Electrical Safety
Handbook for Emergency Responders

Electrical Safety Authority

Public Services Health & Safety Association™

hydro one

Electrical Safety Handbook for Emergency Responders
Revised 5th Edition

Acknowledgment and appreciation is expressed to BC Hydro for permission to adapt their Electrical Safety for Firefighters training package for use in Ontario.

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Electrical Safety Handbook for Emergency Responders

Best Practices for Coping with Electrical Hazards in Rescue and Fire Situations

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Table of Contents

List of Tables

Introduction

This manual has been designed and developed to educate and protect emergency responders who are called upon to respond to emergencies involving electrical systems.

In 2010 there were a couple of situations in which EMS, police and fire fighters put themselves in jeopardy. One situation involved emergency responders and police entering a utility owned outdoor substation to assist a utility worker who had succumbed to his injuries. They attended to the victim inside the station within close proximity of energized electrical equipment. A second situation involved EMS, the fire department and police attending a scene in which a construction worker had succumbed to his injuries from a boom truck wire rope cable contacting an overhead ***power line***. They attended to the victim in the vicinity of the boom truck while the boom cable was in close proximity to the energized ***power line***. The electrical utility was called out afterwards to make the area safe by the Ministry of Labour. Another incident involved EMS entering an attic to attend to a victim who had been electrocuted. At the time they were unaware of the existing electrical hazard presented by an exposed bare conductor.

In 2011 fire fighters responded to a substation transformer fire, breaking down the gate and stripping back the fence fabric. They placed a monitor (unmanned hose) spraying water on the transformer to contain the fire. They did this prior to utility personnel arriving on site and without the utility's confirmation that it was safe to do so. Since that incident, the utility has taken the fire service on an extended series of substation site visits.

In 2012, two fire fighters both received shocks while on their knees trying to battle a fire in a smoke filled basement. The electrical power to the house was still on when they blasted the water towards the open flames in the vicinity of the electrical panel. In another incident, while conducting regular testing/training on a ladder truck, it contacted an overhead 27,600 volt ***power line*** while lowering the ladder prior to retracting the extension. No injuries were sustained.

The number of incidents reported to the ESA involving overhead and underground ***power lines***, vaults and substations from 2001 to 2010 averaged 209 electrical contacts per year. As a result of these electrical contact incidents, about 4.5 fatalities were reported annually. The ESA's Ontario Electrical Safety Report can be found at **www.esasafe.com**.

The best practices and procedures described in this handbook have been developed to protect both the emergency responders and victims. Following these best practices will assist you to respond safely and effectively to emergency situations involving electrical hazards.

Operational Guidelines are important to the health and safety of any organization, especially those involved in providing emergency services. The writing of operational guidelines to deal with specific electrical hazards should be considered to enhance the effectiveness of this handbook. While the handbook provides specific safety distances and steps to follow/consider during a response, the handbook is not intended to replace or become an Operational Guideline.

NOTE: This Handbook is not to replace or supersede any Operational Guidelines. This Handbook is to compliment Operational Guidelines already implemented within emergency services.

1.0 Electrical Facts Emergency Responders Must Know

This handbook has been designed to provide the emergency responder with a simple to use reference guide, to assist in coping with hazards associated with electricity that you will encounter in your day to day duties.

1.1 Common Electrical Terms

The properties of electricity are described in terms of three fundamental factors; the ***potential*** difference ***(voltage)***, ***current*** flow and ***resistance*** to the flow. These three factors are related through Ohm's Law which states: ***potential*** difference "E" ***(voltage)*** is equal to the ***current*** "I" multiplied by the ***resistance*** "R" (E=I x R or V =I x R). Key electrical terms frequently used to describe electricity are ***"voltage", "current", "resistance"*** and ***"grounding"***. For a complete list of other electrical terms see the glossary. Words throughout this document that are italicized and bolded have definitions in the glossary.

"Voltage" the difference in ***electrical potential*** between two points in a circuit. It is the force that causes the flow of electricity, and it is measured in volts. Can be compared to water pressure.

"Current" a flow of electrical charge. It can be compared to the rate of flow of water in a pipe. ***Current*** is typically measured in amperes (or amps).

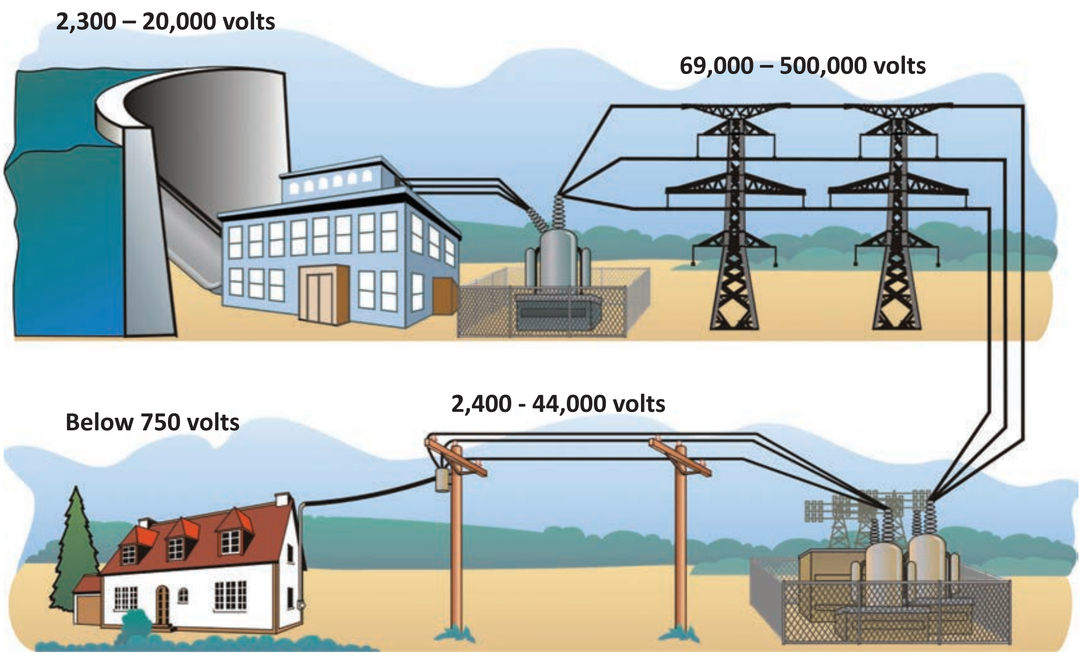
"Resistance" is similar to the effect of friction on the flow of water in a pipe. (Water flows more freely in a large pipe than in a small one.) Different materials have different ***resistance*** to the flow of electricity. Very high ***resistance*** materials are called insulators, while the low ***resistance*** materials are called conductors. ***Resistance*** is measured in ohms.

"Grounding" is the process of mechanically connecting isolated wires and equipment to the earth, with sufficient capacity to carry any ***fault current*** and to ensure the wires and equipment remain at the same ***potential*** (same ***voltage***) as the earth (ground).

1.2 Electrical Installations

Electricity is generated at power stations at ***voltages*** ranging from 2,300 to 20,000 volts. This ***voltage*** is stepped up for efficient transmission over long distances to substations near the load centres. Some transmission lines operate as low as 69,000 volts, others as high as 500,000 volts.

At the substations, ***voltage*** is reduced and power is sent on distribution lines to industrial, commercial and residential customers. Power plants, substations, underground vaults and other electrical utility installations differ greatly from the buildings fire fighters usually face in emergencies. They present unusual hazards, which can seriously handicap rescue and fire fighting and sometimes endanger the emergency responder's life, if he or she is not familiar with the surroundings. In all cases, specialized rescue and fire fighting techniques are required to ensure maximum personal safety and effectiveness. It is therefore important that good communication and cooperation exist between the local electrical utility and police, fire and ambulance personnel. Emergency response personnel, who wish to learn more about the hazards involved in working near electrical equipment, should make arrangements with electrical utilities to inspect installations.



1.3 Faulty Electrical Equipment

Electricity is obviously safe when it's controlled through well designed and maintained equipment and structures. Hazards are created when electrical equipment or wires have become faulty as the result of being:

- worn out or deteriorated
- improperly installed
- improperly maintained
- improperly used
- damaged or broken
- adverse weather/natural events exposure

Any one of these factors may cause arcing or overheating of electrical equipment – the two conditions that cause the majority of electrical fires. Consider each of these conditions:

1. **Arcing:** An electrical arc is a sudden flash of electricity between two points of contact. An arc is extremely hot (e.g. 20,000°C, 35,000°F). As a fire cause, it is usually associated with a short circuit or a ***current*** interruption at a switch point or loose terminal. Arcing can ignite combustible material or gases in the vicinity, including the insulating material around the conductor. Hot material may be thrown into adjacent flammable material, starting a fire.

2. **Overheating:** Overloading of electrical conductors and motors accounts for the majority of fires caused by overheating. There is danger when the amount of electrical ***current*** exceeds the capacity conductors and equipment are designed to carry.

3. **Combustible Materials**: Fires involving electrical equipment may result from the presence of combustible materials. For example, most fires that break out in electrical generating plants originate in fuel systems, oil systems, combustible gaseous atmospheres, combustible buildings or combustible contents.

1.4 Insulators, Conductors and Semi-Conductors

All materials conduct electricity in varying degrees. Materials classified as “insulators” are of high ***resistance*** and conduct electricity in such small quantities it cannot normally be detected. Materials classified as “conductors” are of low ***resistance*** and conduct electricity readily and in large amounts.

Some examples; porcelain, glass and plastic are insulators, all metals (iron, copper, lead, aluminum, silver and gold) are conductors. Humans, largely made of water and dissolved minerals, are good conductors.

Some other materials are classified as “semiconductors”. Wood, earth and rubber tires are semi-conductors. Depending on conditions such as moisture content and contaminants, semi-conductors can conduct electricity

1.5 *Low Voltage* Hazards

Most electrical fires originate in equipment operating <u>below 750 volts</u>. In the electrical industry, this is referred to as low or secondary ***voltage.***

Home heating systems, appliances, electrical outlets and lights typically operate at 120/240 volts or less. It is important for emergency personnel to recognize the deadly hazards of even relatively ***low voltage***. Commercial and industrial ***voltages***, typically range from 300 to 750 volts, when interrupted can produce explosive electrical flashes as a result of the higher levels of ***current,*** known as ***fault current*** which can exceed 8,000 amps.

1.6 *Safe Limits of Approach*

Emergency responders must maintain the ***Safe Limits of Approach*** as required by the Ontario Occupational Health and Safety Act (OHSA) and stated in the Regulations for Industrial Establishments and Construction Projects. The limits are as stated in Table 1.

Table 1. *Safe Limits of Approach*

Voltage **of Live Line Power (Volts)**	**Minimum Distance Metres**
750 to 150,000	3.0 (10 ft)
150,001 to 250,000	4.5 (15 ft)
250,001 and higher	6.0 (20 ft)

High voltage electricity can arc through the air into a person or tool if either gets too close. All persons, tools, and equipment including aerial devices and extension ladders must maintain the minimum distance. This is called maintaining the ***Safe Limits of Approach.***

Do not use an aerial device or ladder in close proximity. Maintain the ***Safe Limits of Approach*** as required by OHSA.

When using an aerial device near these ***Safe Limits of Approach***, you must have a competent worker, designated as a signaller (see 7.3), observe the proximity to the ***power line*** and to signal to the operator.

The operator of the aerial device must be on the aerial device or on a ground gradient mat, not the ground. Secure entry into the area around equipment that is being used in close proximity to ***power lines***, and halt contact with the aerial device when the boom is being repositioned. Always be aware of conductor swing and sag. A conductor can swing 1.8m in either direction and can sag due to heating or power loading.

When forced to work near or overtop live ***power lines***, arrange to have the power shut off with your local utility. This is the only safe way to come closer than the ***Safe Limits of Approach*** (e.g. use a signaller/observer) with equipment that conducts electricity.

Emergency responders must leave enough room for the full range of movement, without violating the *Safe Limits of Approach*.

1.7 Electricity Takes All Paths to the Ground

A key fact to remember is that electricity seeks all paths to ground. More ***current*** will flow through the path of least ***resistance***. The easier the path to ground the more ***current*** will flow through that path. This is true regardless of the electrical source. If a person touches two energized wires, or an energized wire and the ground at the same time, he or she will become part of an electrical circuit, and may be seriously injured or killed.

If a person or live wire contacts a metal fence or guardrail, electricity will travel along the entire length entering the ground at each post depending on its material creating multiple entry points into the ground. Electricity can travel a very long way. Consider for example the fencing around a school yard.

1.8 *Voltage* Gradient on the Ground Surface

Because electricity takes all paths to ground, electrical systems use multiple safety systems to deal with system faults. Conductive ***grounding*** rods are one component used to ensure that any stray electricity is returned to earth. These rods are typically driven deep into the ground to ensure wide dispersal of stray electrical energy. However; if equipment is damaged, electricity can be released at a point that is not protected by these safety systems. For example when a “live” wire lies on the ground, the electricity will fan out from all points of contact with the ground.

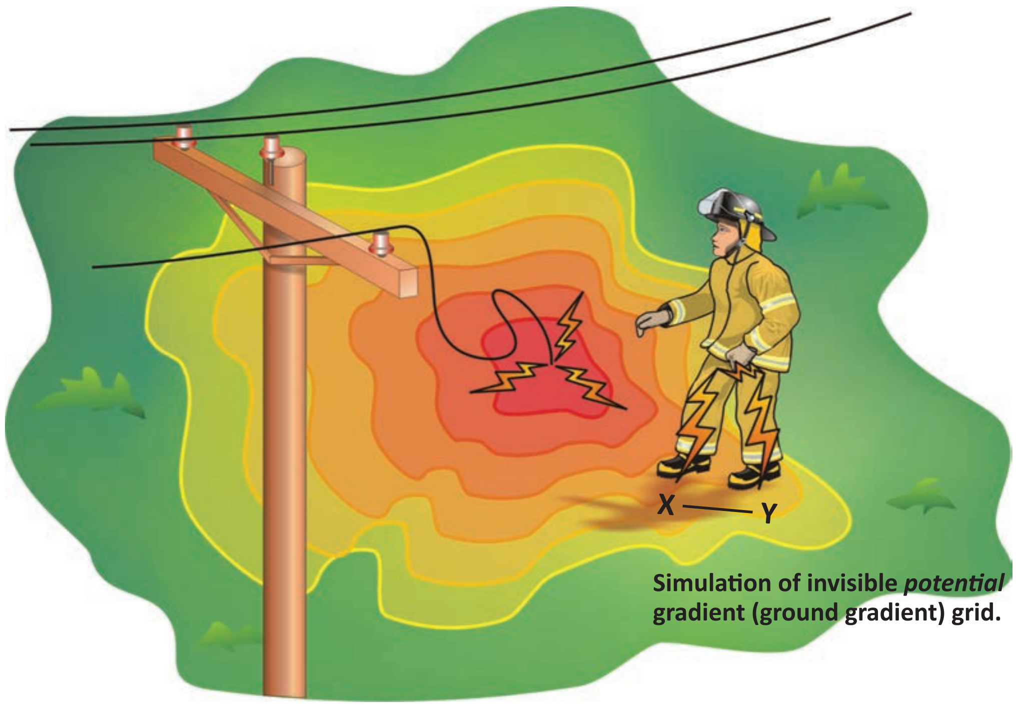
At any point of contact there is a rippling effect that can be compared to dropping a pebble into calm water. In the pool of water, the wave created at the point of contact gets smaller as it rings out. Similarly, in this “pool” of electricity, the energy is at full system voltage at the point of ground contact, but as you move away from the contact point, the ***voltage*** progressively drops. Unlike the water ripple in a pond, the electricity flow can be very unevenly distributed (see diagram on page 10). In wet conditions, the flow of electricity across the ground can be significantly greater. This effect is known as “***potential*** gradient”. It is also referred to as “ground gradient”.

Knowledge of potential gradients may someday save your life.

1.9 Step *Potential*

The ***potential*** gradient, or ***voltage*** difference, creates two problems known as “step ***potential***” and “touch ***potential***”.

Let us assume that a live downed wire is touching the ground and has created a “pool” of electricity. If you were to place one foot near the point of ground contact (at X ***voltage***), and your other foot a step away (at Y ***voltage***), the difference in ***voltage*** (***potential*** gradient) would cause electricity to flow up one leg, through the abdomen and back down the other leg. This can cause muscular contraction that results in the emergency responder involuntarily jumping and falling onto the ground and having ***current*** flowing through the heart or brain. The further apart that “X” and “Y” are, the greater the electrical contact hazard. This effect is referred to as “step ***potential***” and it is illustrated in the picture on page 10.



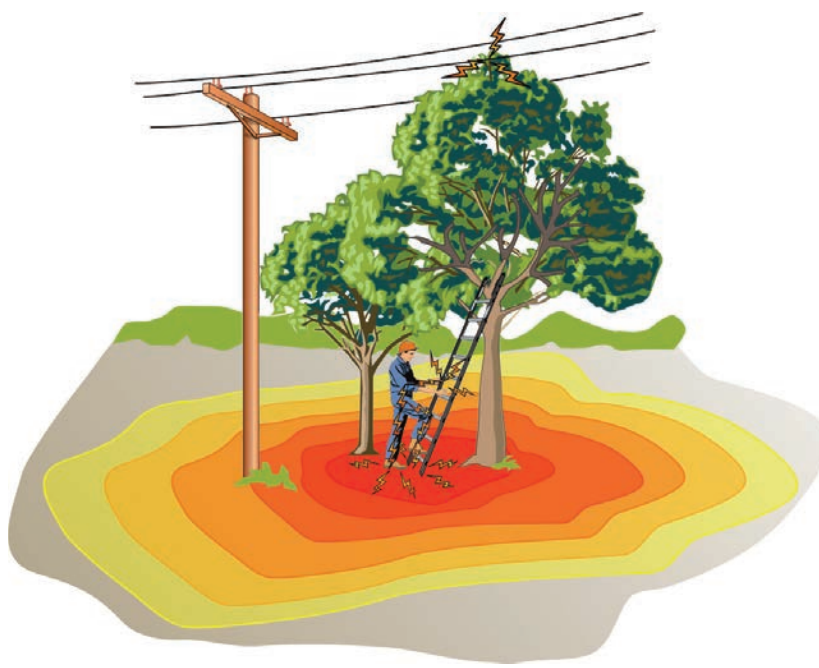
Simulation of invisible *potential* gradient (ground gradient) grid.

Fire fighters' boots are subjected to extreme wear and must not be relied upon to approach any closer than the recommended distances, in this particular scenario, 10 metres (33 ft) or more.

1.10 Touch *Potential*

In a manner similar to step ***potential***, electricity would flow through your body if you were to place your hand on an energized source, while your feet were at some distance from the source. The electricity would flow through the hand, arm, chest, abdomen, leg and foot to the ground. The difference in ***voltage*** (***potential*** difference) in this case is referred to as "touch ***potential***".

The difference in *voltage* from one extremity to the other causes the electricity to flow through the body.



2.0 Injuries Caused by Electric Shocks

2.1 Effects of Electricity on the Body

The effect of electricity on the body is dependent on the amount of ***current*** and the length of time the body is exposed to it. The higher the ***current***, the less time a human can survive the exposure. The path of electricity through the body is also critical. For example, ***current*** passing through the heart or brain is more life threatening than ***current*** passing through the fingers. It takes approximately 1,000 milliamps (1 amp) of ***current*** to light a 120-watt bulb. Here are the effects you can expect from just a fraction of that ***current*** for less than a second.

Table 2. Electrical Effects on the Body

Current **Level milliamperes (mA)**	**Probable Effect on Human Body**
1 mA	Perception level. Slight tingling sensation. Still dangerous under **certain conditions**.
5 mA	Slight shock felt; not painful, but disturbing. Average individual can let go. However strong **involuntary reactions** to shocks in this range may led to injuries.
5mA - 9mA	A GFCI operates.
6mA - 16mA	Painful shock, begin to lose muscular control. Commonly referred to as the freezing *current* or “let-go” range.
17mA - 99mA	Extreme pain, respiratory arrest, severe **muscular contractions.** Individual cannot let go. Death is possible.
21mA - 99mA	Respiratory arrest.
Above 50mA	Heart defibrillation or failure.
100mA - 200mA	Ventricular fibrillation (uneven, uncoordinated pumping of the heart). Muscular contraction and nerve damage begins to occur. **Death is likely.**
> 2,000mA	Cardiac arrest, internal organ damage, and severe burns. Death is probable.

The figures in Table 2, illustrate that a very small amount of ***current*** for less than a second can be fatal. It is the amperage that kills or injures. The ***voltage***, is the pressure that pushes the ***current*** through the body, also has an important effect. When a victim is exposed to household ***voltages***, he or she may suffer a muscle spasm and may be locked-on to the electrical source until the circuit is turned off, the victim is dragged clear, or the victim falls clear of the contact by the weight of his or her body. Relatively long periods of contact with ***low voltage*** (seconds to minutes) are the cause of many electrical fatalities in the home or at work.

At very ***high voltages***, found on distribution ***power lines*** for example, the victim is often quickly blown clear of the circuit, resulting in a significant fall if working from heights. This situation may result in less obvious internal damage, with no visible to severe surface burns at the entrance and exit points of the electrical ***current***.

A victim exposed to a large electric arc can be injured by the intense heat, molten metal splatter or by ultraviolet rays. This can cause burns or clothing ignition without electrical contact, temporary blindness and serious eye damage. In addition to the factors outlined above, the effect of electricity on the body and the severity of the shock depends on the:

1. Condition of the skin,
2. Area of skin exposed to the electrical source,
3. Pressure of the body against the source, and
4. Moisture level of the surface of the skin.

Any victim of electrical shock should be assessed for the following effects on the body:

1. Contraction of chest muscles, causing breathing difficulty and unconsciousness.
2. Respiratory distress caused by temporary paralysis of the respiratory center.

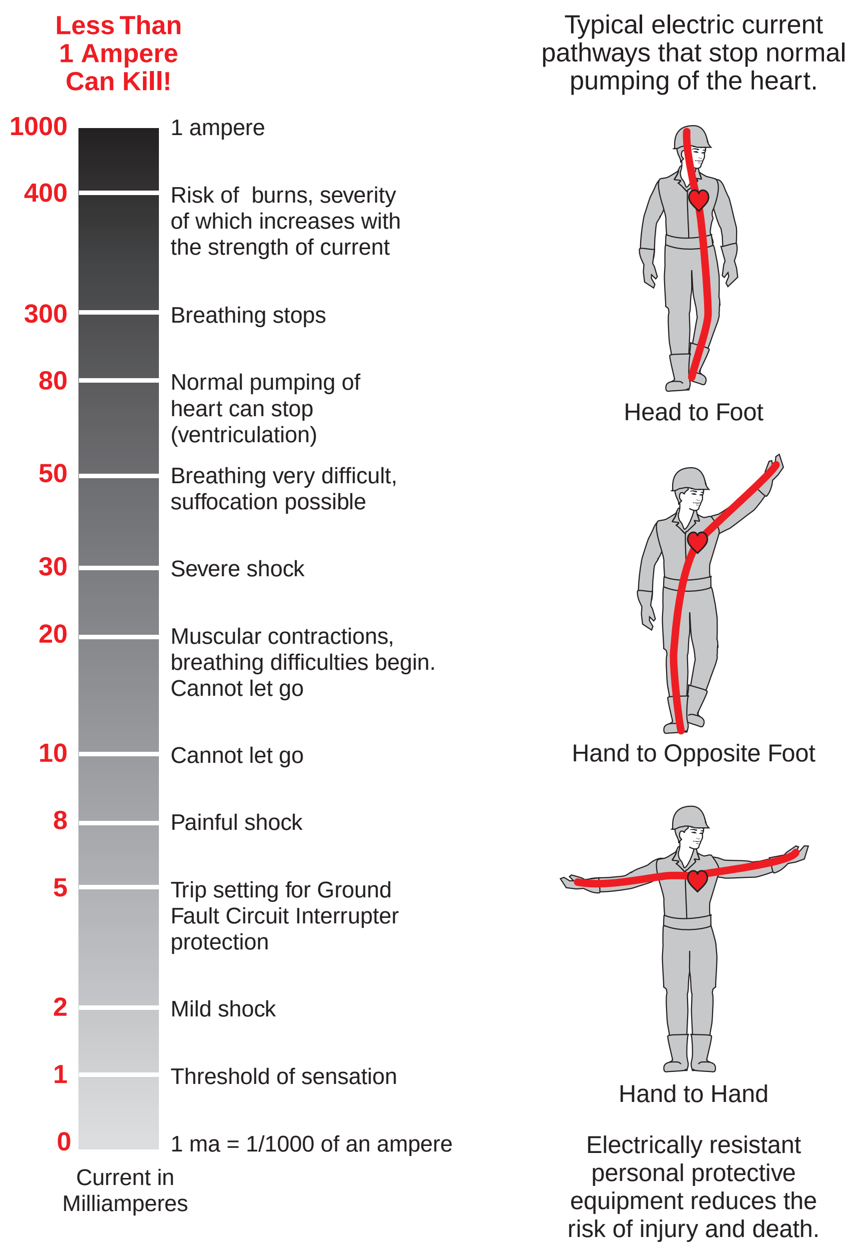
3. Rapid, irregular heart beat (ventricular fibrillation) mainly resulting from contact with ***low voltages***.
4. Burns to tissue at the entrance and exit points.
5. Fractures caused by muscle spasm.
6. Injuries such as fractures, contusions, internal bleeding due to falls.

Any victim of electrical arc flash should be assessed for the following effects on the body:

1. Burns to skin from the ultraviolet radiation of the flash.
2. Burns to the eyes and skin from molten metal splatter.
3. Burns to the skin from clothing including under layers of clothing that were ignited by the arc flash.

NOTE: Temporary blindness from the sheer brillance of the flash called “dazzle” is only temporary, but can be of concern if a person moves around blindly and makes contact again.

Biological Effects of Electricity



2.2 Coping with Electrical Injuries

Before any treatment can be given to the victim, the electrical hazard must be eliminated. The safest alternatives are to either turn off the electrical supply at the main breaker or to have the local electrical utility disconnect the power supply. **If the electrical *current* cannot be turned off or disconnected, you must NOT attempt treatment.**

Electrical Injuries	Action to be taken by Emergency Personnel
Cardiac arrest. Heart action may stop if control centers of the heart are paralyzed.	Start cardiopulmonary resuscitation protocols and/or AED automatic external defribrillation.
Rapid and irregular heart beat (ventricular fibrillation). Heart muscle quivers instead of contracting normally. This condition is more likely to be caused by a shock of relatively *low voltage.*	Start cardiopulmonary resuscitation protocols and/or AED automatic external defribrillation.
Breathing stopped. Electrical contact (shock) often causes breathing to stop.	Start artificial respiration immediately and monitor the pulse to ensure that blood is circulating. If a flow of oxygen to the lungs can be maintained by artificial respiration until the paralysis wears off, normal breathing will usually be restored.
Electrical Burns. *Current* passing through the body generates heat and may cause blisters on the skin. If the ***current*** is strong enough, it may destroy body tissue and result in severe electrical burns. The outward appearance of electrical burns may not seem serious, but the damage is often very deep and healing is slow.	Emergency procedure for burns. Prompt medical attention is required to prevent infection. Examine the victim for an exit burn as well as an entry burn and cover wounds with clean dry dressings.
Shock (electrical contact induced).	Get victim to lie down and treat for physiological shock. Loosen clothing, cool by fanning if skin is hot, cover with blanket if cold or clammy. Monitor to ensure life signs are stable and not deteriorating.
Arc Flash burns. Flash or ultraviolet light burns to eyes.	For skin burns, do not remove clothing that has melted into the skin. Cover both eyes with thick, cool, moist dressings and lightly bandage in place. If after explanation, the patient does not want both eyes covered only cover the eye that is most painful. Get the patient to medical help. Transport the patient on a stretcher. Never have the patient walk.
Fractures. Broken bones caused by violent involuntary muscular reaction to *high voltage* electrical contact. Involuntary muscular reaction may also have caused the victim to jump or fall resulting in more serious injuries such as fractures or contusions.	Assess for fractures or dislocations. Steady and support (immobilize) the affected area.

2.3 Medical Follow-up

Effects can be delayed up to 24 hours. Even a short exposure to electricity can cause an irregular heart rhythm resulting in death within hours. It is critically important to be placed on a heart monitor in a medical facility after a person has made electrical contact. Emergency rooms have access to "CritiCall Ontario" for Doctors/Hospitals only 800-668-4357. This allows access to expertise including for electrical burns. The Ross Tilley Burn Unit at Sunnybrook Hospital has a person on call 24/7 for this purpose.

3.0 Protective Clothing and Equipment

3.1 Emergency Responder Protective Clothing

Standard response protective clothing for fire fighters, police and paramedics, while mandatory for emergency response, does not provide any protection against electrical contact hazards.

3.2 Electrically Shock Resistive Footwear

Footwear (boots and shoes) that is electrically shock resistive must not be depended upon to provide electrical shock protection. Due to the nature of emergency responders work, the electrical resistivety of the sole can be severely degraded.

3.3 Reflective Equipment and Safety Vest

Due to the fact that most electrical distribution ***power line*** right-of-ways run parallel to county roads, responding to emergencies will mean that emergency responders will also be dealing with traffic hazards. For this reason, high visibility CSA or ANSI approved safety vests, or equivalent, should be worn by emergency responders, and high visibility reflective equipment (signs, flares, etc.) should be used to warn drivers.

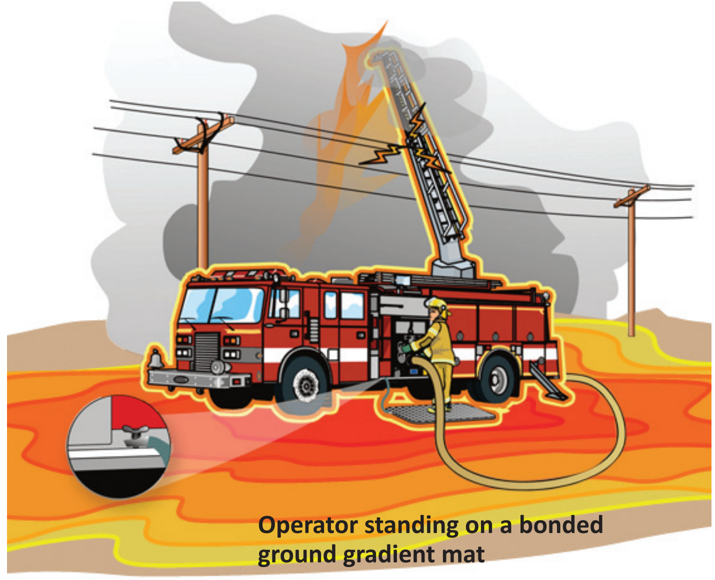
Follow your organization's requirement for high visibility clothing to ensure that you are clearly visible. Be mindful of the flammability of your clothing and vest in an area with an electrical hazard.

3.4 Ground Gradient Control Mats

To avoid injury from step and touch ***potential***, use a portable ground gradient control mat when operating an aerial device near live electrical ***power lines*** when the controls are operated from the ground or where the operation is guided from the ground. For dual purpose vehicles such as combination pumper-aerial, the pump controls must be operated while standing either on a platform supplied and attached to the vehicle or while standing on a ground gradient control mat ***bonded*** to the vehicle. Mats must be ***bonded*** for use in the following manner:

1. place the mat on the ground in front of the control panel,
2. place both feet on the mat, and
3. connect the ground mat cable clamp to the vehicle.

The operator must keep both feet on the operating platform or the ground gradient mat while operating the aerial equipment until the operation has been successfully completed and the ground mat connection removed. If the operator must leave the ground gradient mat, while in close proximity to power lines, he/she must hop with both feet together from the mat. Use the shuffle step to move 10 metres (33ft) away from the vehicle. To get back on to the mat reverse the above procedure.

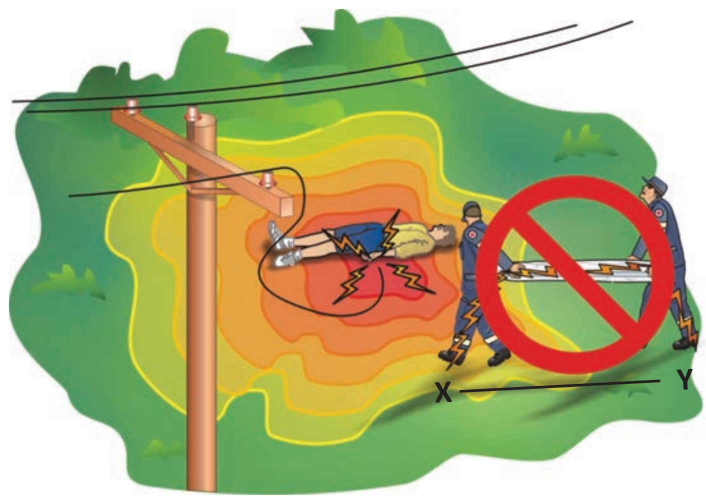


3.5 Equipment Hazards

Ladders and stretchers, due to their length, can present significant "step and touch ***potential***" hazards and must be kept well away from downed ***power lines***. Equipment does not need to be in direct contact with a ***power line*** to conduct electricity. Electricity can jump or arc across to conductive equipment that is in close proximity. In the illustration you will see a greater separation between "X" and "Y" bridged by the stretcher being carried.

Air cylinders of Self Contained Breathing Apparatus (SCBA), extend the size of the "body" behind the rescuer. Emergency responders need to be very aware of the cylinder and to maintain a greater personal safety zone to avoid contact with electrical structures or conduits particularly in electrical rooms or underground vaults.

Other emergency response equipment, such as extendable microwave and communication towers can also create hazardous situations if used in close proximity to ***power lines***. Ensure that you are at least 6 metres (20 ft) away from ***power lines*** when extending these devices.



3.6 Power Inverters, Portable Generators and Cabling

Portable Generators should be of the ***bonded neutral*** type (***bonded*** to frame ***neutral***). In ***bonded neutral*** generators the ***neutral*** wire is ***bonded*** to the generator frame. Check the rating tag affixed to the generator for the ***bonded neutral*** designation. Portable generators, when used during fire fighting or rescue operations, should be positioned in as dry an area as is practicable. Using a ***bonded neutral*** portable generator, with electrical extension cords which are compliant with the Ontario Electrical Safety Code, Table 11 (CSA STW Type Designation) for use in wet environments will enable fire fighters to use portable hand tools and equipment safely. Twist connections and overlapping ***insulated*** rubber connections are also recommended to ensure the safety of fire fighters and to avoid the potential for electrical contact injury. The use of a ***bonded neutral*** type portable generator, in combination with extension cords fitted and approved for wet environments, reduces the need for use of the two ground rods and grounding wire with the portable generator.

Power inverters, portable generators or design-built generators mounted on the truck are also popular for ease of operation. The truck manufacturer should be contacted to ensure all aspects of the installation are safe considering bonding, fuel, cooling, support and exhaust requirements. Mounted power inverters and generators must be ***bonded*** to the vehicle frame and all supply circuits from the generator must be protected by ground fault circuit interrupters (GFCI).

No matter which power source you use, plug into a GFCI for wet or outdoor applications to protect the people using electrical equipment plugged into it. A GFCI is not dependent on a ground connection. If the electrical device you are using is not directly plugged into the generator or power source containing a GFCI, then the tool should be plugged into a GFCI device at the end of the extension cord. This is an OHSA requirement.

3.7 Electrical Arc Flash Protection

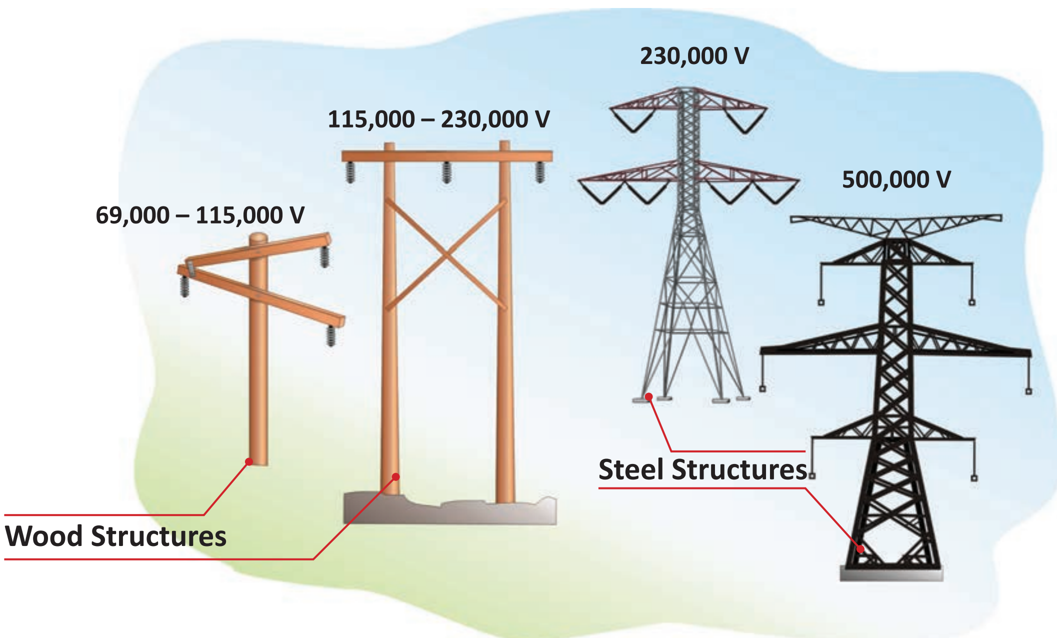
Clothing worn by paramedics and police including protective vests, do not provide electrical arc flash protection. For this reason these emergency responders should not enter areas such as substations, electrical vaults or any areas containing ***open*** energized parts. Standard fire fighter bunker gear is designed to withstand heat and fire and will provide electrical arc flash protection. Fire fighters entering these areas to assist with rescue must wear full bunker gear to ensure their own safety.

Emergency responders all have tools of the trade that they carry which can become an unknown hazard to the responder and those around them in some situations. Whenever emergency responders enter any area containing ***open*** energized equipment (electrical vaults, substations, or generating stations), they need to be aware of the equipment they are carrying. This equipment may create an arcing situation or if contacted, create a path to ground and cause the responder serious injury or death. Equipment such as, but not limited to; stretchers, Oxygen/trauma bags, gun/utility belts, spanners, accountability tags (clipped to the helmet), portable radios, screwdrivers (pocket items) and Self Contained Breathing Apparatus (SCBA) can conduct electricity. Items such as these should be removed in a safe area and only nonconductive items should be taken into electrically hazardous areas. Be aware of your environment. Removing various equipment may not be possible due to the situation encountered (i.e. fire). It is also recommended that whenever possible, local electrical utility personnel either accompany emergency responders or at a minimum provide safety instructions about the area being entered.

4.0 Overhead *Power Lines*

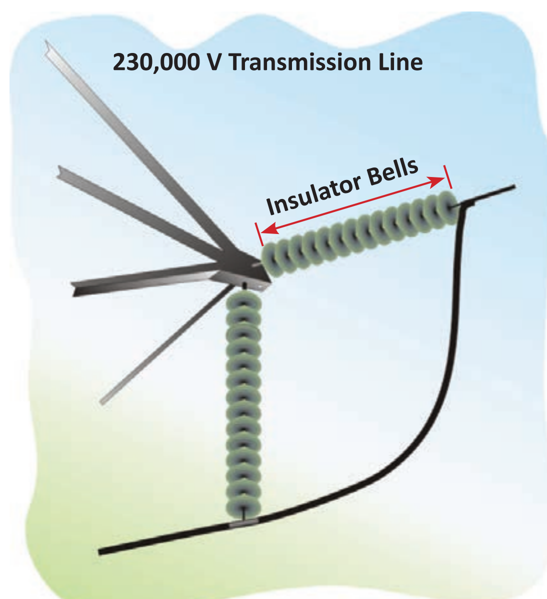
4.1 Overhead *Power Line* Components

There are three parts to a typical electrical system; Generation, Transmission and Distribution. Electricity is transported throughout the province of Ontario by transmission systems. Transmission lines bring power into cities on wood structures, or steel towers at ***voltages*** from 69,000 to 500,000 volts. The design can vary from a single wood pole for 69,000 to 115,000 volts to steel structures for 115,000 to 500,000 volts.



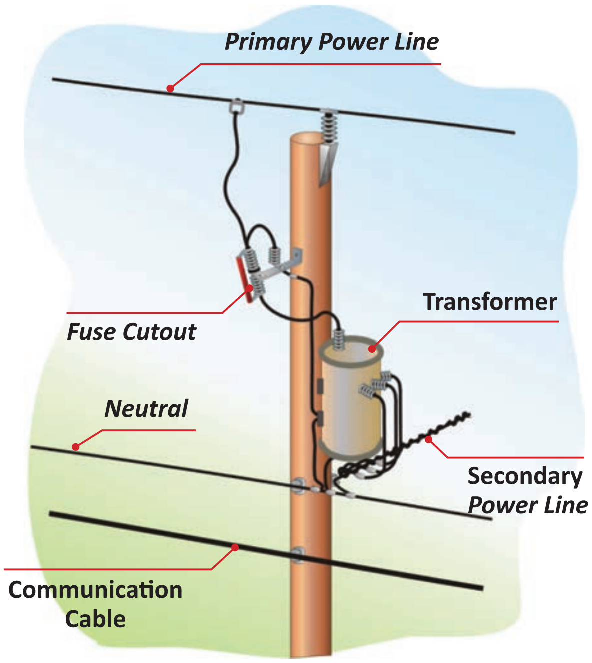
Power lines are supported or suspended from the structures on insulators. Bell-type insulators are suspended from the structure with the conductor running on the bottom of the stack of insulators.

An easy to remember rule for working around live ***high voltage*** transmission lines is to keep at least 6 metres (20 ft) away. If you need to work closer, first determine the ***voltage***. Determine the voltage by contacting Hydro One and providing the alpha numeric (number) found on the leg of the steel structure or the pole.



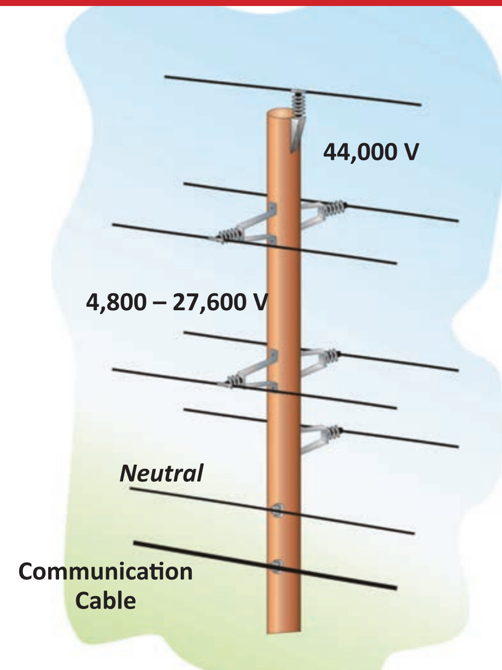
4.1.1 Distribution *Power Lines*

From a substation the ***voltages*** are reduced to 2,400 to 44,000 volts for distribution to local distribution transformers. Smaller transformers on poles or the ground, reduce the ***voltage*** to 347/600 volts for industrial use and to 120/240 volts for residential use. Poles will have from one to three transformers for reducing the ***voltage*** from primary to secondary ***voltages*** (120/240 or 347/600 volts). From the distribution transformers the electricity travels through the ***secondary power lines*** (120/240 and 347/600 volts) to the utility meter and building distribution panel.

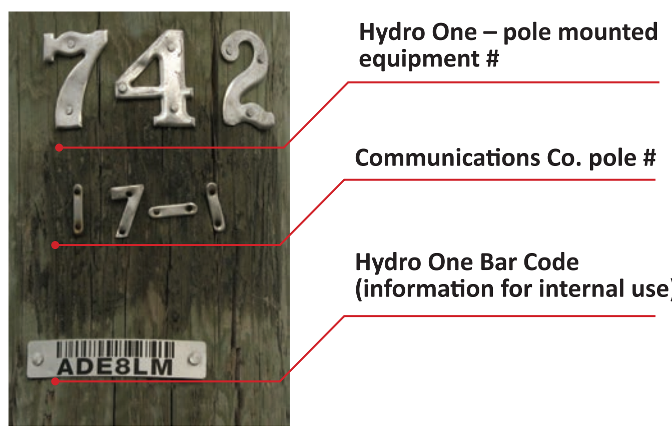


The drawing shows a typical distribution pole. The ***high voltage*** *primary line* (2,400 to 27,600 volts) is usually located above the transformer. The system ***neutral*** and ***secondary power lines*** (120/240 and 347/600 volts) are typically found below the transformer and are weather coated but should not be considered ***insulated*** or safe to touch. Note that deterioration of the weather coating or insulation can expose live bare conductor.

Most of the distribution ***power lines*** in cities and towns are supported on wooden poles; however, concrete, composite and steel are also used. Poles have different ***resistance*** and some can be more hazardous, for example concrete poles are more conductive than wood poles. The ***power lines*** are attached by insulators to prevent the flow of electricity to the ground. Pin type insulators carry

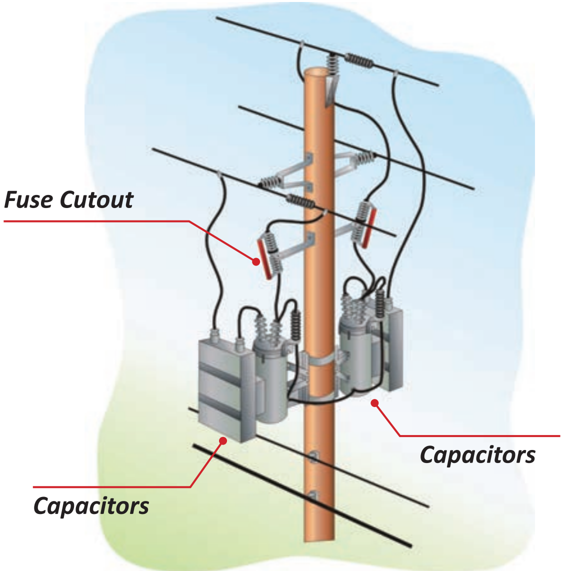


the conductor on top and are used for 44,000 volts or less. If the insulator is broken and the conductor contacts the pole or crossarm, there may be a flow of electricity down the pole creating a hazard. In the case of vehicle accidents, the conductors can be knocked off the insulators and energize the pole, especially if it is wet from rain or snow.



When arriving before the electric utility at a rescue or fire scene involving a utility pole, emergency responders should look for the presence of a pole number. For example, Hydro One Networks' pole number is a six character alpha numeric code located on a silver plate about 1.5 metres (5 ft) from the ground. This number identifies location as well as valuable information about equipment on the pole. **Emergency responders are not to place themselves in a dangerous situation to get the number.** If a pole number is not obtainable, a 911 municipal address or the closest intersections are acceptable alternatives.

4.1.2 *Fuse Cutouts* and *Capacitors*



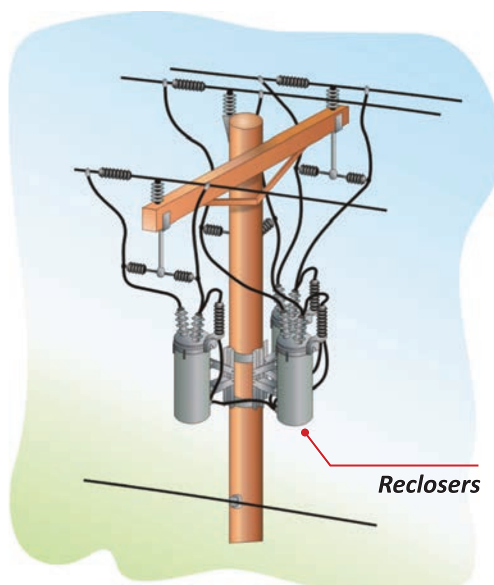
The ***fuse cutout*** acts like a circuit breaker in a house. If there is a power surge or short in the line, the ***fuse cutout*** will blow ***open*** preventing damage to the transformer and customers' equipment. Other equipment that is found in distribution systems includes switches, regulators and ***capacitors***.

Capacitors store energy and can produce lethal *amounts of current,* even when the power is off! If a *capacitor* has fallen to the ground do not touch it or attempt to move it!

4.1.3 *Power Line* Protection Automatic *Reclosers*

Both transmission and distribution *power lines* are protected by automatic circuit breakers and by "*Reclosers*" shown here. When a *power line* is tripped out (i.e. *open*) due to a fault, the automatic breaker or *recloser* will, after a short period of time (typically a fraction of a second to minutes), attempt to close and re-energize the *power line*. This means that a fallen, or low hanging *power line* may be dead one moment but fully energized the next, often with no visible signs of the electricity being present. *Reclosers* may also go through a number of cycles over a period of time that is impossible to predict. *Reclosers* can be located on utility poles or located on substations.

Treat all downed *power lines* as live as most often there are no visible signs of electricity.



<u>Utility Control Room Operations</u> – Utility Control rooms are manned around the clock seven days a week and monitor the distribution system. Equipment at substations is remotely controlled from the control room. Once an Auto ***Recloser*** becomes "Locked Out" due to interference on the line, a Control Room Operator may operate the ***recloser*** and re-energize the ***power lines*** to restore power one minute after a lock out.

4.2 *Power Line* Emergency Scenarios

Electrical distribution lines and/or equipment such as poles may be broken by storms, ice, vehicles snagging the wires or by vehicles striking electrical equipment such as poles or pad mounted equipment. If you come across abnormal situations such as broken, fallen or low hanging wires, assume that the lines are energized and capable of killing people. ***Assess the situation, determine the safe***

zone, secure the area, and then inform the nearest electrical utility office as soon as possible*. It is important to inform the electrical utility if the situation is an *"immediate threat to life"* situation.** When communicating with the electrical utility always use three-way communication techniques and use pole or equipment identification numbers if possible. Verify instructions by repeating them back to the electrical utility representative. ***Qualified power line maintainers will be sent to *isolate* and *de-energize* the ***power lines*. *Don't expose yourself to risk while trying to eliminate the danger.***

4.2.1 *Electrical Backfeed*

The *power lines* of modern electrical distribution systems, may be fed from more than one source or direction, therefore even when a wire is broken both ends may still be live and hazardous. *Power lines* which aren't connected to the system could be energized by backfeed from electrical generators, solar panels or wind turbines. *Current* generated at *low voltage* (120/240 volts) can be increased to *high voltage* (2,400 to 27,600 volts) as the electricity passes through the padmount or pole top distribution transformer.

Treat all downed or low hanging lines as live and secure the area.

Backfeed from Generator

If the situation is life threatening, it may be possible to determine if backfeed is a hazard and eliminate it. To do this contact the home, farm or business owner or manager.

Ask the owner or manager if they have a generator, solar panel or wind turbine, and if they do, ask them to turn it off.

4.2.2 Fallen or Low Hanging Wires

1. **Before getting out of your vehicle, examine the surroundings carefully and make sure you are parked well away from the fallen wires.** If it is night time, use a flashlight to examine the surroundings carefully from the vehicle window. If you are parked over or near the fallen wires, move your vehicle well out of harm's way. A distance of at least 10 metres (33 ft) or more is recommended from the down wire or conductive object it is in contact with.

2. **Stand well back, at least 10 metres (33 ft) or more away. Look for and locate all wire ends.** They may be on the ground or suspended in the air. If a live wire touches a car, truck, metal fence or any other conductive object that object will also be capable of killing people. A pool of water will also become deadly if a live wire has fallen into it.

3. **Establish the safe zone, at least 10 metres (33 ft) away from wires and anything the wires may be touching.** If a wire has fallen onto a fence or metal object, electricity may be conducted to other points some distance away. You will need to ensure all potentially electrified objects are inaccessible. Inform other emergency responders of the hazards.

4. **Secure the area.** Face oncoming pedestrians and traffic and keep people away from broken or low hanging wires or other electrically charged objects. Live wires in contact with objects on the ground may burn through, and one end may then curl up or roll along the ground causing injury.

5. **Do not attempt to move any fallen wires, call and wait for electrical utility personnel.** Most live wires lying on the ground do not show any signs of being live. Only the proper meter in the hands of a ***qualified power line*** maintainer can safely determine this and how to make the area safe.

Keep bystanders back at least 10 metres (33 ft).

4.2.3 Motor Vehicle Accidents

The following instructions are intended to guide only those emergency responders (fire fighters, police) who are properly trained in electrical emergency rescue procedures.

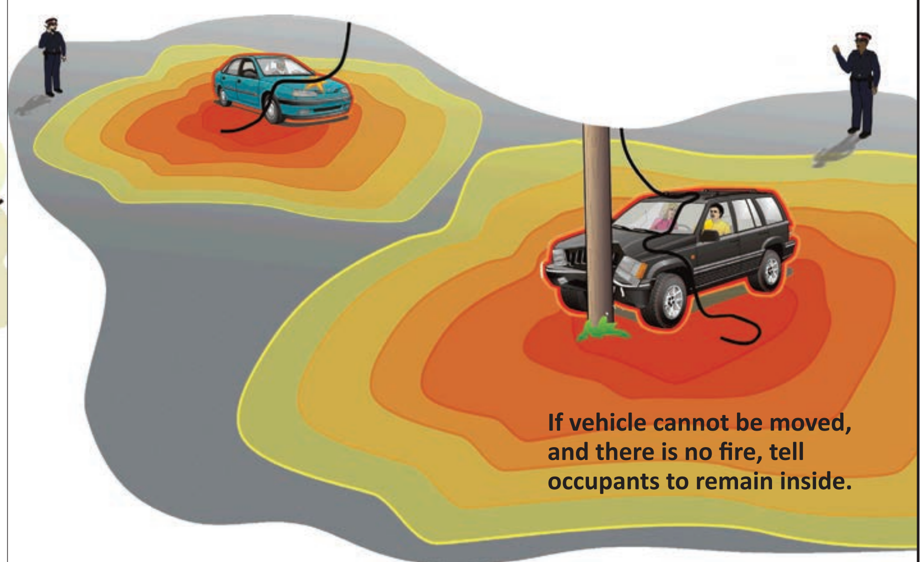
Wherever possible, trained ***power line*** maintainers will handle these situations. However, if electrical utility personnel are not yet on the scene, you may be instructed by utility personnel for these emergency situations.

4.2.3.1 Common Language for Communicating with Victims

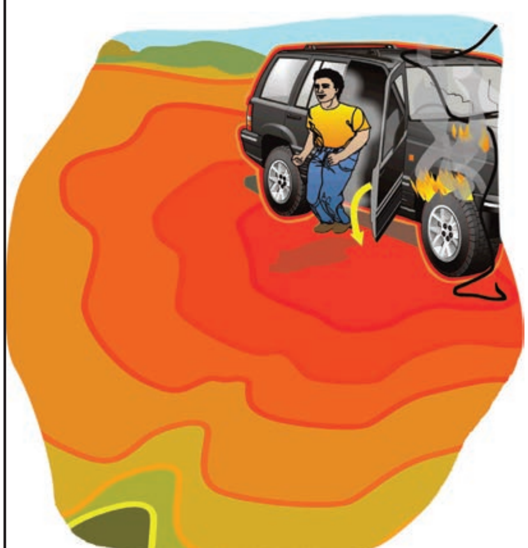
The following statements are suggested for use in communicating with persons involved in emergency situations, such as motor vehicle accidents, that involve ***power lines***, equipment or facilities.

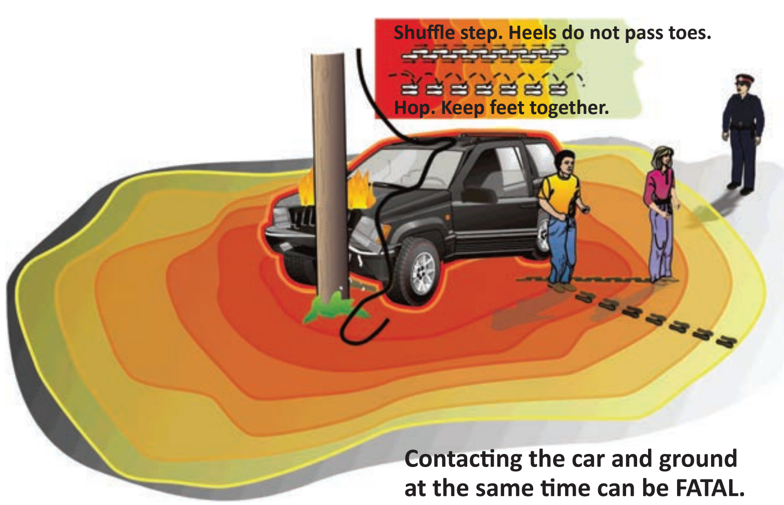
Statement	Rationale for wording
"Stay in the vehicle, we are contacting the electrical utility."	Tells people in vehicles in contact with ***power lines*** that they may be at risk if they leave their vehicle.
"Stay clear, the ground is electrified, you can get injured."	Tells people at the perimeter of the secure area, around downed ***power lines***, why they must stay away.

4.2.3.2 Rescuing Persons from Vehicles Contacting *Power Lines*

Situation	Emergency Responder Action
A fallen wire lies on top of, or under a vehicle with one or more people inside.	1. Assess the situation from 10 metres (33 ft) or more away. Assessing from inside your vehicle increases your safety margin. A *potential* gradient will be present if the line is live and you could be electrocuted. 2. Determine the safe zone and secure the area. 3. Keep yourself and others out of the line of fire of a vehicle's tires. They can explode. 4. Call the local electrical utility. 5. Keep feet close together, shuffle step as you approach 10 metres (33 ft) from the vehicle or energized item. If you have come too close, shuffle step away to maintain the safe distance.
	
The driver is able to move the vehicle.	1. Make sure you and others are not in a position to be injured in case the wire springs up after being released or moves suddenly when the vehicle moves. 2. Instruct the driver to very slowly move the car off of or away from the wire, and clear of any pools of water which may be energized by the live wire. **If the *power lines* get pulled by the vehicle then instruct the driver to stop and to "Stay in the vehicle..." until electrical utility personnel arrive.**
The driver is unable to move the vehicle or the vehicle will not move.	1. Instruct the driver to "Stay in the vehicle..." until the electrical utility personnel arrive. 2. Continually monitor the safe zone, secure the area and keep people away. 3. A vehicle's tires may smoke or explode from heating up, but do not advise leaving the vehicle except in the event of fire.

Situation	Emergency Responder Action
Victim(s) are unconscious and there are fallen wires under or on the vehicle or hanging very close to the vehicle.	1. Determine and continually monitor the safe zone, secure the area and keep people away. 2. Monitor closely for any change in the situation (fire starts etc.) Instruct any victim who might regain consciousness to "Stay in the vehicle..." until the *power line* is deenergized (made safe). **DO NOT take action which would endanger your own life or the lives of others.**
Occupants are not injured and: • The vehicle has a fire which cannot readily be extinguished, and • the vehicle cannot be moved (see illustration below).	1. Explain to the occupants that contacting the vehicle and ground at the same time could kill them. 2. Instruct the occupants on how to jump out of the vehicle and move away. Tell them: "Keep both feet together and jump clear of the vehicle. Avoid touching the car as your feet come into contact with the ground. Take short shuffle steps keeping both feet as close together as possible. They must avoid contacting each other. Move in this manner away from the car for at least 10 metres (33 ft)." 3. Instruct the occupants to jump when they are ready.





Jumping clear of a vehicle can be very dangerous and should only be attempted in circumstances where there is no other alternative (e.g vehicle fire). The condition of the vehicle and physical ability of the occupant must also be considered.

Occupants are injured or unconscious and the vehicle has a fire which cannot be extinguished, and the vehicle cannot be moved. [**This is a worst case situation**]	**The only practical and safe actions require the assistance of trained, qualified and equipped electrical utility personnel.** **Refer to Section 4.2.4.1 for the application of water.**

4.2.3.3 Roadway Stripping Hazard

Road stripping with metal backing is typically used for temporary road marking situations such as in construction areas. Downed ***power lines,*** in contact with this striping, can result in electrical ***current*** travelling significant distances along the metal foil backing. In one recorded incident, ***current*** traveled over 33 metres (100 ft) from where the downed *power line* lay.

4.2.3.4 Vehicle Tires Pyrolysis

Vehicle tires in contact with ***high voltage*** electricity may suffer internal damage. The electricity flowing through the tire causes a chemical decomposition of tires and sets the stage for pyrolysis. This can result in sudden explosive failure of the tire(s) up to 24 hours after contact. Remember, **the larger the tire, the greater the explosion** and **there is NO safe angle of approach.**

Deflated tires have the same potential to explode as inflated tires. Conduct firefighting operations from as far away as possible and from a protected location. Debris and shrapnel from tire explosions can travel several hundred metres and the metal rim can travel up to 15 metres (50 ft), so keep out of the direct line of fire. Keep bystanders and non-emergency persons at least 100 metres (330 ft) from the incident. Isolating vehicles in a safe area for 24 hours and inspection by a *qualified* tire person is recommended prior to returning vehicle to service.

4.2.3.5 Electric and Hybrid Vehicles

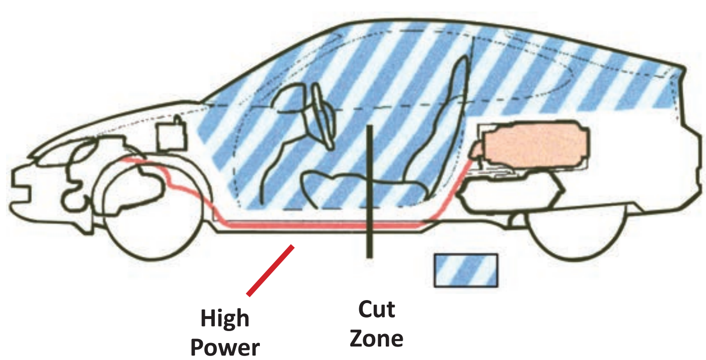
Electric and hybrid vehicles damaged in a motor vehicle accident can present electrical contact hazards to emergency responders. ***High voltage*** energy within the batteries and wiring to the electric motor can carry as much as 650 Volts DC, sufficient electrical energy to cause death.

If damage to any of the ***high voltage*** components or cables is suspected or found, disconnect the ***high voltage*** circuit. You must refer to the manufacturer's emergency procedures manual for alternative ways of disconnecting the ***high voltage*** circuit for each vehicle. Each manufacturer has different means to disconnect the ***high voltage*** circuit and information is available at **www.evsafetytraining.org/resources** from manufacturers.

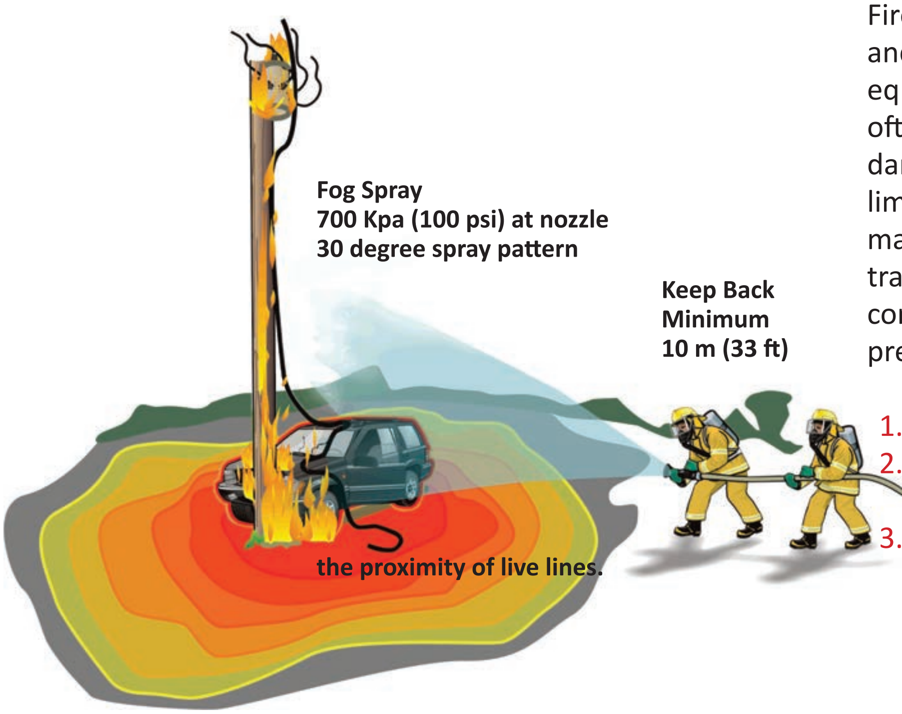
In general, if "extricating" type equipment is required to remove occupants from a damaged electric or hybrid vehicle, be sure to stay within the cut zone illustrated in blue. Typically the ***high voltage*** line is colour-coded orange and runs along the underside of the vehicle chassis. Cutting into this area should be avoided.

If a car fire occurs, the use of an ABC fire extinguisher designed for electrical fires is a first alternative.

For additional information refer to the NFPA Electric Vehicle Emergency Field Guide, 2012 Edition and the additional guidance available at **www.evsafetytraining.org/resources** from manufacturers.



4.2.4 Fighting Fires on *Power Line* Equipment



Fires on wood poles carrying conductors and other electrical distribution equipment do occur. The fires are often caused by lightning, defective or damaged equipment, broken wires, tree limbs, wind or ice storms. Wood poles may be chemically treated and pole top transformers and other equipment may contain PCBs; therefore as a standard precautionary approach:

1. Wear full turnout gear and SCBA.
2. Position apparatus upwind and out of the line of fire of a vehicle's tires.
3. Evacuate people located in path of smoke plume and at safe distances from a ground gradient grid or tire explosion.

Tree fires near distribution right-of-ways can also be complicated by the proximity of live lines.

4.2.4.1 Using Water Safely on Electrical Fires

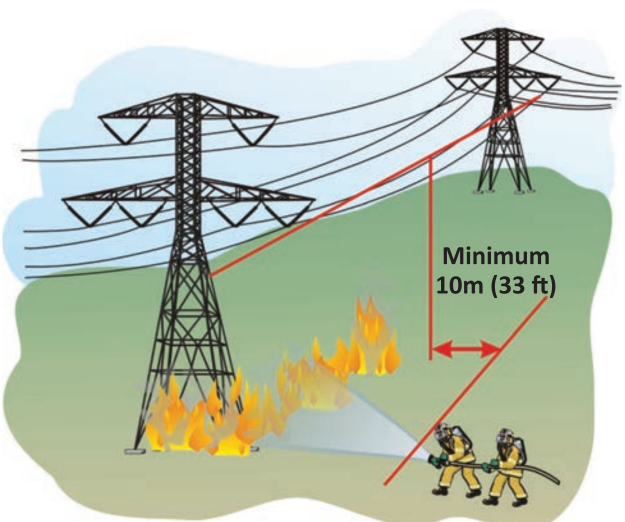
Water can be applied safely by knowing the ***voltage*** involved and strictly adhering to following minimum distances, pressures, nozzle size and spray pattern. A summary of best practices is provided in Table 3. An easy to remember rule is to stay back 10 metres (33ft) unless certain that the ***voltage*** is less than 750 volts.

Table 3. Safe Distances for Using Water on Live Electrical Equipment

Voltage **of Live Equipment**	**Minimum Distances at 700 Kpa (100 psi) at nozzle**
Volts	**Spray (fog)**
0 to 750	1.5 metres (5 ft)
751 to 15,000	4 metres (13 ft)
15,001 to 500,000	7 metres (23 ft)

SITUATION: Fire on *power line* equipment	
ACTION 1. Assess the situation from at least 10 metres (33 ft) back. Attempt to determine the ***voltage*** involved. If you aren't certain assume the highest ***voltage***. 2. Determine the safe zone, secure the area and keep people back at least 10 metres (33 ft). 3. Call the local electrical utility, and inform other emergency responders of the hazards. 4. Set the nozzle to produce fog (minimum 30 degree pattern) and ensure the designed pressure stays at or above 700 Kpa or 100 psi at the nozzle. 5. Direct the fog at the burning pole or equipment. Stay back at least 10 metres (33 ft) unless you are certain of the ***voltage***. It is safe to direct a fog stream at ***high voltage*** lines providing you maintain the separation between yourself and the live wires or electrical equipment.	
DO NOT apply a straight water stream directly on the fire. Electricity can travel through the stream back to the nozzle.	**DO NOT use foam on live electrical equipment. Foam is a good electrical conductor.**

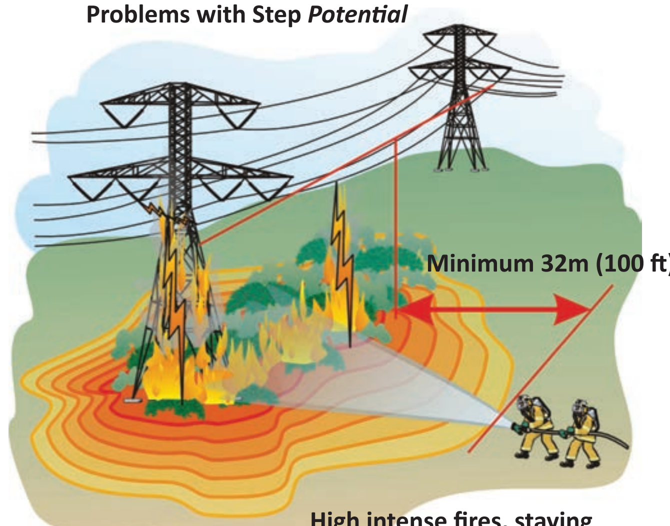
4.2.5 Fighting Fires on Transmission Rights-of-Way



Voltage **unknown, low level fire, staying back - 10 m (33 ft)**

When fighting fires on or near a transmission line right-of-way, the distance between you and the ***power lines*** depends on the intensity of the fire, smoke density and the ***voltage*** involved. The application of water requires special procedures. A ground level fire involving low fuel loads can be fought safely with normal fire fighting procedures. As with distribution ***power lines,*** if there is a chance that water from the nozzle will come into contact with a conductor, a 30 degree fog pattern with a 700 Kpa (100 psi) minimum pressure must be used. High intense fires producing significant flame and smoke require additional precautions. The approach limits must be increased because of ***arc-over*** hazard and dangers of step ***potential.***

Problems with Step ***Potential***



High intense fires, staying back - 32 m (100 ft)

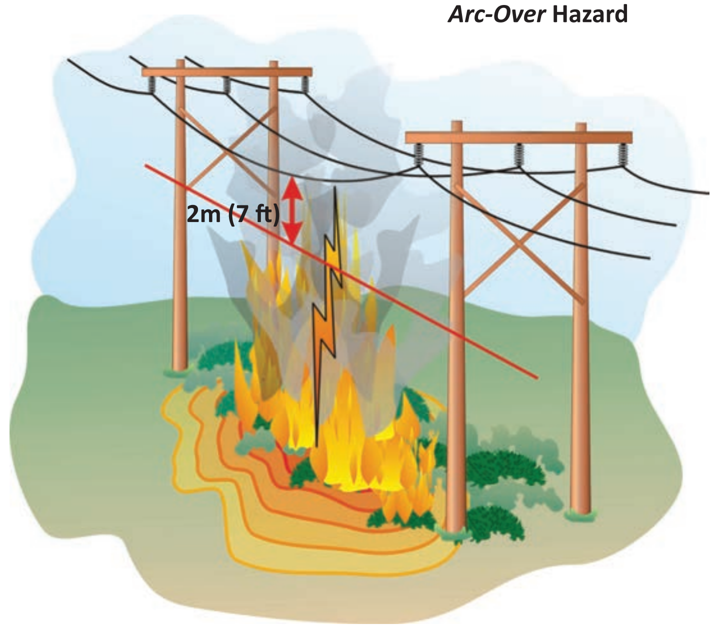
4.2.5.1 *Arc-Over* Hazard

High voltage power lines are ***insulated*** by air space. An intense fire burning on the right- of-way of a transmission ***power line***, may degrade the insulating quality of the air to the point of enabling electricity to jump to the ground surface, if flames reach within 2 metres (7 ft) of the live conductors.

Dense smoke can also create this problem on the transmission right-of-way especially if the smoke contains a high level of particulate material or moisture.

A high transient electric ***current*** then flows through the ground generating a ***potential*** gradient and step ***potential*** hazard. The step ***potential voltages*** may be hazardous to fire fighters and emergency responders working in the vicinity of the arcing point.

Arc-Over **Hazard**



4.2.5.2 *Arc-Over* Hazardous Zone

If an intense fire is burning near live conductors, a step ***potential*** hazard could occur within what is called the ***arc-over*** hazardous zone. This zone extends a distance out from the outer phase conductors. The distance is dependent on the ***power line voltage.***

Even if the fire is under one outside conductor, the safe distance should also be applied to the other outside conductor in case the ***arc-over*** affects the tower or a grounded structure.

Arc-Over **Hazard Zone for 230,000 V (see Table 4)**

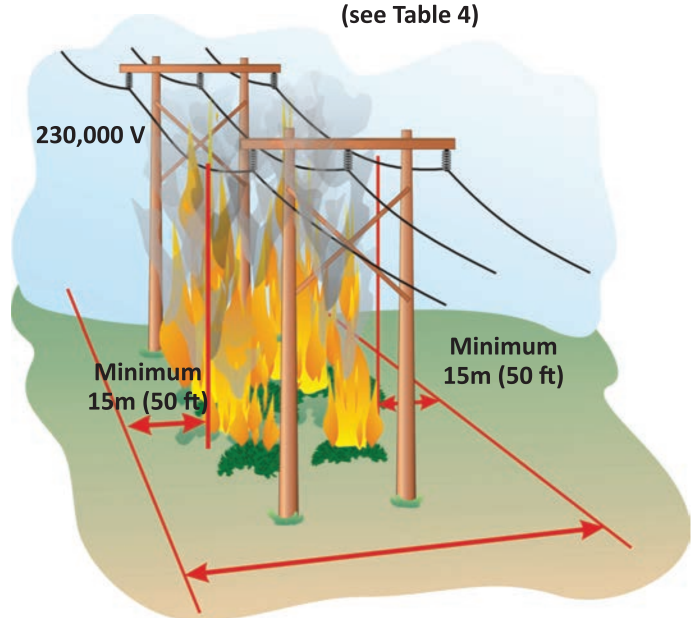


Table 4. *Arc-Over* Hazard*	
***Power line voltage* Volts**	**Hazardous Zone Metres**
115,000 or less	10 (33 ft)
230,000	15 (50 ft)
500,000	32 (100 ft)
*As measured from the outside insulators.	

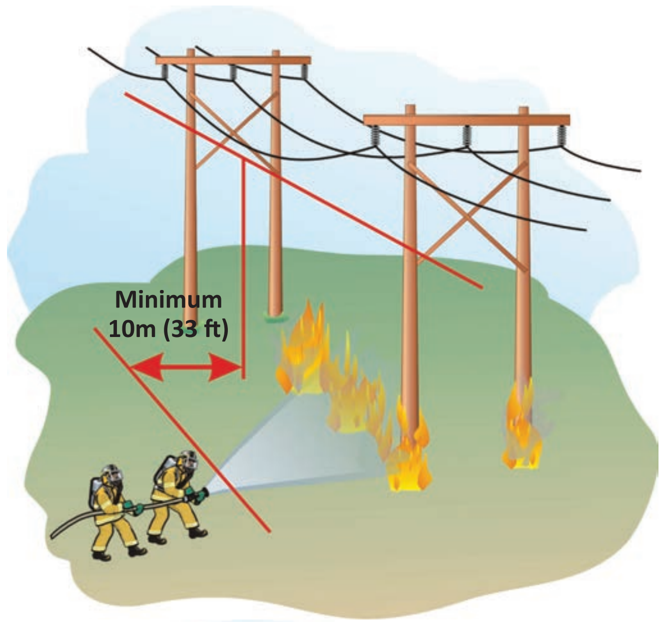
4.2.5.3 Fighting Fires Involving Wood Structures

Wood pole structures present an additional hazard due to their combustibility. In situations where the fire has not reached the right-of-way, efforts should be made to soak down or apply fire retardant to the area, up to 3 metres (10 ft) from the base of the poles.

Fire retardant must not be applied to the pole. Wood poles may be chemically treated and equipment may contain PCBs. Follow the precautions described in Section 4.2.4.

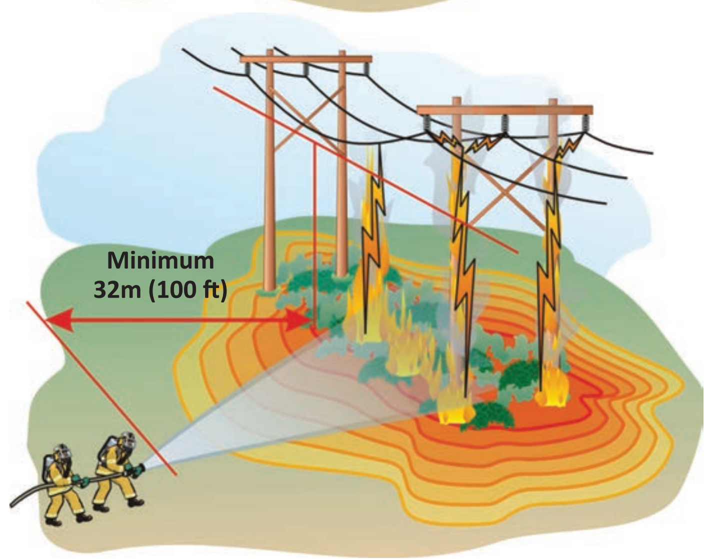
SITUATION: Right-of-way is fully involved with fire, but the fire only involves low level vegetation such as grass or small bushes.

ACTION: Apply limits of approach for step ***potential*** and apply fog stream at 10 metres (33 ft).



SITUATION: Right-of-way is fully involved with fire, the fire involves vegetation such as small trees and flame, or intense smoke is within 2 metres (7 ft) of *high voltage power lines.*

ACTION: Apply limits of approach for step ***potential*** and apply fog stream at 10 metres (33 ft).

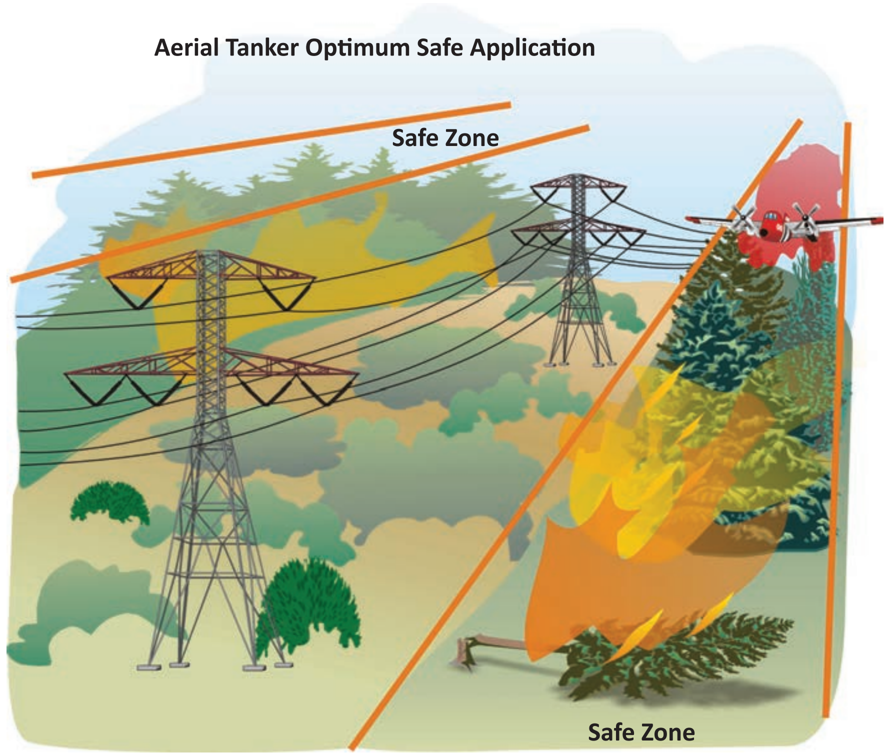


***Voltage* unknown, fire engulfing structure, *arc-over* hazard, staying back at least 32m (100 ft)**

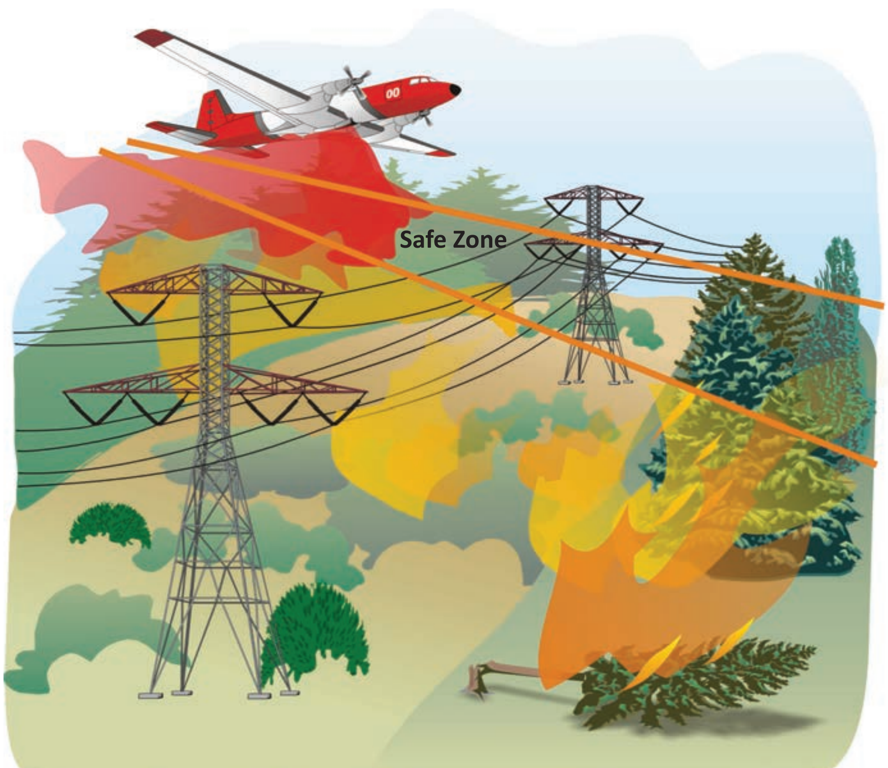
4.2.5.4 Aerial Tanker Optimum Safe Application

When using aerial tankers to drop water or fire retardant on rights-of-way, the application should be made in a way that minimizes the towers and insulators being coated. The retardant used is highly corrosive and an extremely good conductor which if applied to insulators will cause ***arc-over.*** When conducting aerial tanker drops, contact the electrical utility and request that the transmission line be ***de-energized***. If the transmission line cannot be ***de-energized*** have the pilot drop the retardant parallel to the lines (optimum safe application).

Aerial Tanker Optimum Safe Application



Aerial Tanker Alternative Application

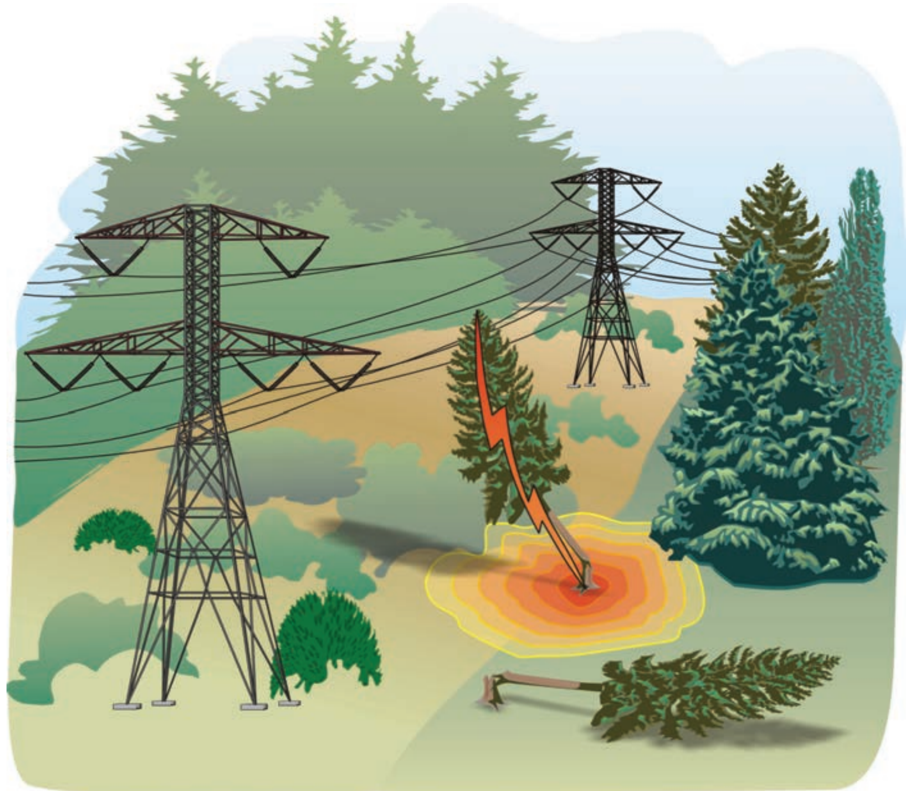


If fire retardant must be dropped across the right-of-way in order to stop fire, then have the pilot drop the fire retardant between the towers at mid span. This will minimize the retardant hitting the insulators and towers.

4.2.6 Trees Contacting *Power Lines*

Emergency responders need to be aware of the potential for severe electrical shock that can occur where tree limbs are contacting or very near ***power lines***. Contact with trees which are in contact with ***power lines*** is a significant cause of fatalities among rescue workers. Trees can conduct electricity. Anyone coming into contact with a tree while it is touching a ***power line*** is likely to receive a shock resulting in serious injury or death.

Emergency responders must recognize this danger when responding to accidents, fires or storms which result in trees or other objects touching overhead ***power lines***.



The felling of trees, natural growth and wind may cause trees to come into contact with ***power lines*** resulting in extreme hazard to anyone nearby. Contacts by trees and other objects do not always "trip out" the circuit and the power may continue to flow to the ground making the area around it dangerous because of the electrical step ***potential*** gradient created.

Even if a line does "trip out" (*open*) it may well be re-energized by remote *recloser* equipment.

If you are called upon to respond to a rescue or fire situation, first assess the area and determine if trees or branches of trees are contacting, are very close to, or are in danger of contacting ***power lines***. If they are, do not approach any closer than the distances shown in the Ground Step ***Potential*** Hazard Table 5. Secure the area, contact the local electrical utility, inform them of the location, and tell them that a tree is contacting the ***power line***. If there is a pole with equipment on it, communicating the pole number, usually found at 1.8 metres (6 ft) above the ground, will help the utility pin point your location and respond more quickly.

Table 5. Ground Step *Potential* Hazard*

Power line voltage **Volts**	**Hazardous Zone Metres**
115,000 or less	10 (33 ft)
230,000	15 (50 ft)
500,000	32 (100 ft)

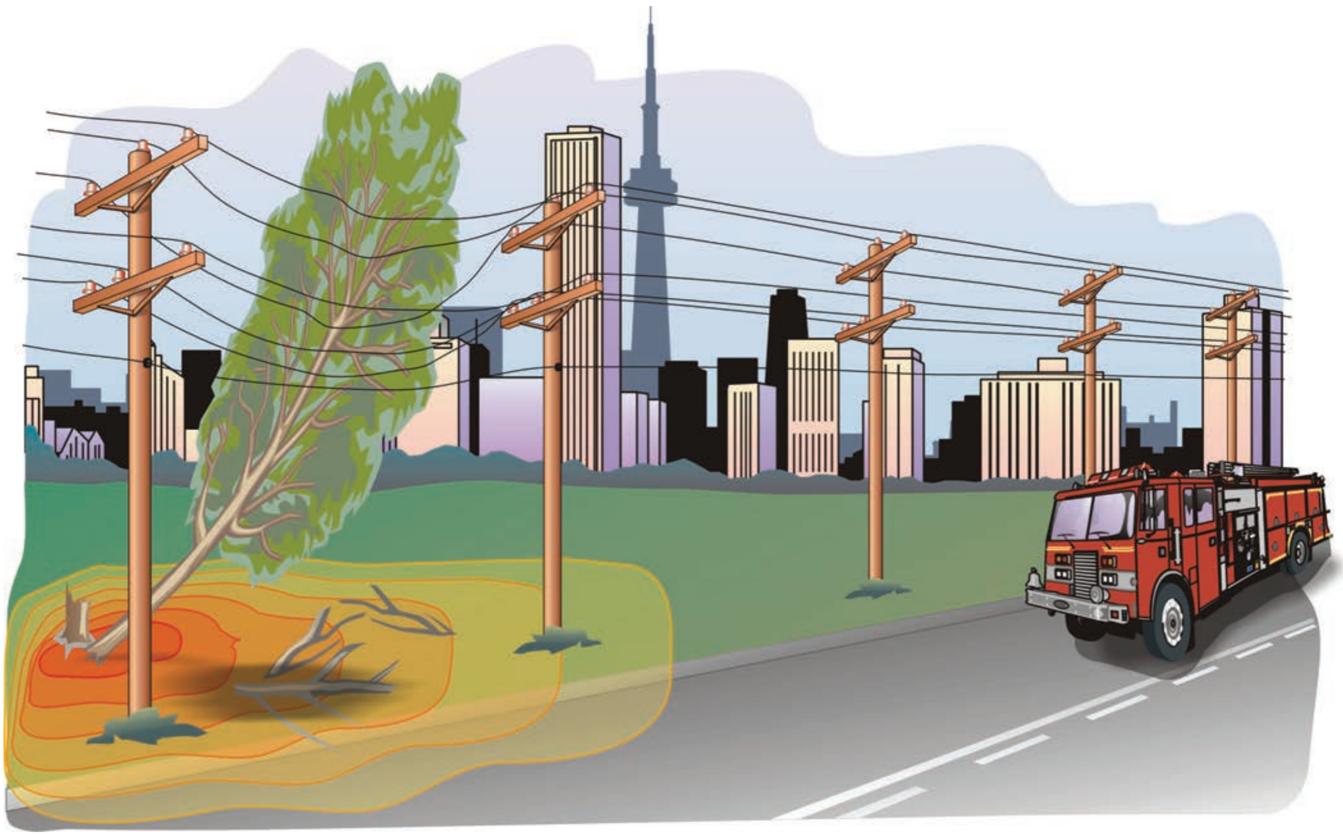
***Measured from base of tree or other object.**

4.2.7 Objects Contacting or in Close Proximity to *Power Lines*

Emergency responders need to be aware of the potential for severe electrical shock that can occur if contact is made with any object that is in contact with or very near ***power lines.*** Contact with objects that contact ***power lines*** result in a number of fatalities across North America each year.

Virtually all things, regardless of composition, will conduct electricity. Anyone coming into contact with a rope, pipe, ladder, scaffold, antenna, or building siding, while it is touching a ***power line*** is likely to receive a shock resulting in serious injury or death. Objects do not need to be in direct contact with a ***power line*** to conduct electricity. Electricity can jump or arc across to conductive objects (e.g. pipe or antenna) that are in close proximity to them. Emergency responders must recognize this danger when responding to accidents, fires or storms which result in objects touching overhead ***power lines.***

Depending on the weight of the object that is being supported by the ***power lines***, it may cause the ***power lines*** or pole to break creating additional electrical and falling hazards.

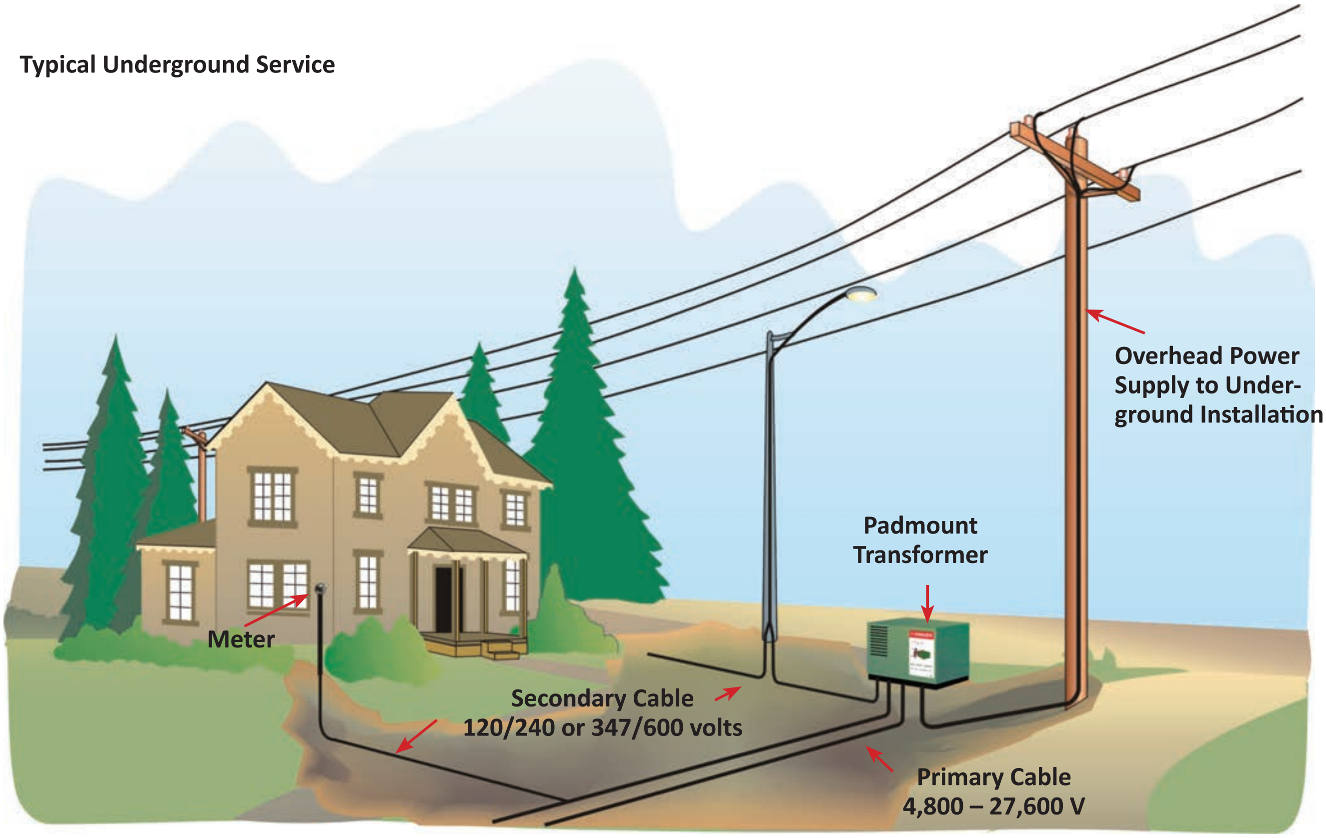


SITUATION: Responses involving trees or other objects in contact with a *power line.*

ACTION

1. Assess the situation from the distances shown in the Ground Step ***Potential*** Hazard Table 5.
2. Determine what objects (tree branch, ladder, pole, etc.) are contacting, or are close to ***power lines.***
3. If objects are in contact with ***power lines***, determine the safe zone and secure the area.
4. Call local electrical utility and inform them of the location and nature of the object contacting the ***power line***. **Do not attempt removal.**
5. Wait for the local electrical utility personnel to isolate and *de-energize* the ***power line.***

5.0 Underground Power Equipment



Padmount transformers and switching kiosks are the above ground portion of an underground electrical installation. In an underground distribution system buried, ***insulated power lines*** carry the ***high*** and ***low voltage*** electricity. Underground ***power lines*** can supply ***primary*** (2,400 to 27,600 volts) and ***secondary*** (120/240 and 347/600 volt) electrical power.

Underground cables are normally buried at least one metre (3 ft) below ground level; however, changes in topsoil cover could increase or decrease the depth below the surface. There can be any number of cables coming out from a padmount transformer or kiosk and it is impossible to predict the location of these cables without using a detector.

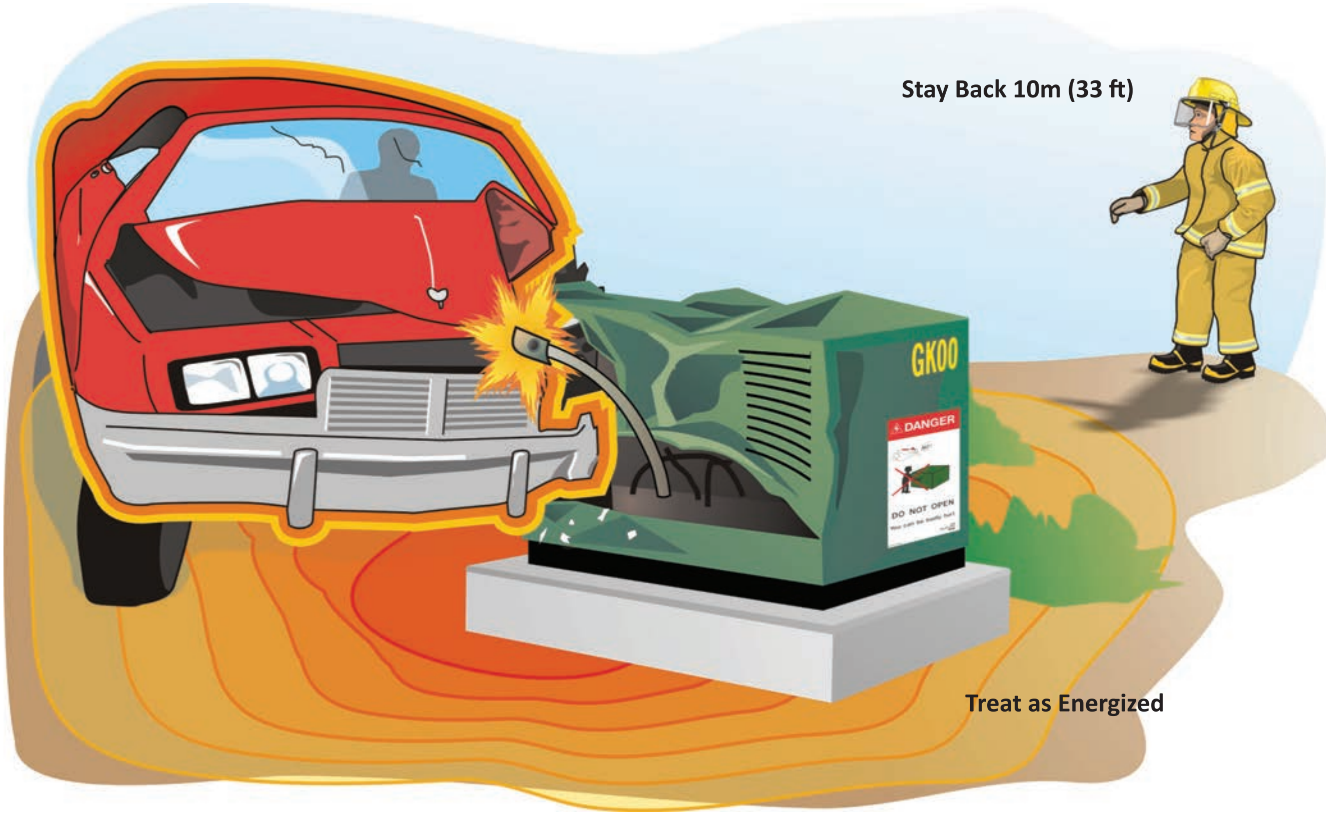
Pad mounted switchgear

Pad mounted transformer

5.1 Underground Power Equipment Emergency Scenarios

5.1.1 Padmount Transformers and Switching Kiosks

Situation	Emergency Responder Action
Padmount transformer or switching kiosk shows evidence of being tampered with, such as hacksaw marks or severe dents, or is found open.	1. Assess the situation from at least 10 metres (33 ft) back. 2. Determine the safe zone, secure the area, inform other emergency responders and keep people away. 3. Call the local electrical utility. Give the location and provide the transformer or switching kiosk location and number. Numbers are stenciled on the unit usually in yellow lettering. 4. Wait for the local electrical utility to *isolate* and *de-energize* the kiosk and initiate repairs.
Padmount transformer or switching kiosk is damaged in a vehicle accident.	1. Assess the situation from at least 10 metres (33 ft) back. 2. Determine the safe zone, secure the area, inform other emergency responders and keep people away. 3. Call the local electrical utility giving the location. 4. Keep feet close together when approaching the vehicle. 5. Tell occupants of the vehicle to “Stay in the vehicle. We are contacting the electrical utility”. 6. Call the local electrical utility and provide the transformer or switching kiosk location and number. Numbers are stenciled on the unit usually in large yellow lettering. 7. Wait for electrical utility personnel to *isolate* and *de-energize* the padmount transformer. Be patient, it may take some time.



Electrical utility personnel will ensure proper isolation and ***grounding*** of the transformer or kiosk and will authorize the removal of the vehicle after everything is safe. Confirm verbal instructions with three-way communication techniques; that is, confirm what you understand by repeating the message back.

5.1.2 Underground *Power Line* Damaged by Digging

Many times a year in Ontario, operators of digging equipment, (e.g. backhoe, post hole digger) inadvertently dig into live ***high voltage*** underground ***power lines***. In the majority of cases, the live ***power line*** is automatically shut off by circuit breakers because the ***current*** flows into the ground. Occasionally, the ***power line*** remains live and energizes the machine. These situations have resulted in serious injury and death due to electrical contact.

SITUATION: Underground live *power line* is damaged by digging machinery.

ACTION

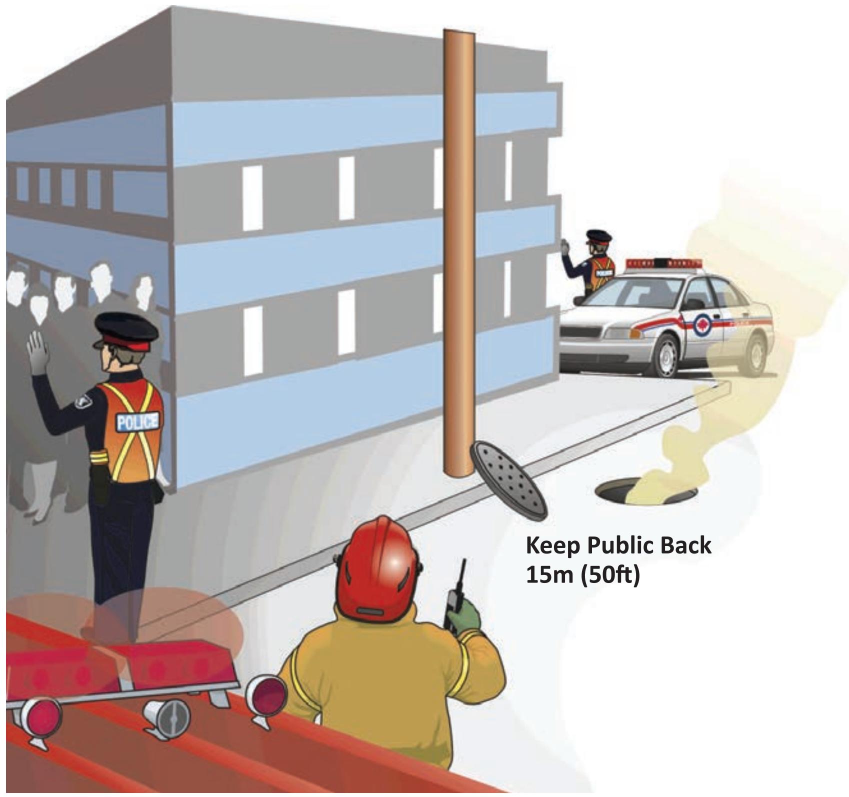
1. Assess the situation from at least 10 metres (33 ft) back.
2. Determine the safe zone (10 metres, 33 ft), secure the area, inform other emergency responders and keep people back.
3. Call the local electrical utility. Give the location and provide the number of the nearest transformer or switching kiosk. Numbers are stenciled on the unit usually in yellow lettering.
4. Tell the operator of the machinery to "Stay in the machine. We are contacting the electrical utility".
5. Wait for electrical utility personnel to isolate and de-energize the underground *power line.*

5.1.3 Fires and Explosions in Underground Electrical Vaults

In the high density areas of every city and in many residential subdivisions, electric distribution wires run through cable tunnels located under the pavement.

Transformers and switchgear for these circuits are situated underground in concrete vaults, with access provided to each vault by a service access hole.

Underground electrical systems are designed to withstand great stress. However, earth movement can crack the concrete walls of cable tunnels, as well as adjacent sewer pipes, natural gas pipes and water mains. Hazardous conditions can result, including accumulations of explosive and toxic gases and dangerously high water levels. Electrical failure of a cable may result in an explosion or fire, which could damage insulation and energize all metal parts within the vault.



5.1.3.1 Vault Explosion or Vault Emitting Fire or Smoke

SITUATION: Service access cover is in place and vault is emitting fire, smoke or fumes.

ACTION

1. Assess the situation from at least 10 metres (33 ft) away.
2. Determine the safe zone, secure the area, and keep the public at least 15 metres (50 ft) back.
3. Call the local electrical utility, ask for assistance, and give the location of the service access involved. Whether the vault cover is off or on always contact the utility.
4. Stop traffic until there is no danger of an explosion (secondary explosions can occur).
5. Do not attempt to remove the service access cover. If gases are present in the vault, removal of the cover may produce a spark or provide sufficient air to cause an explosion.

Always follow Operational Guidelines or preplans regarding vaults.

5.1.3.2 Rescue from Underground Electrical Vaults

Under current provincial legislation, electrical utility personnel working in underground electrical vaults which are identified as ***confined spaces***, must work under ***confined space*** entry procedures.

However, situations could arise due to oversights or unforeseen circumstances and emergency responders could be called upon to either assist a rescue team or perform a rescue. Emergency personnel should not enter any electrical vault except for the purpose of rescue and only when the electrical utility has confirmed that the electrical equipment has been ***de-energized***. Emergency responders must adhere to the most current ***confined space*** regulations and Guidance Notes and have the specialized training and equipment.

6.0 Substations

Although most substations are unattended, they are equipped with automatic signal systems which summon electrical utility personnel in an emergency. Substations use transformers to reduce the ***voltage*** and send it along distribution lines to users. Substations and substation buildings present different hazards from buildings that emergency responders usually enter and can endanger anyone who is unfamiliar with them. During your preplanning, it is important to obtain emergency preparedness or emergency response plans and to arrange familiarization tours of substations in your service area.

6.1 Substation Components

6.1.1 Buildings

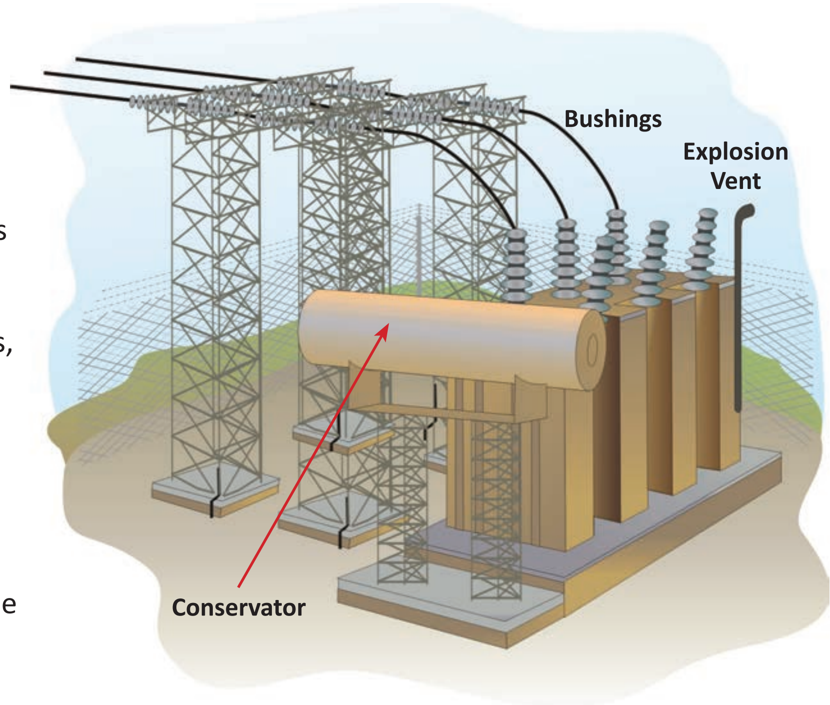
Buildings contain a wide variety of equipment, which can make rescue and fire fighting hazardous. They can contain banks of batteries containing sulphuric acid, energized relays, control cabinets, energized electrical cables with combustible insulation (PVC), oil-filled transformers and circuit breakers, and compressors.

6.1.2 Transformers

Transformers are devices used to step-up or step-down ***voltages***. They usually contain large volumes of cooling insulating oil which is combustible and has a flash point of 145°C (295°F). Some of these oils may also contain small quantities of PCBs (see “PCBs”, Section 6.2.7).

A transformer consists of an iron core on which is placed two or three coils of conductors. By varying the number of turns on the coils, the ***voltage*** can be changed. The turns on the coils need to be ***insulated*** from each other to withstand the ***voltages***. This insulation is usually paper and is combustible.

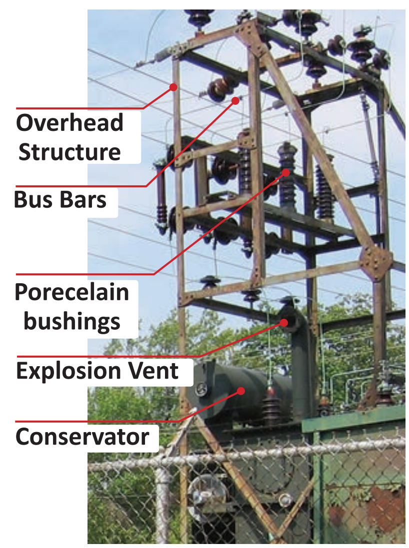
For both cooling and insulating purposes, transformers are placed in large metal tanks. Additional components can include pumps, fans, radiators or a large tank called a conservator, at the top of the main transformer tank, which also contains oil. Usually it is possible to extinguish transformer fires before all the oil has been consumed, thereby saving adjacent equipment from damage.



6.1.3 Conservators

These large tanks located at the top of transformers (see diagram, Section 6.1.2) allow for expansion and contraction of the cooling oil when the transformer is carrying load.

There will be no large build-up of pressure, but if one of these tanks were ruptured, it could provide a large supply of fuel in the event of fire.



6.1.4 Explosion Vents

These are large vertical pipes (see diagram, Section 6.1.2) with rupturable discs fitted to the transformer tops and are intended to relieve pressure in the event of an internal transformer fault. It is unlikely to be a hazard to the people fighting a fire.

6.1.5 Porcelain Bushings

These simply enable ***high voltage*** transformer connections to pass through the grounded metal tank without energizing it. Typically they contain the same insulating material found in transformers - paper and oil. When subjected to high temperatures, the porcelain material can explode, resulting in flying projectiles and more oil as fuel for the fire.

6.1.6 *Bus* Bars

These are metal conduits or pipes (see diagram, Section 6.1.12) that are used within substations to carry the electricity from transformers to other devices inside the substation. These ***bus*** bars are energized but ***insulated*** from the steel support structures by insulators.

Depending on the support structure design, it may be difficult or impossible to distinguish the live *high voltage bus* from the structure.

6.1.7 Overhead Structures

Metal structures are often built over the top of electrical equipment to support insulators and ***high voltage*** conductors. These structures will sag and eventually collapse when subjected to high temperatures. Apart from the obvious hazards, such collapses could also result in breakage of the porcelain bushings with the consequence described above.

6.1.8 Control Cables

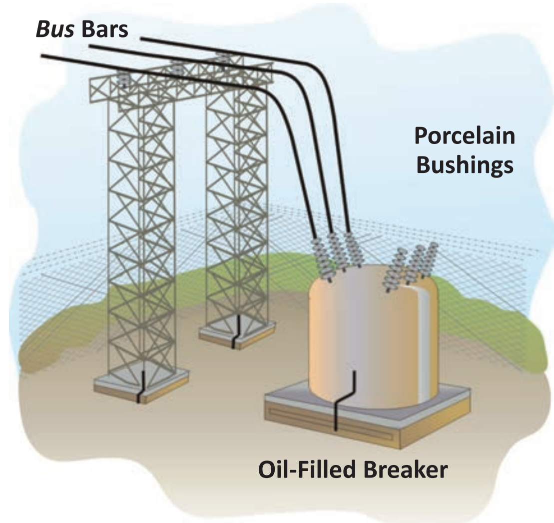
Cables are attached to large power transformers to carry ***low voltage*** electricity for controlling cooling fans, pumps and motors. They usually de-energize themselves if faulted. The insulation surrounding the conductors is combustible and may allow flames to migrate to other equipment along cable trenches.

6.1.9 Cable Trenches

Cable trenches carry the control cables previously mentioned. In the event of a substation fire, cable trenches can carry transformer oil that may have leaked from a burning transformer or a broken porcelain bushing. Thus, a fire can be carried to adjacent equipment fairly readily. To reduce this type of hazard, some cable trenches may be filled with sand.

6.1.10 Circuit Breakers

Circuit breakers are large switches. Some types of circuit breakers are equipped with porcelain bushings and contain combustible oil. Some newer very ***high voltage*** (e.g 500,000 volt) breakers can be filled with sulpherhexafloride, SF6 gas. SF6 gas is a relatively inert, odourless gas used in electrical equipment for it's insulating properties and electrical arc extinguishing abilities.



6.1.11 *Capacitors*

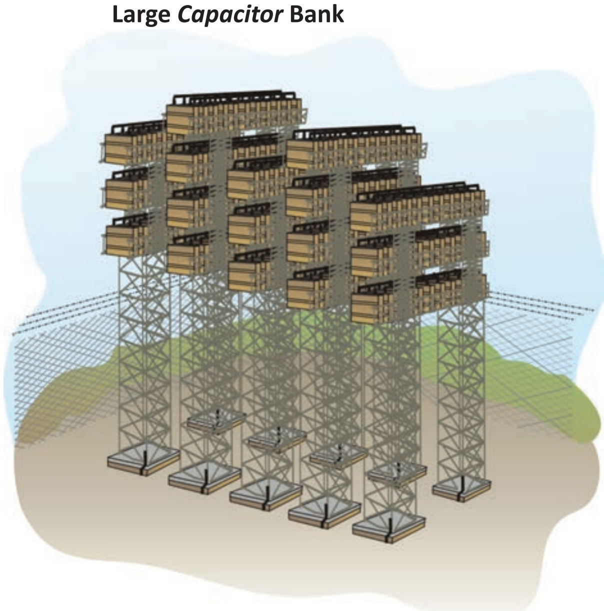
***Capacitors* store energy and can produce lethal *voltages* of electricity even with the power off. Any wires connected to the *capacitors* will be energized. In the event of a fire, electrical utility personnel would, as soon as practical, make them safe to handle.**

Capacitors are located in some but not all substations. A ***capacitor*** bank is comprised of a number of small units measuring approx. 25 cm x 45 cm x 60 cm high. Individual ***capacitors*** are sealed units which could explode when heated.

Some of the ***capacitors*** contain polychlorinated biphenyl's (PCBs) which can be hazardous to your health and the environment. In the event of a spill, extreme caution should be exercised, while containing and then cleaning up PCBs.

Provincial health and environmental guidelines must be followed and spills must be reported to the Spills Action Centre.

Large *Capacitor* Bank

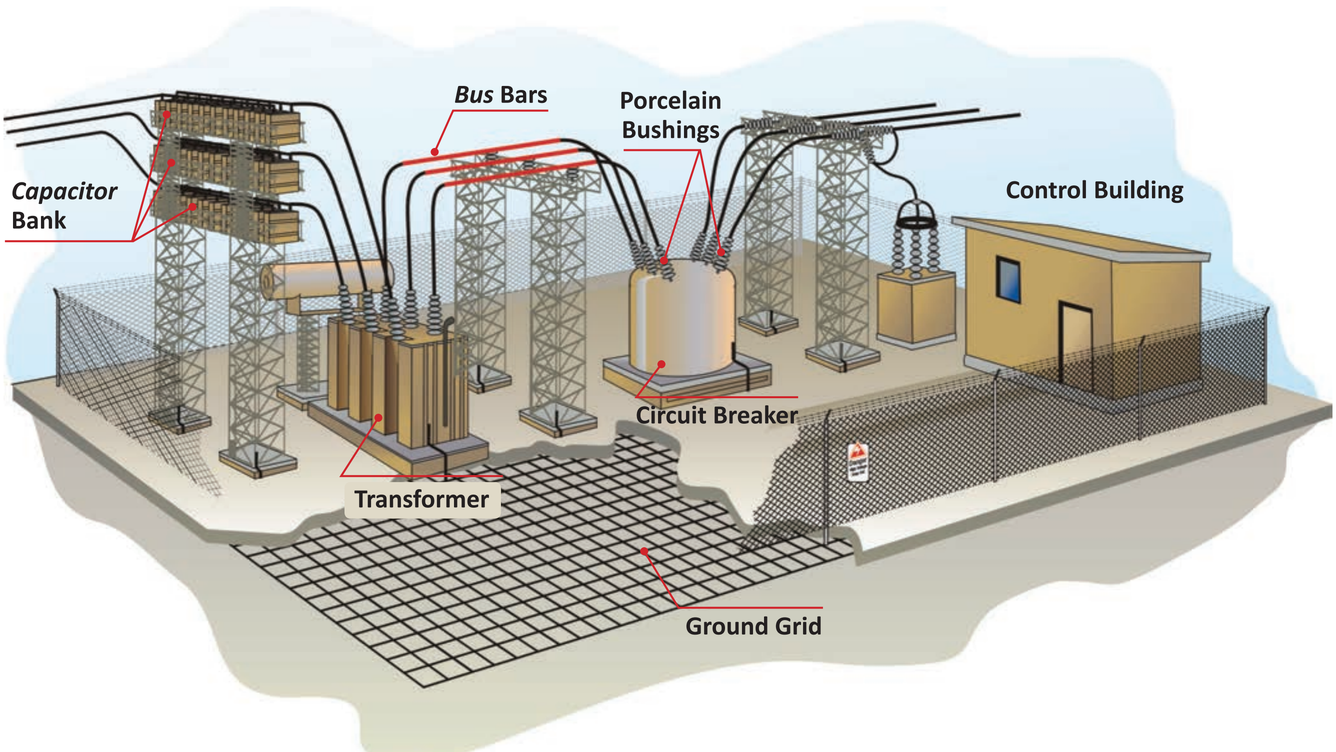


6.1.12 Substation Ground Grids

An extensive ***grounding*** grid system is located under the gravel in all distribution and trans-mission substations, and all equipment including the fence is connected to it. The grids function is to protect personnel from ***high voltage*** levels during fault conditions on the ***power lines*** outside the substations. For example, should lightning strike a ***power line*** it could cause an insulator ***arc-over*** at the station, which would raise the ground ***voltage*** several thousand volts.

Under normal circumstances, personnel would not be exposed to any hazard because the ***grounding*** grid would distribute the ***voltage*** over a wide area.

The gravel covering substation property is used to insulate people from the ***grounding*** grid and provides a means to contain oil which may flow from transformers or other electrical equipment if they fail.



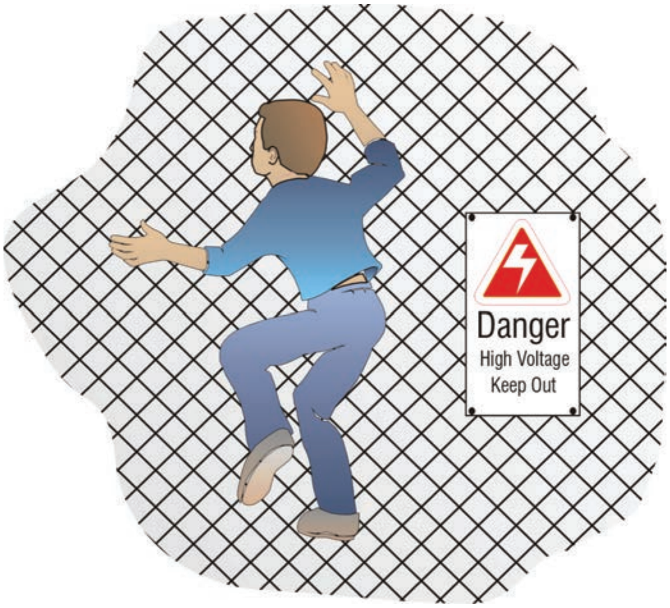
6.2 Substation Emergency Scenarios

6.2.1 Trespassers in Substations

A dangerous situation arises when children and young adults are playing around electrical distribution and transmission substations. Frequently, young people will enter these facilities to retrieve a ball or other object.

Most people do not understand the components that are inside a substation and the electrical hazards they present.

All equipment inside substation fences must be considered to be electrically hazardous.



SITUATION: People are seen climbing over a fence into a substation or inside a substation.

ACTION

1. If the person is on equipment, calmly say, “Stay still, don't move and don't touch anything”.
2. If they are inside, on the ground, calmly tell them if it is safe to do so, to come to the fence and tell them to remain there.
3. Warn of the danger.
4. Call for assistance from the local electrical utility and follow their instructions including waiting for them to arrive.

SITUATION: Injured person in a substation.

ACTION

1. Calmly, tell the person to move to the fence if they are able.
2. Call the local electrical utility for assistance and follow their instructions including waiting for their arrival.
3. When electrical utility personnel arrive, initiate rescue under their direction.

SITUATION: You are called to retrieve an object from a substation.

ACTION

1. Immediately proceed to the substation.
2. Ensure people don't attempt to go in and retrieve it “on their own”.
3. Call the local electrical utility for assistance and follow their instructions including waiting for their arrival.

6.2.2 Substation Fires

When responding to a fire in a substation, call the electrical utility immediately. Be aware that shutting off the flow of electricity into a substation may take time. Be patient and resist the temptation to enter the substation.

Upon arrival, park vehicles and apparatus well away from transmission or distribution ***power lines***. ***Power lines*** may break and fall.

Assess the situation and obtain, if possible, a copy of the emergency response plan for the site. Inform other emergency responders of the dangers (eg. electrical, explosion, chemical).

Keep on-lookers well back, if possible a minimum of 100 metres (330 ft) due to the risk of explosion. Porcelain pieces propelled and burning oil from an exploding oil-filled breaker or transformer can be deadly.

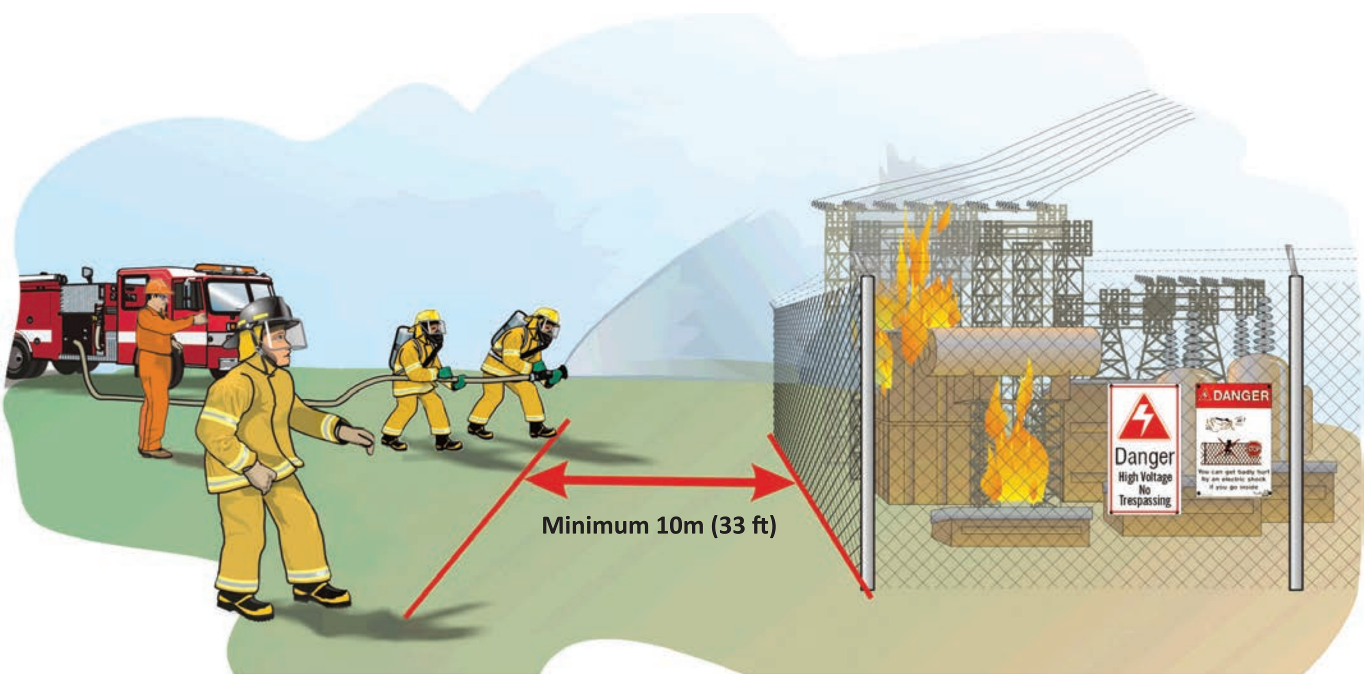
Prepare equipment and protect surrounding property.

Do not enter any substation without a ***qualified*** electrical utility representative on site. They will inform you of any hazards specific to that station.

Fight substation fires only with the guidance of the ***qualified*** electrical utility personnel on site.

Ensure that the limits of approach are maintained with all apparatus and lines, even with those substation components which are ***de-energized***. Fire fighting vehicles that could contact live equipment must be connected to the ground grid or to a ground gradient control mat that the operator must stand on.

Metal ladders must not be placed against a substation fence or used in fighting substation fires. Metal objects, such as tape measures and extension cords, can also create a hazard and must not be used inside substations.



SITUATION: Called to a fire in a substation or switchyard

ACTION

1. Notify dispatch to call the electrical utility immediately, and inform other emergency responders of the identified dangers.
2. Upon arrival, park vehicles and apparatus well away from the substation.
3. Secure the area, keep on-lookers back at least 100 metres, 330 feet (explosion risk).
4. Obtain a copy of the emergency response plan for the substation.
5. Prepare equipment and protect exposures (surrounding property) applying water using fog spray (700 Kpa, [100 psi at the nozzle], 30 degree).
6. Wait for electrical utility personnel to arrive. Do not enter the substation unescorted.
7. With advice from the electrical utility personnel, fight the fire.

6.2.3 Substation Personnel Emergency

SITUATION: Suspected injury to utility worker working alone

ACTION

1. Local electrical utility has called for emergency responders.
2. Upon arrival, emergency responders establish radio or telephone communications with electrical utility.
3. Emergency responders shall follow their Operational Guidelines and/or preplans when following emergency site access directions provided by electrical utility personnel (controlling authority).
4. Emergency responders put on necessary personal protective equipment (PPE).
5. Emergency responders shall follow their Operational Guidelines and/or preplans when advised on the means to gain access and are coached to the general vicinity of the injured worker.

6.2.4 Substation Control Buildings

Substation control buildings require special consideration when fighting fires. The nature of the equipment installed within the station, its high value and susceptibility to damage from many extinguishing agents requires careful consideration in agent selection. Preference must be given to carbon dioxide, as an agent, when using hand portable extinguishers. Indiscriminate use of water could result in significant damage and interruption of services and therefore must be cleared by electrical utility personnel.

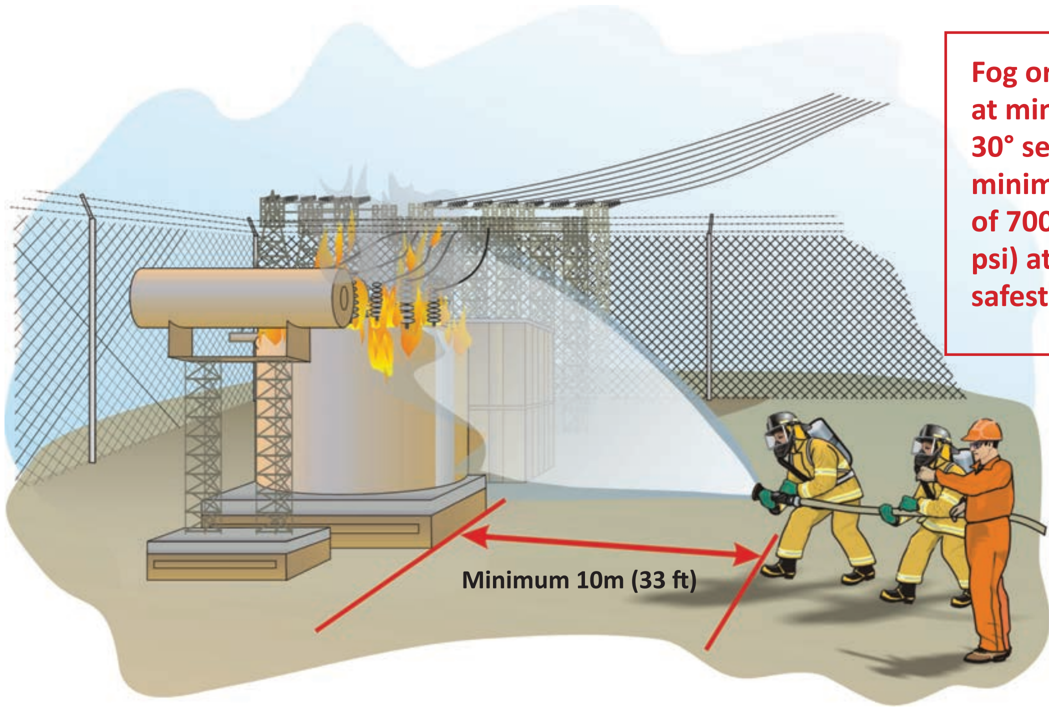
Fires inside substation control buildings may involve PVC cable insulation as a fuel. The combustion gases given off by PVC are extremely toxic and corrosive. Self contained breathing apparatus must be worn when entering a control building to fight fires, and special attention given to clean-up and decontamination of equipment.

Some control buildings have automatic fixed fire suppression systems. The most common type of installation utilizes sprinkler and/or pre-action systems with full fire detection and alarm. Equipment and control rooms can contain a range of gases (e.g. SF6, Novec 1230) that could present an oxygen displacement hazard. Control buildings will always have batteries which contain strong acid. Use SCBA when entering enclosed facilities. Operating sequences and characteristics must be reviewed at the preplan stage.

The air handling systems for control buildings, compressor buildings and other support facilities, should be reviewed to assess shutdown requirements to prevent soot contamination from switchyard fires migrating into buildings.

6.2.5 Fire Fighting inside Electrical Substations or Switchyards

Follow the guidance provided by the onsite ***qualified*** electrical utility personnel in fighting a fire, and especially in applying water on or near electrical equipment. Maintain the minimum recommended distance (10 m, 33 ft) for the use of water fog or spray on electrical equipment. Water must never be discharged in the form of a straight stream.



Fog or water spray at minimum of 30° setting with a minimum pressure of 700 Kpa (100 psi) at the nozzle is safest.

The majority of fires in substations involve combustible insulating oil used in transformers, circuit breakers, and ***capacitors***. This insulating oil has a minimum flash point of 145°C (293°F) and will generate temperatures in excess of 1000°C (1850°F) in the immediate fire zone. Some substations have oil-filled equipment containing oil in quantities in excess of 90,000 litres (20,000 imperial gallons) per unit. Some of the problems encountered with these oil-filled equipment fires concerns the damage to adjacent equipment (within 10 m/33 ft) and the re-ignition of the oil caused by hot metal surfaces. The effects of these problems can be minimized by the continued application of water in a fog form onto adjacent equipment or hot metal surface areas. If the equipment has been confirmed as ***isolated*** and ***de-energized***, foam may also be used to prevent reignition.

Keep on-lookers well back, if possible a minimum of 100 metres (330 ft) due to the risk of explosion.

Porcelain pieces propelled and burning oil from an exploding oil-filled breaker or transformer can be deadly.

Another serious potential problem with combustible insulating oil is the entry of burning oil into cable trenches, cable tunnels, and access holes. Fires in these areas can be difficult to extinguish as the combustible cable insulation may ignite.

Attempt to establish containment to minimize the environmental impact from the oil spill. Electric utility personnel have been trained to contain oil spills and can be relied upon to provide assistance to contain the oil and runoff.

6.2.6 Privately Owned Substations

There are numerous privately owned and maintained substations throughout Ontario. These substations may not be serviced and maintained to the standard found in electric utility owned stations. Additional difficulties that may be encountered include:

- identifying or locating the owner
- problems locating the occupant's electrician
- property overgrown with shrubs, bushes and trees
- poor housekeeping practices and maintenance of equipment

If the privately owned substation is required to be isolated and de-energized contact the utility to disconnect the incoming supply at the right-of-way. Emergency responders shall not enter a substation until the electrical utility personnel have been contacted or arrive on site and the station has been made safe. Privately owned substations may contain PCBs.

6.2.7 Polychlorinated biphenyls, (PCB) Storage Areas and Hazards

Electrical utility equipment and storage areas known to contain PCBs are clearly identified with approved warning signs.

Under certain conditions, PCBs in the presence of oxygen when heated between 250-700°C (450-1100°F) may produce harmful products of combustion such as dioxins and furans. Fire fighters in such a situation must take every precaution necessary to protect themselves, other responders and all members of the public present. All provincial environmental guidelines must be adhered to.

Polychlorinated biphenyls, PCBs, were used as cooling and insulating oil in transformers because they don't support combustion. PCBs have mostly been replaced by mineral oils because PCBs are an environmental contaminant. High temperature fires may cause PCBs in oils to break down into extremely toxic components. The known presence of PCBs should be indicated by warning signs. The use of large volumes of water, on potentially PCB contaminated equipment (transmission and distribution) that has spilled oil and is burning, will result in the wide distribution of trace PCB contamination in the environment. Where safe alternatives to water are available (carbon dioxide [CO_2], dry chemical), they should be used. If non-water alternatives are not an option, the quantities of water should be minimized to the extent possible to limit the spread of contamination.

Runoff control should also be considered and used if appropriate. Ultimately, contamination can be cleaned up, so responder and public safety should be the primary consideration.

SITUATION: You suspect PCBs in a fire.

ACTION

1. Consult the Emergency Response Guidebook (ERG).
2. Wear full turnout gear and SCBA.
3. Position apparatus upwind and approach from upwind.
4. Use dry chemical, CO_2 or foam if possible.
5. Provide for liquid runoff containment.
6. Evacuate people located in path of the smoke plume.
7. Follow standard decontamination procedures.
8. Ensure you and your gear are tested afterwards for possible exposure.

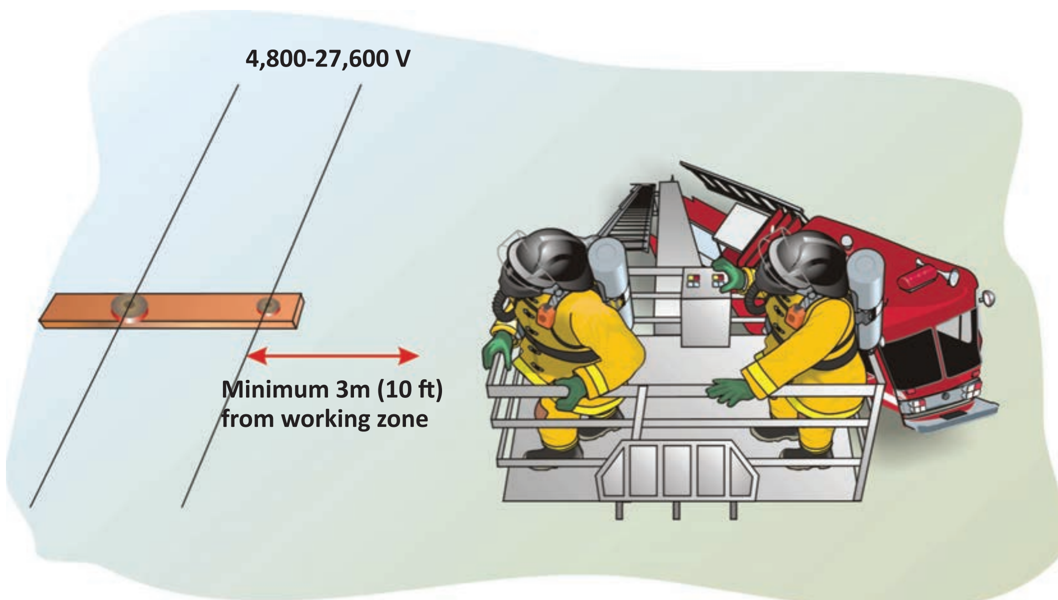
7.0 Electrical Hazards when Fire Fighting in Houses & Other Buildings

Fire fighters often face possible electrical hazards when they fight fires involving structures. The majority of structures within a community have an electrical service or electrical power supply.

Leaving the power and lights on aids evacuation, rescue and fire fighting.

The greatest possibility for injury and death can be attributed to the direct body contact with energized wires or contact through equipment. In limited visibility, walk with the palms of your hands facing towards you. If you encounter any live electrical equipment the contraction of your muscles (from the ***current***) will force your hands and arms towards you and away from the source of electricity.

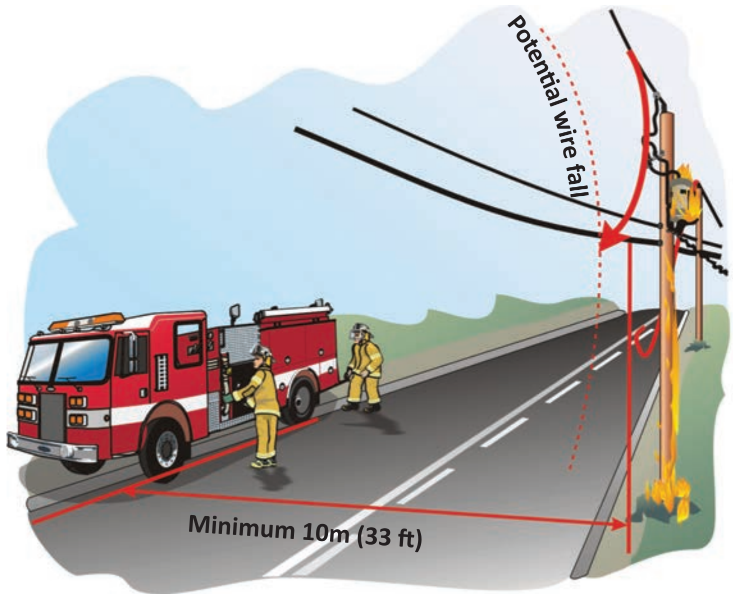
7.1 Overhead *Power Lines* Near Buildings



Overhead ***power lines*** present one of the most significant electrical hazards to fire fighters when responding to structural fires. Fire fighters and rescuers can avoid injuries by observing a few basic rules. When rescuers or fire fighters are working from an aerial device, it is essential to maintain the limits of approach of 3 metres (10 ft) away from the ***power line***. This minimum distance must be maintained by all persons, tools and equipment on the platform. Ensure that you have enough room for the full range of movement required without encroaching on the OHSA ***safe limits of approach*** (Section 1.6). If ***safe limits of approach*** cannot be maintained, either have the electrical utility disconnect all sources of electricity from the overhead ***power lines*** or use alternative means to fight the fire. For known difficult situations preplan the fire or emergency response.

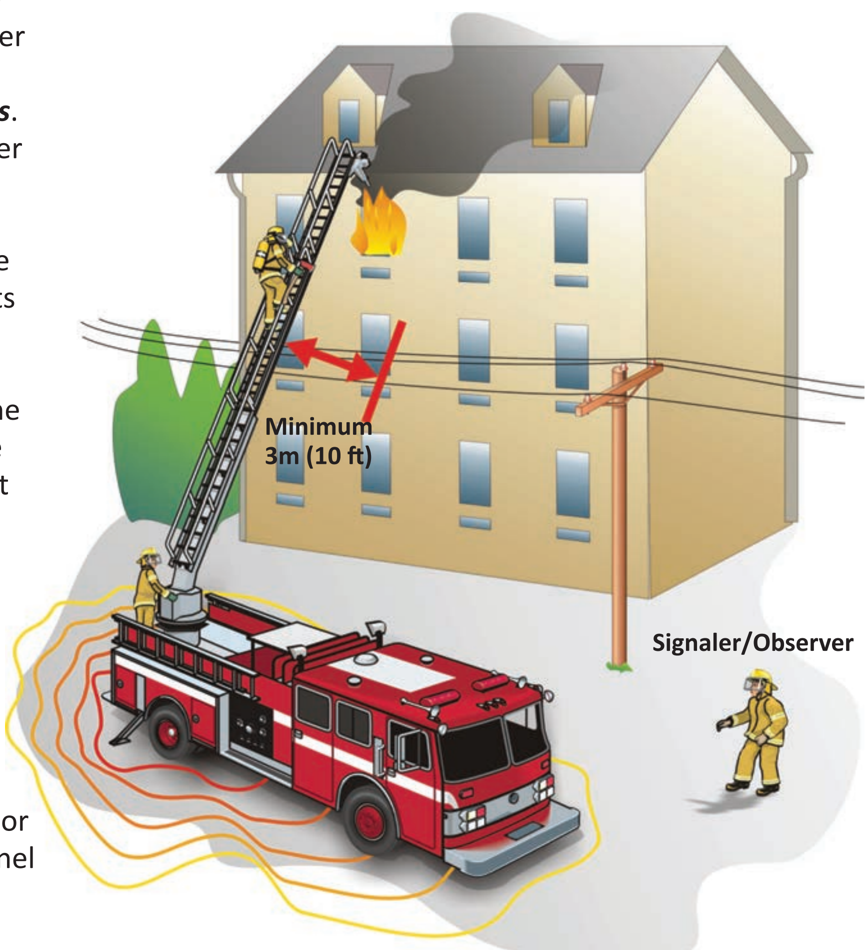
7.2 Vehicle and Emergency Apparatus Placement

Ensure vehicles and equipment are positioned where they will be safe. In the event the growth of the fire results in damage to either power lines or supporting structures use collapse zone distances or Operational Guidelines for apparatus placement.



7.3 Aerial Equipment Setup

Before setting up aerial equipment, make sure you know where all ***power lines*** are located. You must use a second fire fighter as a dedicated signaller/observer when working in close proximity to ***power lines***. The signaller/observer watches the ladder (boom) and warns the operator if the boom gets close (3m). You must ensure that you have enough room for full range of movement, without violating the limits of approach.



The aerial device operator must be on the apparatus, on a platform attached to the vehicle, or on a ground gradient mat that is ***bonded*** to the device.

Extra precautions must be taken when forced to work overtop ***power lines***. Tie off tools and equipment so that they don't drop into the ***power line*** and move hydraulics very slowly to minimize bouncing and swaying. Ensure the pump operator works from a ***bonded*** platform or ground gradient mat and ground personnel halt contact with the vehicle while the ladder (boom) is being repositioned.

7.4 Working Around Service Meter and Mast

The service connection to a building can vary in design. While the ***voltage*** is considered low at 120/240 for residential and 347/600 volts for commercial applications, it is still dangerous and when contacted can cause serious injury or death.

If possible keep at least 1 metre or more (3.5 ft) away from the service drop and do not contact it. The wires are weather coated and this coating can not be relied upon to insulate you from the electrical ***current***. Some connections do not have insulating covers which will expose first responders to exposed (bare) energized connections.

7.5 When Electricity Endangers People or Property

When the electrical supply to the building must be shut off, either shut off the main power switch or have the local electrical utility disconnect the supply. Caution is required when shutting off the main power switch to the building since the “line side” of the switch and the incoming wires are still energized.

When turning off the main power switch, wear dry leather gloves. Use your left hand and turn away when shutting off the power. Alternatively, keep your back towards the wall with your face turned away from the panel and then shut the panel off. This way your forearm will be propelled in a normal forward position minimizing injury if there is an explosive flash. ***Fault currents*** may have energized the grounded electrical box and these precautions will prevent you from being injured.

For example, commercial and industrial settings commonly use multibranch 347 volt systems, with singlepole breakers for lighting. A fire can cause a single-pole breaker to trip off, deenergizing only one branch of the circuit leaving the other two energized.

Since a 347 volt circuit connects ***neutral*** to ground, it is possible for ***current*** on the ***neutral*** side to backfeed to the circuit making the ***neutral*** live.

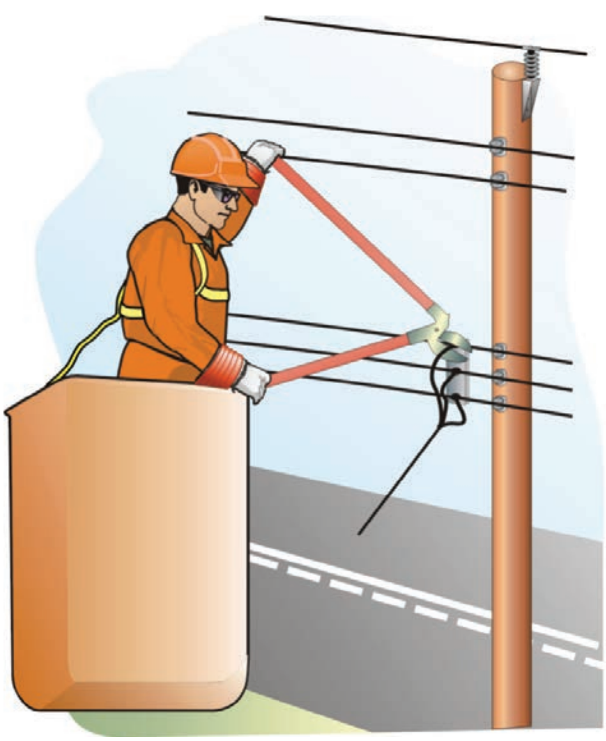
For commercial and industrial situations where the 600 volt power supply is heavily utilized (large ***current*** flow), shut off individual circuits first to reduce ***current*** flow, then shut off the main switch. This practice will minimize the possibility of an explosive flash when operating the main switch. If the main power switch cannot be shut off, contact the electrical utility and ask them to disconnect the electrical supply at the pole or transformer switch.

For high rise complexes, townhouses and strip malls, where individual units may have their own electrical sub panels, these sub panels should be used by emergency responders to shut off the electrical supply to the unit.

In the event Emergency Responders have shut off electrical hazards, they are to leave the breakers in the off position. Emergency Responders are NOT authorized to turn on (reenergize) the equipment as the site's electrical equipment needs to be inspected by the Electrical Safety Authority.

Do not pull the meter to disconnect the power supply as it may violently arc or explode. Pulling the meter does NOT guarantee that the power supply has been interrupted. For example, the meter base terminals remain live since they are connected to the supply, or power theft situations (grow ops) typically by-pass the meter.

7.6 Entering Wet or Flooded Buildings



When entering a wet or flooded building use caution as water and live wires can be a lethal combination. Shut off the power or call the local electrical utility and ask that they disconnect or "cut down" the service at the pole.

Extra care must be taken when working in flooded basements or on wet floors. It is important to shut off power, either from a dry location inside the building or from outside, prior to entry. Signs of electrically charged floors could include unusual sparking, unconscious victims or persons receiving shocks from equipment touching the wet area. If the building is flooded, best practice is to disconnect power from outside prior to entry, as these signs are not always present.

Emergency responders also need to determine if emergency or portable generators are in use. Contact the owner or building maintainer and ensure that these sources are shut off or disconnected.

7.7 Electrical Vaults in High Rise Buildings

Electrical vaults located in buildings such as industrial or commercial buildings, high rise residential or office buildings present a range of hazards other than electrical contact to emergency responders. Often, electrical vaults are located several floors below ground and contain electrical equipment such as oil filled transformers, capacitors and switches and exposed ***open bus*** bars. Hazards include large volumes of thick toxic black smoke, fire, explosion, flying debris and possibly flammable gases. An environmental hazard (methane) should be considered since floor drains may be directly connected to storm sewers. It is important to keep the public well back from the area. Typically there are grates located in sidewalks or the side of a building which are used for direct ventilation. Vaults can be accessed from inside of a building such as an underground parking garage, from the outside grade level or through the ventilation grates themselves. The access doors are typically marked “DANGER ***HIGH VOLTAGE***” and contain utility contact information. Emergency responders should not access a vault unless the local utility has been notified and has confirmed the power has been disconnected. If smoke is seen exiting the ventilation grates, evacuate the building and keep vault door(s) closed until the local utility has disconnected the power.

Access for emergency responders can be difficult. Emergency responders should never attempt to remove anyone from inside a vault unless they are certain that the power is off or the victim is not in contact with an electrical power source. Fire fighters entering these vaults should wear long duration SCBA and have a well-planned (preplans) escape route.

SITUATION: Thick black smoke is emitting from the ventilation grate on the sidewalk

ACTION

1. Assess the situation from at least 10m (33 ft) away.
2. Determine the safe zone, secure the area, and keep the public at least 15m (50ft) back.
3. Call the electrical utility and inform them of a fire at one of their electrical vaults.
4. Stop traffic until there is no danger of an explosion.
5. Do not attempt to remove the ventilation grate.
6. Do not attempt to open any vault doors marked DANGER ***HIGH VOLTAGE*** since this can introduce sufficient air to cause an explosion.
7. Wait untill the electrical utility isolates and de-energizes the electrical equipment.

Exterior access transformer vault door and ventilation

Sidewalk grates used for transformer access and ventilation

7.8 Portable or Emergency Generator *Electrical Backfeed*

Due to extreme weather conditions that occur during Canadian winters, many houses, commercial and office buildings have either portable or emergency generators that supply electricity in the event of a power supply interruption. Fire fighters and other emergency responders need to be aware that generators may automatically start as soon as the regular electrical supply is disrupted, and may only supply power to critical circuits.

7.8.1 Portable or Emergency Generator Transfer Device

Transfer Switch

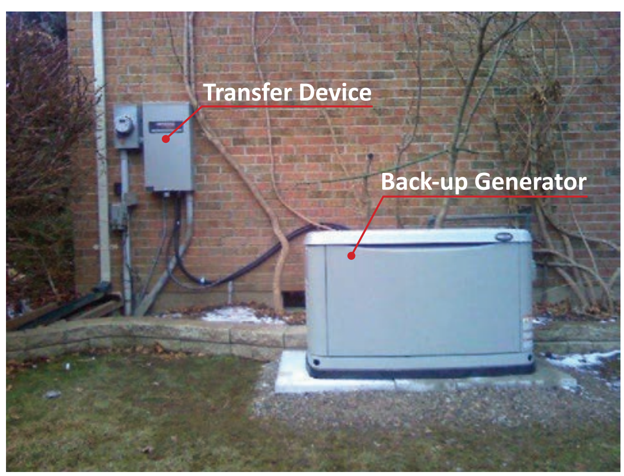
In homes, commercial and industrial settings portable or emergency generators correctly installed shall be connected into either an automatic or manual transfer device.

The transfer device is required by the Ontario Electrical Safety Code. Approved transfer devices can be connected directly onto the meter base or installed as a disconnect switch.

Fire fighters in an emergency situation should look for a transfer device between the main panel and the emergency or portable generator. Check the lights or position of the throw switch to confirm that electricity from the generator is not flowing out of the building into the distribution system. If there is no transfer device, turn off the generator to eliminate possible ***electrical backfeed***.

During inspection activities, confirm that a generator transfer device is used if a portable or emergency generator is present. An incorrectly wired installation or installation without a transfer device may result in life threatening shock or fire hazards for building occupants, electrical utility personnel, emergency responders or others.

Meter Base Transfer Device



8.0 Other Emergency Situations

The following provides a description of new technologies and situations which can present hazardous electrical situations to emergency responders. Understanding the hazards presented by these situations can protect you from serious injury or death.

8.1 Distributed Generation Technologies

The move away from traditional fossil fuel based electrical energy generation to more renewable electrical energy generation technologies has created a shift to photovoltaic (PV), wind turbine, fuel cell and small hydro generating facilities and installations. Due to government incentives these new electrical generation technologies, particularly photovoltaic and wind turbine installations are becoming common for residential, farm and commercial properties.

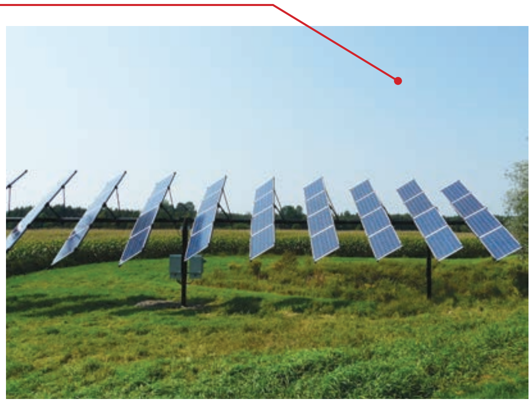
8.1.1 Solar Photovoltaic Technologies

A solar photovoltaic system converts solar energy into electrical energy. Typical solar PV installations can be fastened on residential and commercial roofs, ground mounted or attached to a structure. Residential applications may be on a rack system or integrated into the actual shingles (Building Integrated Photo Voltaic, BIPV). The installations can be tied into the larger electrical grid (Grid Tied) or independent or stand alone systems (Off Grid). Off Grid or stand alone systems rely solely on PV panels to produce direct ***current*** (DC) electrical energy and contain battery banks to store the energy. A typical system is

Residential Roof Top

BIPV

Ground Mounted Commercial



Commercial

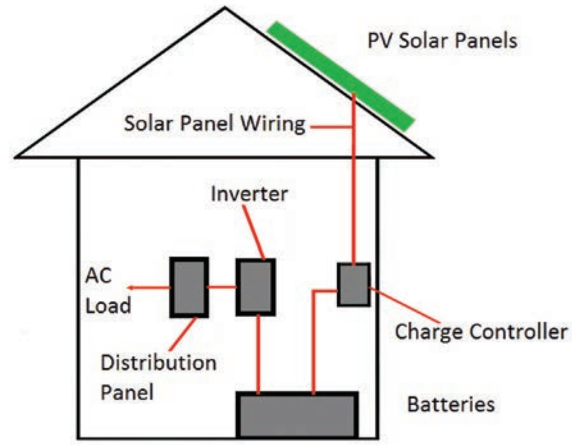
made up of solar PV panels, combiner boxes, charge controller, disconnect devices and battery banks. Caution is required when fighting a fire in a building with an Off Grid installation since the batteries typically contain lead acid and can be located anywhere in the building.

Grid Tied systems generate electrical power through solar PV panels and any excess electricity is sold back to the grid. A typical system is made up of solar panels, combiner boxes, inverter, disconnect devices and metres.

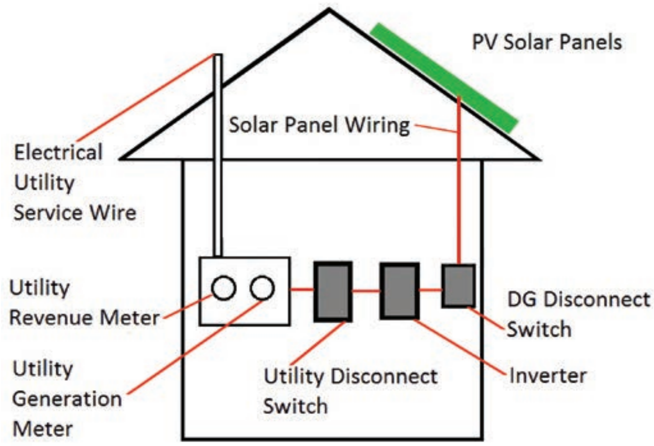
The solar PV panel is the basic electricity generating element in the system. The typical module is 1 x 1.75 meters (30 x 50 inches) and weights about 14 Kg (30 lbs). The modules generate electricity from light. Modules are rated between 125 and 250 watts each and produce between 24 and 48 volts of direct ***current*** electrical energy. When modules are connected in series the ***voltage*** can increase typically up to 600 volts DC for residential roof top installations.

Since solar PV systems produce DC power, an inverter is required to convert the DC electrical energy to alternating ***current***, AC. Inverters can be located on the roof, exterior or interior wall, garage, basement near the main electrical panel, attics or lofts.

Disconnect



Off Grid System



Grid Tied System

Off Grid or stand alone systems, typically found in rural or remote areas, rely solely on PV panels to produce direct ***current*** (DC) electrical energy and contain battery banks to store the energy.

CAUTION: Depending on the location of the disconnecting device, emergency responders will be exposed to continually electrically energized 'live' components.

Disconnecting devices are required to provide disconnection of all electrical equipment. The location of the disconnecting devices varies from the exterior to the interior of a building. Typically the disconnect device is located adjacent to the inverter.

Identifying PV systems on the roof-tops of houses or commercial/industrial buildings could present a challenge to fire fighters as they might not be seen from street side and are usually difficult to see at night. Some clues that might attract fire fighters' attention are locating inverter boxes outside, labels/signs; disconnect switches, additional meters and conduit installed on the exterior of the building.

Fighting fires at facilities with solar PV systems creates unique electrical and tripping hazards. For example: Any presence of light such as sun, moonlight, scene lighting and even light from a fire will energize the solar panels, associated equipment and all connected electrical circuits. Operating disconnecting devices and/or contacting the local electrical utility to disconnect power from the grid does not shut off power from the solar PV system. Significant tripping hazards arise from the conduits or wires connecting the PV panels.

Emergency responders are encouraged to develop a contact list of solar panel installers/ maintainers to safely assist and advise on the disconnection of alternative generation systems.

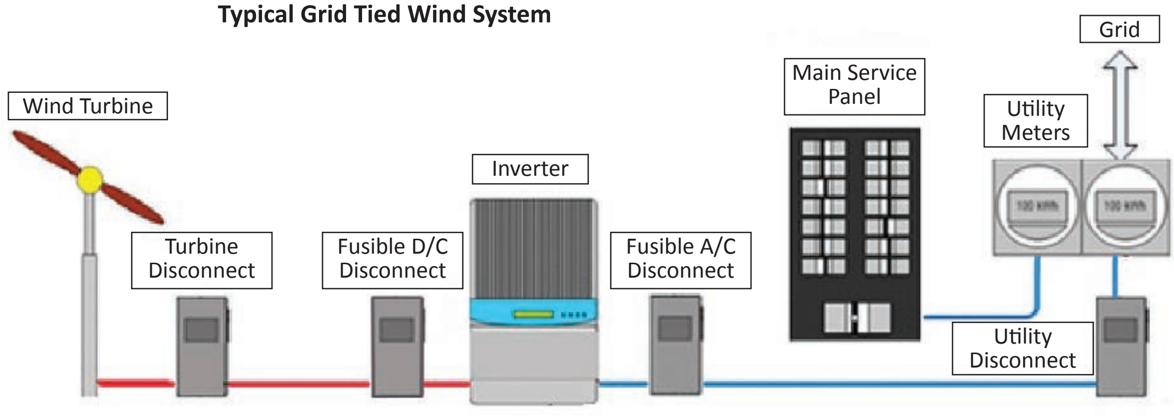
8.1.2 Wind Turbine Technologies

A wind turbine is used to convert kinetic energy from wind into mechanical energy. The turbine drives a generator to produce AC or DC electrical energy (power). There are two types of systems; small wind system and a large wind system.

A small wind system consists of one or more wind turbines with a rated output up to and including 100 kW. Small wind systems are typically found on farms and rural residential properties. Small wind turbines may not have a disconnecting device (means). They would incorporate a shorting plug or a switch instead.

A large wind system consists of one or more wind turbines with a rated output exceeding 100 kW. Large wind systems will typically have a number of wind turbine towers arranged into an array or wind 'farm'.

Typical Grid Tied Wind System



A Nacelle is the body, shell and casing covering the gear box, generator, blade hub and other parts mounted on the top of the tower structure of a propeller-type wind turbine. It is electrically connected to the rest of the wind turbine generator electrical system after installation.

Hazards with Wind Generation:

When a turbine is disconnected from the utility source, the turbine will continue to produce energy as long as the blades continue to rotate. Wires inside the structure will remain electrically energized 'LIVE'. Some wind generating systems may employ storage batteries similar to those found on large UPS systems (uninterruptable power supplies).

These can supply power as long as they hold a charge. Contacting or shorting the live parts should be avoided. Combustibles include the plastic construction of the Nacelle housing, hydraulic fluids and lubrication oils, the interior foam sound insulation and cables.

Ensure a collapse zone is established and exposure protection is in place.

8.1.3 Fuel Cell Technology

A fuel cell is a device that generates a DC electrical ***current*** by the electromechanical combination of a continuously supplied gaseous fuel and oxidant. The fuel cells may be either stationary or portable. Fuel cells can run on a variety of fuels including natural gas and hydrogen. Fuel cells produce electricity via electrochemical transfer and operate very quietly producing nearly zero noise. Disconnecting device is required to be labelled and installed within site of the fuel cell or integral to the equipment. The location of the manual fuel shut-off valve should be marked at the location of the primary disconnecting device of the incoming building supply.

8.2 Illegal Activities

8.2.1 Illegal Activities - Grow Ops

The illicit growing of controlled substances is often referred to as 'Grow Ops'. These 'Grow Ops' are typically found in residential single family buildings. 'Grow Ops' can also be found in warehouses, industrial and commercial facilities. 'Grow Ops' typically present electrical contact, shock and fire hazards to emergency responders.

Dangerous wiring methods are typically used to avoid suspicion that would be associated with the very high consumption of electrical power. Typically the electrical service has been tampered with in order to by-pass the electrical meter and tap directly into the incoming electrical utility line. Some signs of tampering include:

- Taps made underground by coring through foundation and splicing into the utility feed,
- Cutting into the utility feed before the meter if the overhead mast is concealed in the attic.

As a cautionary note, entering a 'Grow Ops' before the incoming utility supply has been disconnected puts first responders at risk and susceptible to shock hazards. Hazards include electrical, fire and entanglement.

Electrical Contact/ Shock Hazards:

- Even if the meter was removed, the tapped connections are done on the utility feed which is live at all times until the utility company disconnects the feed from the street,
- Unapproved wiring methods such as unprotected wiring,
- Exposed wiring, terminals and connections,
- Equipment not ***bonded*** or grounded properly, creating short circuits and hazards,
- Metals in close proximity becoming energized causing serious injury or electrocution,
- Deliberately set booby traps of various types attached to doors, handles and windows.

Fire Hazards:

- High heat producing equipment placed on or near building combustibles,
- Overloaded circuits with inadequate or bypassed overload protection,
- Use of undersized extension cords,
- Use of gas producing batteries in an enclosed area (basement).

Entanglement Hazards:

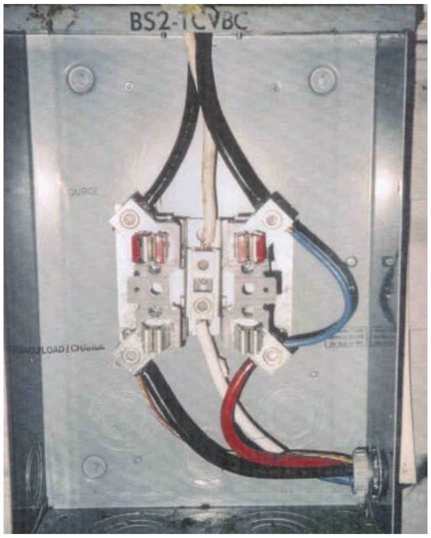
- Extensive use of extension cords,
- Improperly installed low-hanging flexible ducting,
- Improperly strung and unprotected wiring,
- Batteries or ***capacitors*** randomly positioned and wired together.

Serious injury, severe burns or electrocution risk is elevated even more for the firefighters who are entering a building under heavy smoke conditions which significantly reduces visibility. Entering a Grow Op facility should only be done after all sources of energy from the incoming utility supply have been disconnected.

Once the incoming utility supply has been disconnected, caution is still required when entering a facility. Stored energy devices such as batteries and ***capacitors*** may be located on site and contain sufficient electrical energy to cause injury if in-advertently contacted.

Safety Procedures:

In addition to risks of electrical shock or entanglement, off-gassing from a fire presents a high risk due to the numerous chemicals and carcinogens present in the vapours and smoke coming from combustibles following a fire. The presence of Toxic Industrial Chemicals (TICS) used for the production of marihuana contain organophosphates and are highly toxic.



There is also the potential for explosive gases to be present, due to the numerous chemicals involved with a Grow Op. These gases can create a deadly explosive mixture and cause a flash fire even after the fire has been extinguished. There will also be a strong presence of molds such as Stachybotrys, Aspergillus and Penicillium in the building that present a respiratory hazard.

The first responders should always wear appropriate respiratory protection in addition to personal protective equipment (clothing) due to these chemical and biological hazards.

As part of the incident response process, it is recommended that all departmental operational guidelines be followed when dealing with a Grow Op situation.

Defensive fire fighting tactics may be the safest way to deal with a fire of this type.

SITUATION: A Grow Op location identified by police in a residential location.

ACTION

1. Do not enter until the electrical utility has disconnected the incoming utility supply to the residence directly from the source. Do not pull the meter, it will not disconnect any wiring when by-passed.
2. Task force to check for deliberately set traps.
3. Enter with caution since there may also be batteries present.

Grow Op Wiring

Grow Op Plants

8.2.2 Illegal Activities – Copper Theft

Heavy copper wire is used to carry electricity and is also used to ground electrical and nonelectrical equipment to protect members of the public and electrical utility workers. With the price of copper increasing, there have been many situations in which emergency responders attend at a scene involving a substation. Theft of copper creates hazards to members of the public, emergency responders and utility workers that rely on the copper ***grounding*** to protect against step and touch potential hazards. For these reasons, the actions to be taken by emergency responders may differ from those noted in Section 6.2.1 Trespassers in Substations.

Typical break-ins include holes cut into the fence, cut or damaged barbed wire or cut locks. Once the thieves have exited the substation, the site has become unsecured due to holes in the fence fabric which allow access into the station and hazardous areas.

A major concern is that young children may wander into the unsecured station.
Emergency responders should not enter a substation unless the local electrical utility has been informed and made the site safe.

Hazards such as exposed energized 'live' unguarded electrical apparatus are common in substations.

Fence gate is in the normally closed position in this photo.

SITUATION: Police are notified by a member of the public of a break-in at an electrical substation.

ACTION

1. Immediately notify the electrical utility and wait for them to arrive on site. Do not enter the substation.
2. If someone is found in the substation, warn of the danger and calmly tell the person(s) not to move.
3. When the electrical utility personnel arrive, enter only when instructed.

9.0 Glossary of terms

Arc-over
A term used to describe the phenomena of ***high voltage*** electricity jumping through intense fire or smoke to ground. This terminology was chosen to avoid confusion with the word “flashover” which has different meanings for ***power line*** maintainers and fire fighters.

Electrical backfeed
Hazardous electrical ***current*** that may exist due to a power source feeding through the ***low voltage*** (secondary) side of a transformer, or any other source of electrical energy.

Bonded
A low impedance path obtained by joining all non-***current*** carrying metal parts to ensure electrical continuity and having the capacity to safely conduct any ***current*** likely to be imposed on it.

Bus
A conductor which serves as a common connection for the conductors of two or more electrical circuits.

Capacitor
A device typically installed in transmission, distribution and industrial systems to provide power factor correction. The device improves system ***voltage*** and reduces electrical energy line losses.

Closed
When used to convey the position of an electrical switch, it means that the contact points are touching and the circuit is energized.

Confined space
A fully or partially enclosed space, that is not both designed and constructed for continuous human occupancy, and in which atmospheric hazards may occur because of its construction, location or contents or because of work that is done in it.

Current
A flow of electric charge. Can be compared to the rate of flow of water in a pipe. ***Current*** is typically measured in amperes (amps).

De-energized
In the electrical energy sense the equipment is isolated and grounded (electrically connected to earth).

Dielectric
A term used to describe tools and equipment that are designed to withstand the flow of very ***high voltage*** electricity (100,000 or more volts).

Fault current
The maximum electric charge (energy) that will flow through a ***neutral*** or ground wire when an electrical device or circuit fails.

Fuse cutout
A combination fuse and switch typically used on distribution ***power lines*** to protect equipment from power fluctuations in the same way that fuses are used in a building to protect circuits.

Grounding
Is the process of mechanically connecting isolated wires and equipment to the earth with sufficient capacity to carry any ***fault current*** and to ensure the wires and equipment remain at the same ***potential*** (same ***voltage***) as the earth (ground).

High voltage
Any ***voltage*** above 750 volts. Also referred to as primary ***voltage***.

Isolated
Physically disconnected or separated from sources of dynamic energy by approved procedures or specifically designed devices.

Induction magnetic
The phenomena where isolated wires running parallel and close to a live wire can become

energized by the magnetic field created by the ***current***. The strength of the induced ***voltage*** is dependent on atmospheric conditions, distance of paralleling, proximity and ***voltage*** of the energized ***power line***.

Induction electrostatic
A build up of static charge on an object as it moves through a ***high voltage*** area such as a substation.

Insulated
Separated from other conducting surfaces by a ***dielectric*** substance or air space that provides a high ***resistance*** to the passage of electrical ***current***.

Kilovolt – kV
The short form for kilovolt is kV. One kilovolt is equal to 1000 volts.

Low voltage
Any ***voltage*** from 31 to 750 volts inclusive.

Neutral
The part of an electrical circuit that provides the electric charge a return path to ground.

Open
A common term used in the electrical industry, which means that electrical energy cannot flow because the position of a switch has broken the continuity of the circuit.

Potential (electrical potential)
A term commonly used in the electrical industry. When used in the electrical sense, it means the difference in electrical charge between any two objects capable of carrying an electrical charge. ***Electrical potential*** is measured in volts (see ***voltage***).

Power line
That part of a metal wire or cable intended to carry the flow of electrical energy.

Primary power line
A term used in the electrical utility industry to describe the wires that typically carry ***high voltage*** electricity. ***Voltages*** carried by these wires range from 2,400 to 500,000 volts.

Qualified
A person who is competent because of their knowledge, training and experience to perform the assigned task or work.

Recloser
An automatic switch-like device that is used to protect ***high voltage power lines***. These devices are typically set to "*reclose*" or "reset" a number of times before remaining in an ***open*** position and shutting off the power.

Resistance
Is similar to the effect of friction on the flow of water in a pipe. (Water flows more freely in a large pipe than in a small one.) Different materials have different ***resistance*** to the flow of electricity. Very high ***resistance*** materials are called insulators, while the low ***resistance*** materials are called conductors. ***Resistance*** is measured in ohms.

Secondary Power lines
Electrical wires that carry the lower ***voltages*** (120/240, 347/600 volts) typically used in houses, offices and commercial buildings. Can be installed overhead or underground.

Safe Limits of Approach
A procedural barrier intended to minimize the risk associated with working up to a specified limit to exposed energized or live electrical equipment.

Underground cable
One or more ***insulated*** wires or conductors designed for and used underground. Can be installed in a duct or directly buried.

Voltage
The difference in ***electrical potential*** between two points in a circuit. It is the force that causes the flow of electricity, and it is measured in volts. Can be compared to water pressure.

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APPENDIX A: TREATING VICTIMS OF ELECTRICAL CONTACT / FLASH INCIDENTS

Hydro one strongly recommends that all victims of electrical contact / flash incidents be provided medical attention. Bring this page and the completed form on the reverse to the treating health care professional.

TREATING HEALTH CARE PROFESSIONAL

ELECTRICAL CONTACT/FLASH INCIDENT

The information provided in this package is intended to assist you in the evaluation, diagnosis and treatment of individuals who may have been involved in an electrical contact or flash.

As a concerned corporate citizen who recognizes the potential serious nature of the injuries that may result, as well as the relative infrequency of treating this type of injury, **Hydro One strongly recommends consultation with a burn unit, for specialist support and advice. Consultation with an electrical burn specialist can be immediately obtained through the Provincial Criticall program 1-800-668-4357.**

Please see the attached **Electrical Contact/Flash Incident form** which will provide you with information that may help to determine the potential severity and complexity of the injury. Be aware that the extent of the victim's injuries may be worse than is first clinically apparent.

Yours sincerely,

Dr. Doug Morrison,
Chief Physician,
Hydro One

ELECTRICAL CONTACT/FLASH INCIDENT FORM

Please complete the following information below and give to the emergency department attending physician/nurse.

Victim Name: .... **Time of Incident:** ....

What was the victim doing? ....

What type of electrical contact was involved?
☐ Direct Electrical Contact ☐ Arc Blast
☐ Arc Flash

☐ **Other(describe):** ....

Estimated Duration of direct electrical contact: .... **seconds**

Voltage details: ☐ AC ☐ DC

Voltage Level: ☐ volts ☐ kilovolts

Electrical current details: .... **Amperes (Amps)**

What was the main pathway through the body?
☐ Hand to hand ☐ Head to foot
☐ Hand to opposite foot

☐ Other(describe): ....

Conditions at point of contact:
☐ Wet skin ☐ Contact with water ☐ Humidity of air
☐ Dry skin ☐ Non-intact skin

☐ Other(describe): ....

Level of consciousness:
☐ Fully alert ☐ Dazed/confused ☐ Lost consciousness Duration: ....

Did victim require:
☐ CPR ☐ Defibrillation ☐ No resuscitation

Did victim fall from height? ☐ Yes ☐ No

If yes, explain: ....

Was victim immobilized? ☐ Neck collar ☐ Joints/bones splinted

Was victim wearing personal protective equipment?

☐ Yes ☐ No

☐ Arc Outerwear ☐ Dielectric boots ☐ Safety Glasses

☐ Gloves ☐ Hard hat

☐ Other(describe): ....

Did the incident take place in an enclosed/confined space?

☐ Yes ☐ No

If yes, explain: ....

Any other hazards in vicinity of electrical contact impacting on injury?

☐ Yes ☐ No

If yes, explain: ....

Contact for further information:

Name: .... Phone: ....

Notes:

Notes:

Notes:

Printed on recycled paper

Electrical Safety Authority

Public Services Health & Safety Association™

hydro one