Electrical Safety

A Handbook for Emergency Personnel

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All the time.

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Electrical Safety

A Handbook for Emergency Personnel

Instructions on how to handle electrical hazards created by motor vehicle accidents, storms and fires.

This handbook was developed by Maritime Electric to assist police and fire departments, emergency medical attendants and members of the Emergency Measures Organization in the performance of their duties. Maritime Electric recognizes the valuable service you provide in our communities across Prince Edward Island.

Emergency personnel demonstrate great personal sacrifice and outstanding dedication in the performance of their duties.

In recognition of this valuable service to our community, Maritime Electric dedicates this booklet to the members of these organizations. We also wish to recognize the late Miles Boulter for his contribution to this handbook. Miles was the Chief Training Instructor for the PEI Firefighters' Association Fire Training Centre for almost 30 years.

Thank you for your service to our community!

All our energy.
All the time.

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Electricity – Some Basic Facts

Electricity should be respected, not feared. Electricity will always seek the easiest path to ground. This is true whether the electricity comes from a household lighting circuit, a high voltage power transmission line or from lightning.

Any person between any two energized conductors, or any energized conductor and the ground, will become part of an electrical circuit. This can cause serious injury or death.

Common Electrical Terms

Voltage can be likened to water pressure. It is the force that causes the flow of electricity.

Current can be likened to the rate of flow of water in a pipe.

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 resistances to the flow of electricity. Very high resistance materials are called insulators, while the low resistance materials are called conductors.

In an electrical system, the force or pressure is measured in volts and the current flow in amperes (amps). Resistance is measured in ohms.

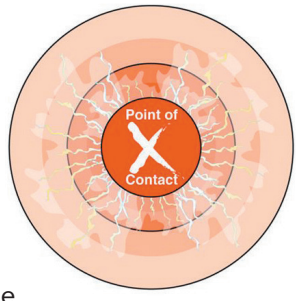
Insulators, Conductors and Semi-Conductors

All materials conduct electricity in varying degrees. Materials classified as insulators conduct electricity in quantities too small to be measured. Materials classified as conductors conduct electricity readily in large amounts. For example, glass is an insulator and metal is a conductor. Some other materials are classified as semi-conductors. These include wood, earth and rubber tires. Depending on conditions, such as moisture content and contaminants, semi-conductors can conduct large amounts of electricity.

Low Voltage Hazards

In the electric industry, low voltage is below 750 volts. Most electrical fires originate in equipment with low voltage, such as home heating systems and appliances, which operate at 120/240 volts. Although the hazard is increased with high voltage installations (greater than 750 volts), it is important for emergency personnel to recognize the hazards of even relatively low voltages.

Voltage Gradient on the Ground is Surface



If a live wire lies on the ground, the electricity will fan out from the point of contact. This causes a rippling effect that can be likened to dropping a pebble into calm water. In a 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 where it contacts the ground, but as you move away from the contact point, the voltage drops progressively. This effect is known as ground gradient and a knowledge of how it operates could save your life someday.

Walking through a ground gradient area is extremely dangerous because of the difference in electrical potential between the person's feet touching the ground. This also applies to first respondents dragging hose lines, carrying ladders or other objects in an area where downed wires are present and can result in serious injury or death.

When raising ladders, be very careful to avoid electrical contact hazards. Possible contact with live electrical wires or equipment could occur either by the ladder or by the person climbing it. Before placing a ladder, make sure the required limits of approach can be maintained at all times (i.e. when raising the ladder, using it and lowering it). In some cases, the ladder may come to rest and maintain safe limits, yet encroach upon safe limits while raising it. Alternate methods for raising and lowering ladders may be required. Always maintain required limits of approach.

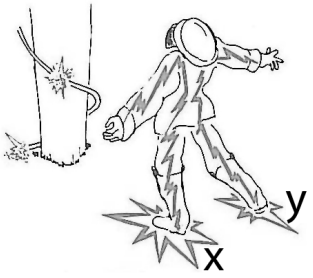
Step Potential and Touch Potential

The ground gradient, or voltage drop, creates two problems known as step potential and touch potential.

Assume that a live downed wire is touching the ground and has created a pool of electricity. As shown in the Step Potential drawing, below, 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 would cause electricity to flow through your body. This effect is referred to as step potential.

Similarly, 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 difference in voltage in this case is referred to as touch potential.

Step Potential



Touch Potential

Note:
Firefighters' boots are subjected to extreme wear and should not be relied on to provide electrical protection in any situation.

Injuries Caused by Electric Shocks

Effects of Electricity on the Body

The effect of electricity on the body depends on the amount of current and the length of time the body is exposed to it. The higher the current, the less time someone is likely to 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 100 watt bulb. The table below and the figure on the following page illustrate that a small amount of current for a few seconds or more can be fatal.

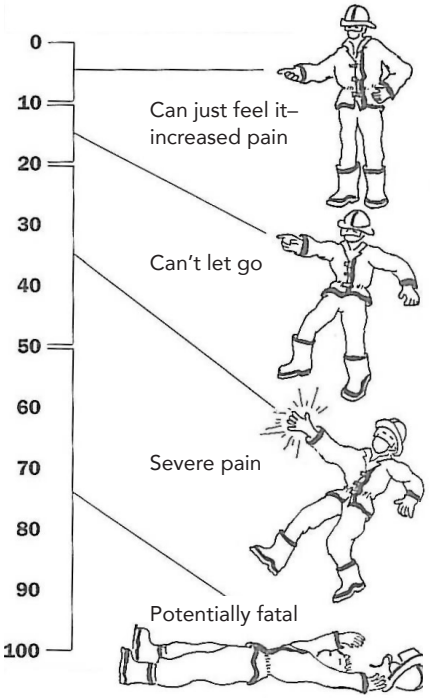
Amount of Current	Effect on a Human
1 to 4 milliamps	Can just be felt
5 to 9 milliamps	Increasing pain
10 to 20 milliamps	Cannot let go
21 to 50 milliamps	Severe pain, muscular contractions
Above 50 milliamps	May be fatal, destruction of tissue (burning), and breathing stops

It is the amperage that causes injuries or death. But the voltage, which pushes the current through the body, is also important.

When a victim is exposed to household voltages, they may suffer a muscle spasm and may be locked onto the electrical source until the current is turned off, or until the victim is dragged clear, often by the weight of their body falling clear of the contact. Relatively long periods of contact with low voltage are the cause of many electrical fatalities in the home or at work.

At very high voltages (on power lines, for example) the victim is often quickly thrown clear of the circuit. This results in less internal damage, such as heart failure, but results in terrible surface burns on the body at the entrance and exit points of the current.

Electrical Current in Milliamps



Note:
All electrical shock and burn accident victims should receive prompt standard first aid treatment, followed by professional medical attention, regardless of the severity.

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

1) contraction of chest muscles, causing breathing difficulty and unconsciousness;

2) temporary paralysis of the respiratory organs resulting in failure to breathe;

3) ventricular fibrillation of the heart (mainly from lower voltages);

4) burns to tissue at the entrance and exit points (mainly from higher voltages); and

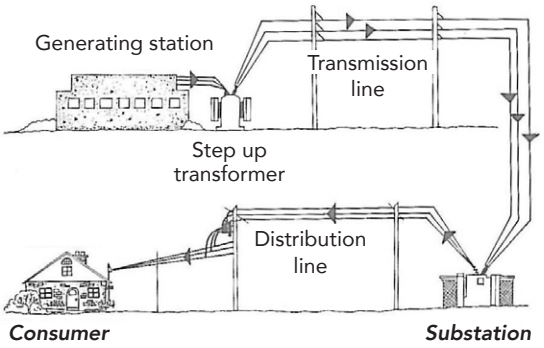
5) fractures caused by muscle spasm.

Generation and Distribution of Electricity

Electrical generating stations produce power 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. On Prince Edward Island, some transmission lines operate at 69,000 volts, others as high as 138,000 volts.

At the substations, voltage is reduced and electricity is sent on distribution lines to industrial, commercial and residential customers.

Power plants, substations, underground vaults and other Maritime Electric installations differ greatly from the buildings firefighters usually face in emergencies. They present hazards which can prevent firefighters from using conventional techniques and sometimes endanger the firefighter's life if they are not familiar with the surroundings. In all cases, specialized firefighting techniques are required to ensure maximum personal safety and effectiveness. It is therefore important that good communication and cooperation exist between Maritime Electric and the police and fire departments.



Maritime Electric Substation

Identification and Safe Limits of Approach to Electrical Equipment and Apparatus

All equipment and metal structures in substations are bonded to a grounded grid. The grounded grid (covered with 6 inches of crushed rock) is under the entire substation. The substation's fence is 3 feet inside the grounded grid and is bonded to the grounded grid. Only authorized personnel are permitted inside the substation.

Standard Voltages and Safe Limits of Approach

Occupational Health and Safety Regulations for the Province of PEI state that except for utility workers, employees shall not carry out any work which is liable to bring any person, apparatus, machine, machine component, material or property within a distance of energized electrical conductors, closer than as specified in the table on the following page.

Nominal Phase to Phase Voltage of Live Power Line	Minimum Distance
Up to 750 volts	0.9 metres (3 feet)
751 - 100,000 volts	3.6 metres (12 feet)
100,001 - 250,000 volts	5.2 metres (17 feet)

Maritime Electric equipment and the safe limits of approach are shown below.

Transmission Line



Standard Voltages	Safe Limits of Approach
69,000 volts	3.6 metres (12 feet)
138,000 volts	5.2 metres (17 feet)

Distribution Line

Standard Voltages	Safe Limits of Approach
All distribution voltages	3.6 metres (12 feet)

Commercial and Industrial

Standard Voltages
Up to 750 volts

Safe Limits of Approach
0.9 metres (3 feet)

Residential

Standard Voltages
120/240 volts

Safe Limits of Approach
0.9 metres (3 feet)

Communication with the Electric Utility

In an emergency, it is vital to get the right message to the right utility person as quickly as possible. Use the un-listed numbers for Maritime Electric, which are available through the Fire Marshall's Office and Police Services.

Before an emergency happens, take the time to familiarize yourself with electrical installations in your area. Maritime Electric welcomes emergency personnel who wish to visit installations to learn about the hazards involved in working near electrical equipment.

Arriving at the Scene of a Fire in Homes or Other Buildings

Electrical service is usually supplied to homes at 120/240 volts. Voltage to industrial plants and commercial buildings usually ranges from 220 volts to 750 volts, but can be 12,000 volts or higher in larger industrial installations.

A survey of electrical facilities before setting up firefighting equipment is essential. Vehicles and equipment should not be set up under power lines that may be subjected to extreme heat. When exposed to extreme heat, the lines could expand and burn off.

When arriving at the scene of a fire do not attempt to turn the power off by removing the meter. Meters are not designed to turn the power off and may explode if an attempt is made to remove them. Also, the metering of electricity is done in so many different ways, that pulling a meter no longer guarantees the isolation of electricity in the building. Maritime Electric does not sanction the practice of removing meters to isolate power.

A meter could explode if you or somone else tries to remove it.

Arriving at the Scene of a Substation Fire

On arriving at a substation fire, DO NOT ENTER THE SUBSTATION. Firefighters should hook up and stand ready to protect adjacent properties. A utility representative will tell firefighters when the substation has been made electrically safe. Firefighters can then proceed to put out the fire with conventional firefighting equipment.

Most substations are unattended, although an automatic signal system should notify the utility when an emergency develops. If a utility representative is not present when the firefighter arrives, the utility must be contacted.

Utility representatives are familiar with the substations they service. They are trained in the use of the specialized station firefighting apparatus and can identify the areas that are electrically safe.

Metal ladders must not be placed against a substation fence or used in fighting substation fires. Measuring tapes, extension cords and other metal objects can also create a hazard and are not permitted in utility substations.

The gravel covering substation property serves two vital functions:

1) it insulates people from the grounding grid, and

2) in the event of a fire, it cools down oil which may flow from transformers or other electrical equipment.

Note:
Maritime Electric equipment and storage areas containing PCBs are identified with approved warning signs. Under certain conditions, PCBs in the presence of oxygen when heated between 205°C - 700°C may produce harmful by-products such as dioxins and furans. Firefighters in such a situation must take every precaution necessary to protect themselves and all member of the public present. All environmental guidelines must be adhered to.

Arriving at the Scene of a Pole Fire

Pole fires are normally caused by the failure of insulators or switches and the catastrophic failure of transformers or oil-filled switching equipment.

Some poles used in the utility industry are highly conductive as a result of preservatives used to treat the wood. The treatment also causes the poles to burn rapidly and sustain fire easily. These poles can be easily recognized by their distinct green colour.

When pole fires are caused by an insulator switch failure, current can flow to the pole through the metal hardware components of the insulator or switch. Since the pole may be highly conductive due to the preservative treatment, dangerous levels of voltage may be present at the base of the pole.

When pole fires are caused by catastrophic failure of transformers or other oil-filled equipment, the situation is compounded. Current may be leaking to the pole as in the first case, plus oil from the equipment could fuel the fire.

In the above cases, the following action is recommended:

1) When the call is received at the station reporting a pole fire, the information should be reported to Maritime Electric or to the utility owning the line as quickly as possible. State the exact location of the pole.

   Note:
   You may need to use Maritime Electric's emergency number which is available through the Fire Marshall's Office or Police Services. This unpublished number has been put in place strictly for the use of fire and police personnel and should only be used for emergency situations.

2) When arriving at a pole fire, firefighters or police personnel should carefully survey the situation. Do not place your vehicles under or near wires that may burn off or fall due to the fire.

3) Crowd control is extremely important. The public must be kept well away from the affected area as a precaution against wires that may burn off and fall, or equipment that may explode.

4) Firefighters should hook up and stand ready to protect adjacent properties.

5) Do not apply a direct stream of water on a pole fire. A non-conductive extinguishing agent is best to control the fire should it become necessary to protect property or life.

   Note:
   A pole fire that is caused by a flow of current cannot be put out until the electricity is turned off and the flow of current stops.

6) Electric utility personnel who respond to the scene of the pole fire will make the conditions electrically safe. When they confirm that conditions are safe, firefighters may then proceed to extinguish the fire using conventional means, including water.

7) Be aware that other wires may be weakened and may fall. Position yourself accordingly.

Example of a pole fire

Arriving at the Scene of Various Accidents

Dealing with Fallen Wires in the Street

Electrical wires may be broken by storms, ice or by vehicles striking power poles.

If you come across abnormal situations such as broken or fallen wires, do not expose yourself to risk while trying to eliminate the danger (see Note below). Always assume the wires are energized and capable of causing serious injury or death. Inform the utility as soon as possible and qualified utility personnel will be sent to remedy the situation.

Note:
In a modern electrical system the power lines 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. Also, the power may be turned off and on automatically by automated equipment, or in some cases by operators at the utility's Energy Control Centre.

Maritime Electric crews arrived on site to restore power after Hurricane Dorian and found this line that had fallen across the road.

Action to be Taken on Arriving at the Scene

1) The hazard area may be greater depending on conditions. Before exiting the vehicle examine the surroundings carefully. Ensure you are parked well away from fallen wires by visually examining the surrounding area from inside the vehicle. If it is nighttime, use a flashlight or spotlight to assist in carefully examining the surroundings from inside the vehicle. If you are parked over or near a fallen wire, move your vehicle well out of harm's way; at a distance of at least 30 metres (100 feet).

2) Stay at least 30 metres (100 feet) away from the scene. Visually locate all wire ends. They may be on the ground or in the air. If a live wire touches a car, truck, or other object such as a metal fence or guard rail, that object will become energized and capable of causing serious injury or death. A live wire in a pool of water is extremely dangerous. Protect yourself and supervise the public to prevent any contact with energized objects.

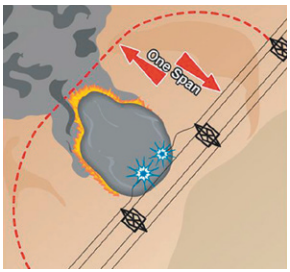
3) Place a guard around the danger zone and call your utility for help. Don't forget the emergency number.

4) If a wire has fallen on a metal fence or other metal object, electricity may be conducted to other points some distance away. In fact, the ground itself can be energized to a dangerous level near the fallen wire.

   Keep people away from the broken or sagging 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. Wait for the utility.

6) If a grass or vegetation fire has started due to a downed wire, it is advisable to cordon off an area around the break for a distance equal to one span. Ensure the utility has been notified and do not begin to fight the fire until it has burned away from the break a distance of at least one span.



Aiding Victims Trapped in a Vehicle by Fallen Wires

Whenever possible, utility personnel will handle the following situations. If utility personnel are not yet on the scene, the following actions are intended to guide only those emergency personnel who are properly trained in emergency rescue procedures.

Situation: A downed wire lies under a vehicle carrying one or more people.

Action: Do not touch any part of the vehicle and remember the possibility of a ground gradient. You could be electrocuted.

Note:
There are two basic procedures when a vehicle is in contact with energized conductors or equipment. The first is to maintain safe limits of approach and to tell the occupant to remain still and stay in the vehicle. If the vehicle is operational, the second is to instruct the driver to move the vehicle clear of the power line or apparatus.

Situation: The driver is unhurt and can still move the vehicle.

Action: Instruct the driver to move the car off the wire and clear of any pools of water which may be energized by the live wire. Make sure you are not in a position to be injured in case the wire springs up after being released when the vehicle moves by staying at least 30 metres (100 feet) away. Also make sure no one else in the vicinity is standing in a dangerous location when the vehicle is moved.

Special Situation: The occupants of the vehicle are unconscious or unable to move.

Action: Firefighters or law enforcement officers should not take any action which would endanger their lives or the lives of others. Monitor closely for any changes in the situation (i.e. fire, etc.). If a victim regains consciousness instruct them to stay in the vehicle.

Padmounted Transformers

Padmount transformers are the above ground portion of an underground electrical system.

Situation: A padmount transformer shows evidence of being tampered with, such as hacksaw marks or severe dents.

Action: Call your utility, giving the location of the transformer and the number on the side of the transformer.

Situation: A padmount transformer has been struck by a vehicle.

Action: Do not touch the transformer or the vehicle. Treat them as energized objects capable of causing serious injury of death. Warn the occupants of the vehicle to stay put. Warn bystanders to stay away. Call the utility and do not approach the vehicle until utility personnel have made the site electrically safe.

This is what a typical padmounted transformer looks like.

Other Types of Incidents Requiring Police Attention

Unauthorized Persons in Substations

Another dangerous situation is when an unauthorized person enters a substation or any electrical installation.

If you observe this situation, instruct the person to immediately come to the fence and remain there. Warn them of the danger. Call the electric utility for assistance.

Tampering with Electrical Equipment

Transformer enclosures are located throughout the Province. They are safe to touch provided they are closed, locked and not damaged.

Never try to open an enclosure or poke wires, sticks or other objects into it. Significant amounts of electricity pass through these transformers; don't let that current pass through you.

If you should happen to see an open or damaged transformer enclosure, report it immediately to the electric utility and keep others away. It could be dangerous.

Vandalism

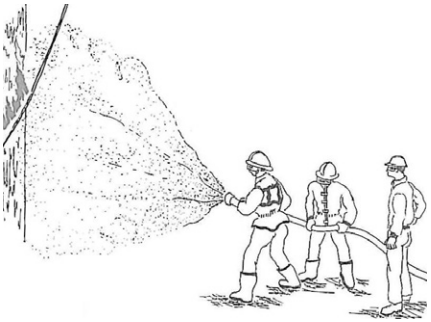
If you see damaged utility equipment, contact the utility immediately. Damage to substations, apparatus and line insulators may create serious electrocution hazards. Stay clear and encourage others to do so until electric utility personnel arrive and make the area safe.

Special Procedures

How to use Water Safely on Electrical Fires

If the exact voltage of electrical wires or equipment is not known, it is advisable for firefighters to maintain a distance of at least 30 metres (100 feet) between the nozzle and any live equipment. If a utility representative is on the scene to advise you as to the voltage, you may use the table on the following page which shows the minimum distances that must be maintained between a nozzle producing a fog stream of fresh water and a live conductor. These distances include a safety factor. Nozzle pressure must be 700 KPa (100 PSI).

Voltage of Live Equipment	Minimum Distance
0 - 750 volts	1.5 metres (5 feet)
751 - 15,000 volts	4 metres (13 feet)
15,001 - 230,000 volts	5 metres (17 feet)



Opening Main Switches in Buildings

In some fire situations it may be desirable to open the main switch to isolate the power in the building. While not usually dangerous, the fire may have caused fault conditions which could over-load the switch.

To minimize risks:

1) do not stand in water or on wet floors;

2) wear dry, protective, heat resistant gloves;

3) wear eye and face protection; and

4) stand to one side when opening the switch and look away.

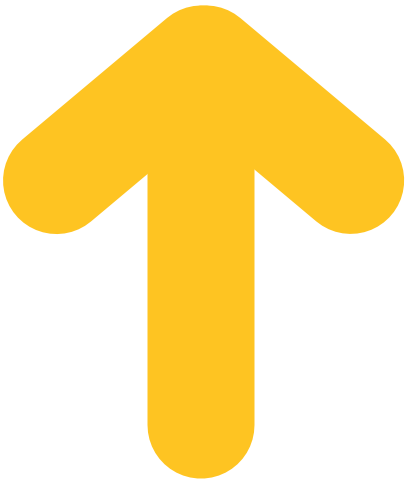
Note:
Use a non-conductive extinguishing agent if possible. Only put a fog stream on electrical fires when it is absolutely necessary to protect life. Electrical equipment that catches fire will need to be replaced anyway.

Entering Flooded or Wet Buildings

The electrical hazards are increased when flooding and wet conditions exist in buildings. Any open wires can be lethal if you place yourself between the live wire and the wet ground.

The late Miles Boulter, Chief Training Instructor for the PEI Firefighters Association Fire Training Centre from 1992 - 2021, demonstrating how to open main switches in buildings.

LOOK UP



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