METRES TO SAFETY

   Stay back at least 10 metres (33 ft.) from any downed power line, exposed underground cable, or where there is contact with an overhead power line. Depending on voltage, this distance may increase up to 32 metres (105 ft.).

2. LOOK UP AND LIVE

   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.

3. KNOW YOUR LIMITS

   When operating machinery or equipment in close proximity to power lines, always maintain the limits of approach: 3–6 metres (10–20 ft.), depending on the voltage. For proper safe working distances, see the table on page 32 or contact the owner of the power system or WorkSafeBC. Where any portion of a machine or equipment may come closer than the minimum distance prescribed, a form 30M33 must be completed before work begins. This allows the owner of the power system to provide some form of protection.

4. DON'T HANG AROUND OPERATING EQUIPMENT

   On the ground stay at least 10 metres (33 ft.) away from operating equipment because if it contacts an energized line the electricity will go to ground. The operator should be on 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.

5. SHUFFLE OR HOP, DON'T STEP

   If the machinery you are operating contacts an energized line, move it away from the line to break contact. If this can't be done, remain on the machine. If there is an uncontrollable fire, jump off 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. OR, hop with both feet together to a minimum distance of 10 metres (33 ft.).

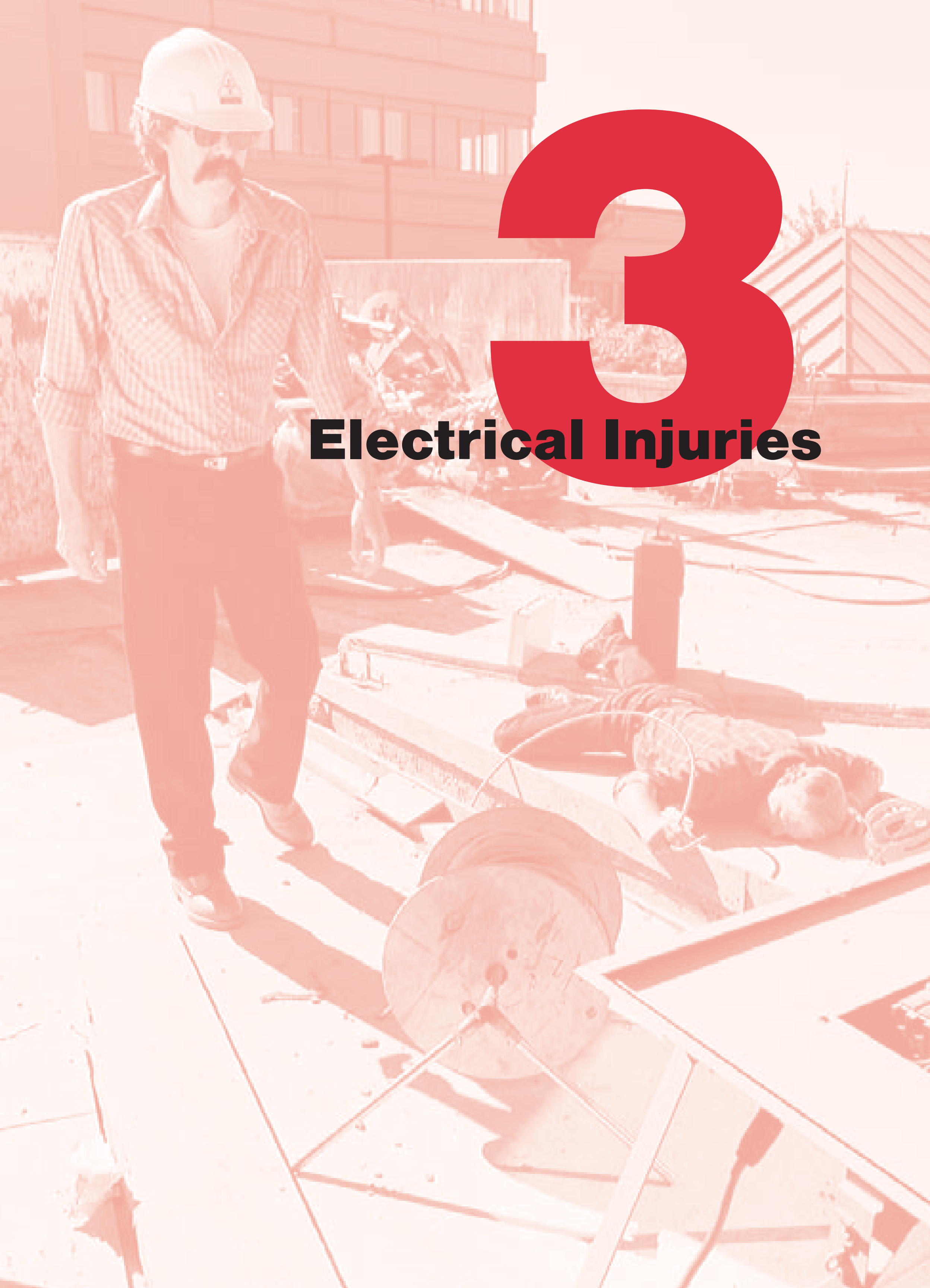
6. **CALL BEFORE YOU DIG**

   Whenever digging or drilling is to occur, the location of all underground services in the area must be accurately determined. Call the owner of the power system before you dig. (See page 42 for more 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 metres (33 ft.) away and have the operator remain on the vehicle. If the operator must leave the vehicle because of fire, the operator should follow the "Shuffle or Hop, Don't Step" rule.

7. **DON'T BECOME A VICTIM**

   Always call your local emergency services when someone is injured in an electrical accident. If they are still in contact with the electrical source and you touch them, you could be seriously injured or killed. Keep everyone back a minimum distance of 10 metres (33 ft.), and have someone call for help immediately.

3 Electrical Injuries

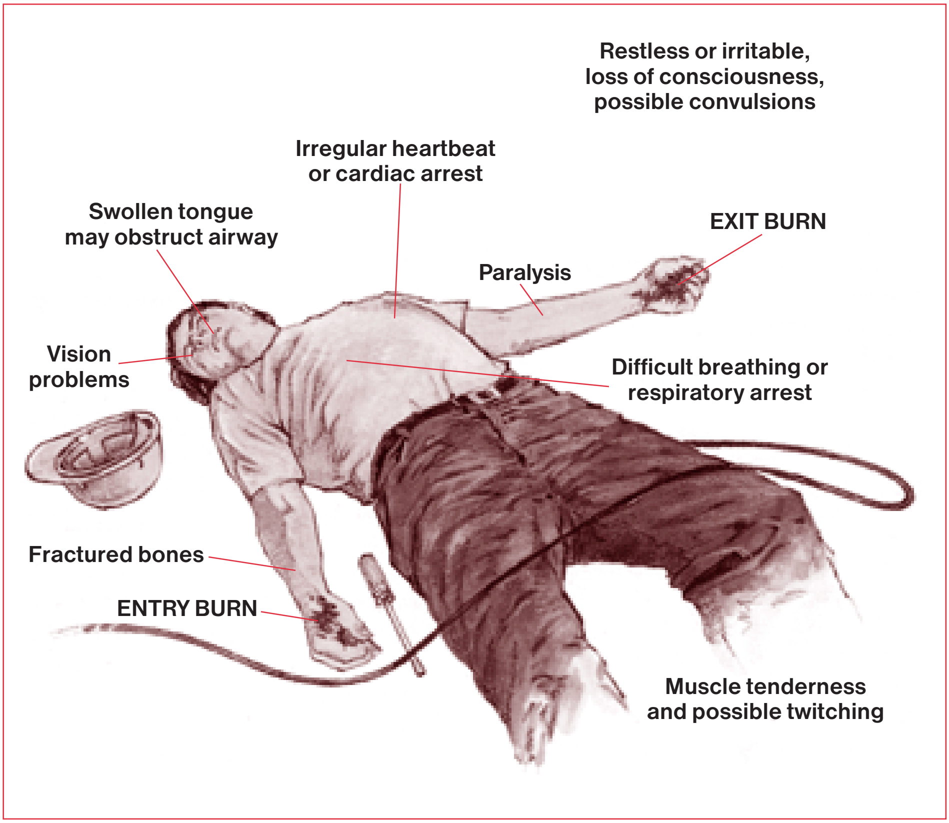


Types of electrical injuries

Electrical injury is a term for all injuries caused by contact with electrical energy. Electrical contact can cause a wide variety of injuries involving most organ systems. Most electrical injuries are classified as one of the following:

- Burns
- Electric shock injuries
- Eye injuries

As well as these injuries directly related to the electrical accident, the worker may be thrown or may 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 any of a number of signs and symptoms.

Burns

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

Flash burns are caused by heat released when an arc is formed 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 thousands of 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.

Arcing burns occur when the current jumps from the current source to the worker or from one part of a body surface to another.

Flame burns caused by the ignition of clothing are common, particularly with high-voltage exposure.

Contact burns occur when the skin touches hot surfaces of overheated electrical conductors or other equipment.

Electrical burns are the result of electrical 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 3,000°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. As well as the electric burn injuries discussed on page 50, there may be internal bleeding, unconsciousness, respiratory paralysis, and cardiac disorders.

The electric current can cause involuntary muscle contractions. These may prevent the 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 length of time the current is flowing through the body

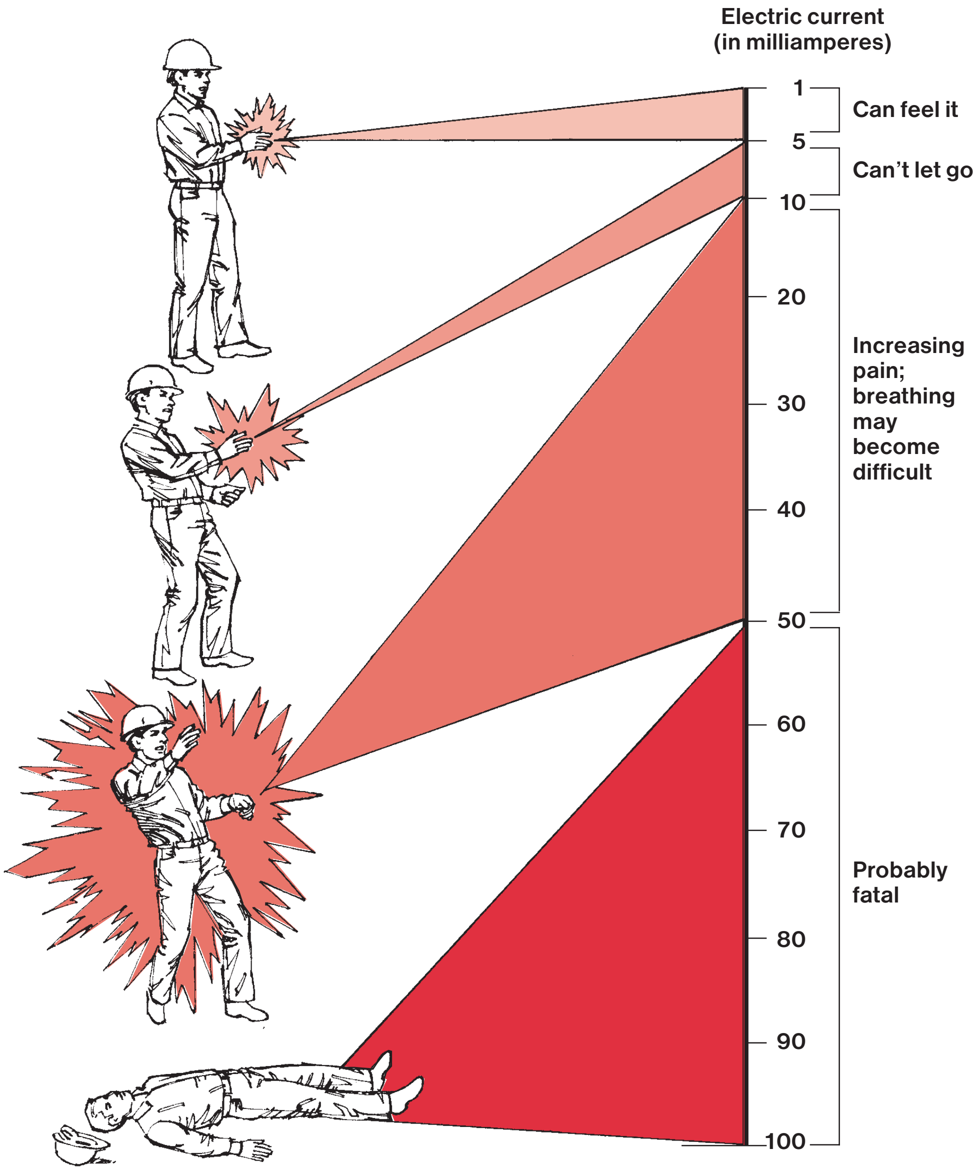
Other factors that may affect severity of injuries from electric shock are:

- 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 52 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 a just few seconds. Current that is strong enough to run a 5 or 10 watt light bulb can kill you. Low voltages can be extremely dangerous.

As shown on page 52, a difference of less than 50 mA (milliamperes) exists between a current that is barely perceptible and one that can kill. The degree of injury is proportional to the length of time the body is in the electrical circuit. The longer you're exposed to the current, the more serious the shock. **Low voltage does not mean low hazard!**

Range of body tolerance



A 100 watt light bulb uses 1000 mA (milliamperes) of current. It takes only 5 mA to trip a ground fault circuit interrupter (GFCI). A small amount of current running through the body for a few seconds can give the effects shown in the table.

Eye injuries

Like any other part of the body, the eyes can be burned. Regular safety glasses may not protect against flash burns from electric arcs. Direct or reflected light from an electric arc may cause a surface burn to the cornea. Although flash burns are very uncomfortable, most of those caused by shorter flashes are not serious and usually heal in 12 to 24 hours. With longer flashes of a couple of seconds, permanent retinal damage may occur from the ultraviolet light.

If there is a fire, 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.

First aid

Electric shock and electrical burns are serious injuries and should receive immediate medical attention. Contact the first aid attendant, if available, or get other medical help. Arrange for transport to hospital immediately.

Make sure you keep yourself and the injured worker out of further danger:

- 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 metres (33 ft.) until the owner of the power system says it is safe to approach. Do not become a second victim. If the voltage is over 60 kV (60,000 V), you may need to keep as far away as 32 metres (105 ft.). See page 31 for more information on rescue work around power lines.

First aid for electrical injuries includes the following:

1. Remove the worker from the heat and put out the fire on any clothing by smothering the flames with a blanket or dousing the worker with water. Make sure that fabric is no longer smouldering. Cooling more than 20% of the body at one time can cause hypothermia. Wet dressings and any clean source of water may be used for cooling. *Never* apply ice.

2. Initiate priority action following the ABC approach:
   A. Airway: Establish and maintain an open airway.
   B. Breathing: Check and maintain breathing. If the injured worker is not breathing, start assisted ventilation (using mouth-to-mouth or a pocket mask).
   C. Circulation: Monitor the worker's circulation constantly. Initiate cardiopulmonary resuscitation (CPR) if necessary, and carry on until more advanced life support is obtained. Electrical workers should be familiar with CPR.
3. Keep the injured worker warm and at rest.
4. If the injured worker is conscious, offer reassurance.
5. If the injured worker vomits, turn the worker onto one side to keep the airway clear.
6. Transport the injured worker to medical aid. While waiting for transport or en route to medical aid, administer first aid for burns (see box below).
7. Do not leave injured workers unattended. Maintain a constant watch on their airway, breathing, and circulation while they are transported to medical aid.

First aid for burns

First aid for burns can be administered while the injured worker is waiting for transport or being transported to medical aid:

- Remove rings, wrist watches, and footwear, if possible.
- Elevate burned extremities, if possible, to decrease fluid loss. Do not splint burned limbs unless there is an obvious fracture or dislocation. Avoid handling the affected body parts unnecessarily.
- Apply wet dressings on burns to less than 20% of the body surface. Any burns in excess of 20% can be covered with dry dressings or clean sheets. Do not apply tight, encircling dressings.
- Do not break blisters.
- Do not apply creams, ointments, or other medications to the burned area.
- Do not examine burned eyelids. Cover them with sterile dressings until they can receive specialized treatment.

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