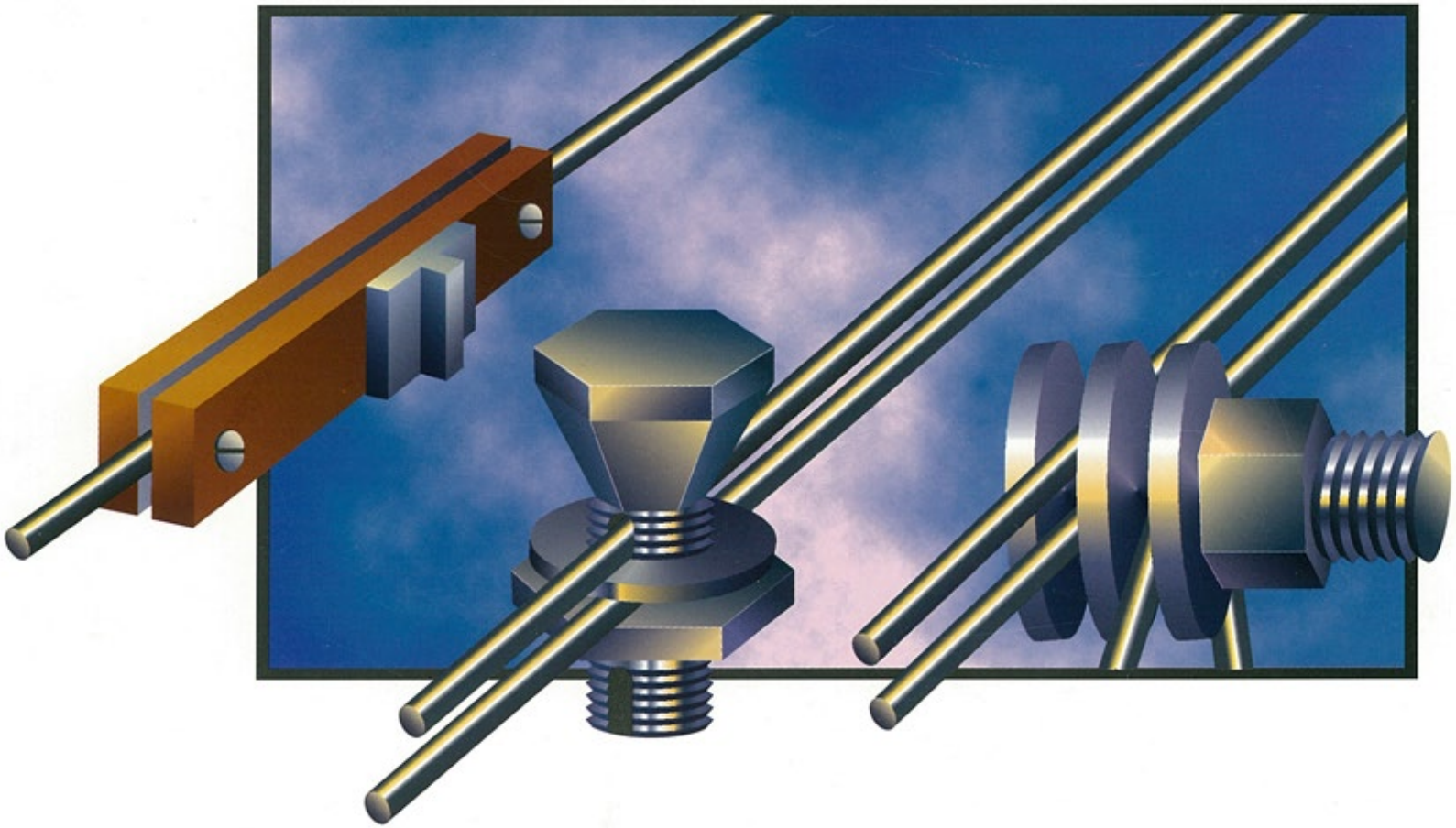
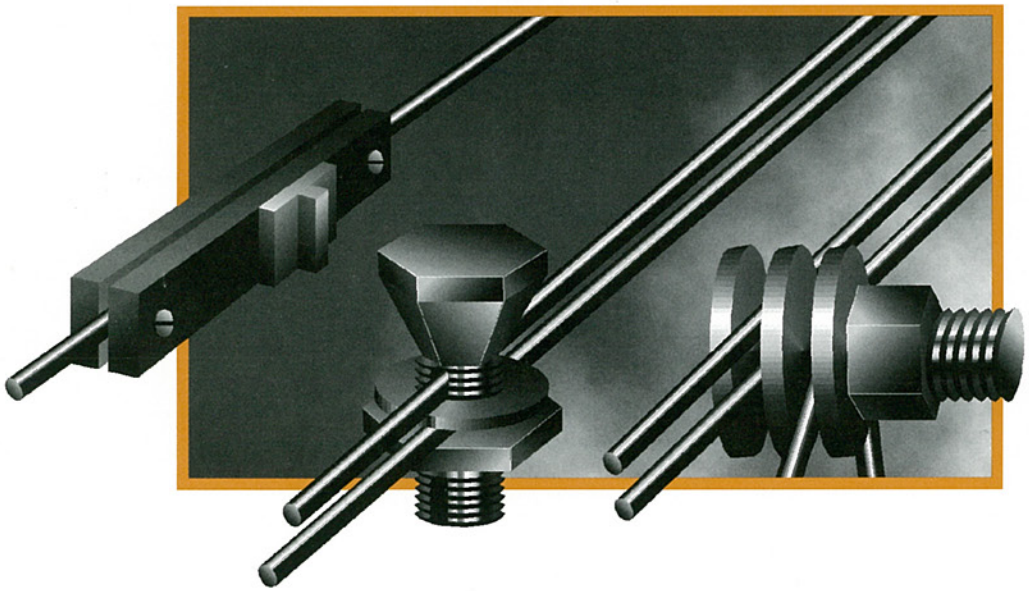
FENCING WITH ELECTRICITY



Fencing with Electricity



Brian Kennedy
Principal Author

FENCING WITH ELECTRICITY

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Brian Kennedy
Regional Agricultural Engineer

Introduction

An electric fence may be just what you are looking for. They are low cost and much more effective than traditional fences. Traditional fences restrain animals by providing a physical barrier. Electric fences use psychology to restrain animals. Animals fear a fence that "hurts" when touched, so they avoid contact with it. An electrified fence produces this psychological barrier.

Electric fences can be permanent or temporary. Permanent electric fences can be used as pasture boundary fences, cross fences, predator control fences or as protection for gardens and feedyards. They are also used for grazing management.

Electricity

To understand the concept of electric fencing, a basic knowledge of the principles of electricity is needed. Electric fences are an application of a direct current (DC) electrical circuit. In any electrical circuit, electricity must flow from the energy source, through the circuit and back to the energy source.

An electrical current is defined as the flow of electrons or electricity. Therefore, the higher the current, the greater the electrical flow. Electrical current is measured in amperes (amps). The pressure created to cause this electron flow is measured in volts. A high voltage simply indicates a high electrical pressure. A conductor (wire) is used to carry the electrical current. It also has the ability to restrict the flow of electricity, depending on the material that the conductor is made of, its diameter and length. This resistance is measured in ohms. Volts, amps and ohms are related to one another through "Ohm's Law", which states:

Volts = Amps x Ohms

The power in the circuit or the rate of energy flow is measured in watts. A watt is the product of volts multiplied by amps.

Watt = Volts x Amps

Electric fence energizers are often rated by their output in joules. A joule is a unit of energy. It is the product of an electrical current, a voltage and the time over which it is applied.

Joules = Volts x Amps x (Pulse Time)

Shock strength is also measured in joules. A high energy (joule) rating indicates a high shock value and the ability to energize long fences. Battery-powered fence energizers produce a shock of 0.5 to 1.0 joules. A 120-volt electric fence energizer will produce a 4.0 to 5.0 joule shock.

A capacitor has the ability to store and release electrical energy. A capacitor is formed when two conductors are separated by an insulating medium. In an electric fence system, air acts as an insulating medium separating the fence wires and the ground. This gives the electric fence the ability to store electrical energy. Therefore, the longer the fence and the more wires used in its configuration, the greater is its capacitance or ability to store electrical energy. To be effective, the electric fence energizer must overcome this fence capacitance.

There are several factors that can hinder the effectiveness of an electrical fence. Extremely dry or frozen soil is a poor conductor of electricity and will reduce the fence voltage due to poor grounding. Vegetation growing around and in contact with the fence also makes the fence ineffective. Vegetation contacting the fence short circuits the fence.

Another important factor to consider is the "guard voltage". This is the minimum voltage the fence requires in order to overcome the insulating qualities of an animal's coat. It varies with the type of animal that is to be controlled. See page 16 for more information about guard voltages.

Electric Fence Components

A successful electric fence depends upon the following major factors:

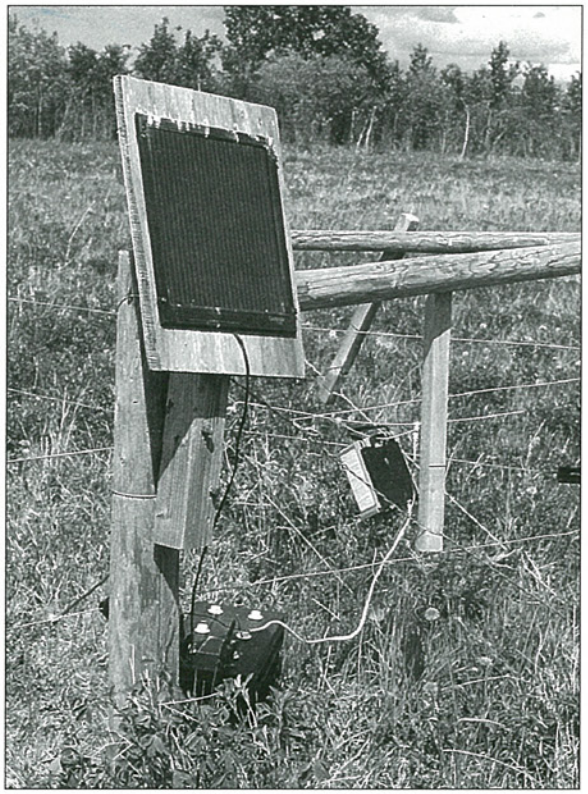
- electric fence energizer
- wire and posts
- insulators
- grounding
- type of animal controlled.

Electric Fence Energizers

The two most common types of electric fence energizers available are: battery operated and 120-volt. Battery-operated fencers are useful in locations where portability is desired or there is no electrical service. Batteries for these units may be either dry cell or deep discharge wet cell. Dry cell batteries are expensive and non-rechargeable. They are only recommended for short-term use. Wet cell batteries are rechargeable and have a storage capacity of three weeks to three months, depending on the power level of the fence energizer. Recreational vehicle (RV) batteries are the recommended type of wet cell battery. They have a deeper discharge cycle than automotive batteries and a lower self-discharge rate.

Solar panels are often used to charge wet cell batteries. They are best suited for remote areas because they are able to store energy for use under cloudy or night conditions and require little maintenance. Proper design of solar systems is important. Hours of sunlight, panel size, and the requirements of the electric energizer must all be considered. Undersized solar panels will result in battery discharge, leaving the fence dead (no guard voltage). See Appendix A for further information on sizing solar-powered fences.

Most battery-operated fence energizers are designed to be mounted outside in a cool, shady location. In the summer, high temperatures will



Solar-powered electric fence

speed up the discharge rate of wet cell batteries. At 35° Celsius, a battery will discharge three to four times faster than on a 20° Celsius day. A fully charged battery stored in 35° Celsius temperatures will self-discharge in about 90 days.

Several models of electric fence energizers are available, from those designed for a short one-wire fence to ones designed for up to 60 kilometres or more of wire. Depending on the design of the electric fence energizer and fence conditions, these units will have a guard voltage of 500 to 9,000 volts. Where adequate power is readily available, 120-volt electric fence energizers are preferred. They are more powerful than a battery-operated fence energizer, have lower maintenance requirements and a higher capacity.

Some electric fence energizers have more than one output level. This usually means they have a low, medium and high output terminal. The output level of an electric fence energizer is a pulse of electrical energy of several thousand volts and a few milliamps of current that lasts for a fraction of a second. The pulse is repeated approximately once per second. Thus, the output energy (in joules) is a combination of volts, amps and pulse duration and frequency. The higher the energy rating is, the higher the shock intensity will be. A switch or special regulator is used to obtain the varying outputs. This feature is used for special applications such as training. A medium output with a higher current will reduce the problems caused by grass and weed growth near the fence. Short fences use a low output.

High capacitance fences (long, many wires) require the use of a low impedance electric fence energizer. Properly chosen, a low impedance electric fence energizer will maintain an effective voltage on a high capacitance fence. Most 120-volt electric fence energizers are of the low impedance type and produce a medium to high voltage at a high current (high energy, high joule output). They produce the highest energy shock over the widest range of conditions. Battery-operated fencer energizers have a medium to high impedance that produce a lower voltage and current.

Bipolar electric fence energizers have positive and negative terminals connected to alternate fence wires and a ground terminal connected to the ground. A 2,500+ voltage is obtained between either the positive (+) or the negative (-) terminal and ground. A 5,000+ voltage is obtained between the positive (+) and negative (-) terminals. Bipolar electric fences are particularly suited to situations that have a high level of weed growth in contact with the fence. Animals will receive a shock if they contact the positive (+) and negative (-) wire, or if they contact a positive (+) or negative (-) wire and the ground. The advantage of bipolar fencing is a decreased potential for line losses to ground. A shock will be generated even when there are poor grounding conditions. Bipolar electric fence energizers can handle up to four times the length of

conventional electric fence due to reduced losses of electricity caused by grass and weeds.

The technology associated with electric fence energizers is constantly changing and improving. PAMI (Prairie Agricultural Machinery Institute) tests many of these products under standard conditions and reports on their findings. These reports are available from PAMI and AFMRC (Alberta Farm Machinery Research Centre). AFMRC is located at:

3000 College Drive South,
Lethbridge, Alberta, T1K 1L6,
Phone: 403-329-1212.

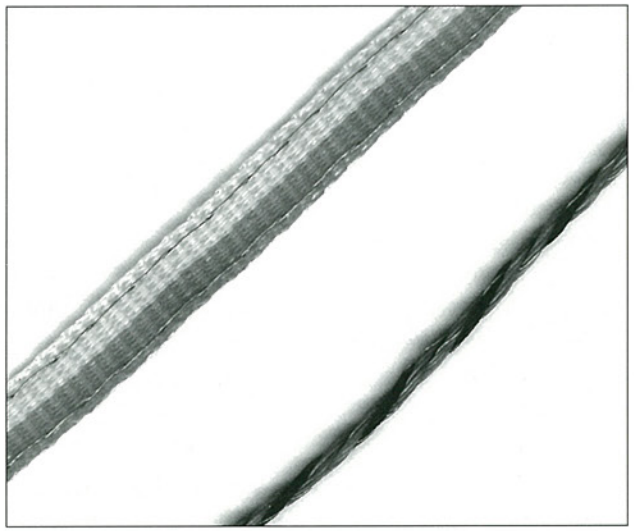
Contact PAMI at:
P.O. Box 1900,
Humboldt, Saskatchewan, S0K 2A0,
Phone: 306-682-2555, or 1-800-567-7264
or
P.O. Box 1060,
Portage la Prairie, Manitoba, R1N 3C5,
Phone: 204-239-5445.

Wire and Posts

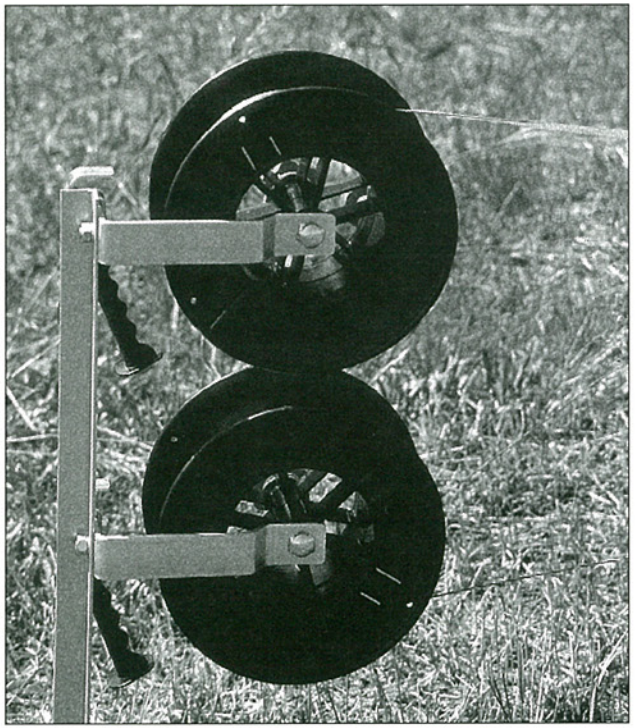
Wire acts as the conductor of the electrical fencing system and is available in a variety of products. The cross-sectional area of the material and the conductance determine the electrical resistance. High resistance wires are only suitable for short lengths of temporary fencing (200 - 400 metres).

High tensile smooth wire is strong, a good electrical conductor, easy to handle and has a long service life. It is an excellent product for permanent electric fences.

Electro-plastic products are ideal for short-term applications, such as temporary pastures. They consist of fine strands of intertwined stainless steel or aluminum wire and plastic webbing. Electro-plastic wire comes in a variety of colors and shapes for improved visibility. This type of wire has an electrical resistance that is 120 times greater than 12.5 gauge, high-tensile smooth wire. It is lightweight, elastic and only requires hand tightening. However, it weathers poorly and breaks are difficult to locate within the filaments.



Electro-plastic wire



Reel

Electro-plastic wire should only be used when temporary fencing is needed.

Mild steel galvanized wire can also be used for electric fencing. It is not recommended for permanent fencing due to its tendency to stretch. It should only be used for temporary fencing.

Barbed wire should never be used for electric fencing. Animals or people can get caught in the barbs and have difficulty escaping. This may lead to serious injury or death.

A variety of posts are available for electric fencing. Wooden posts are ideal for permanent fences. Wood has a natural resistance to electric currents that makes it the most popular fence post. Materials such as plastic or fiberglass are designed for temporary fencing and do not require insulators. Metal posts are only recommended for temporary fences. They must be used with insulators to avoid the danger of shorting.

End Braces

The end brace (or end structure) is the foundation of a fence. Forces of wire tension and animal pressure placed on the fence are transmitted to the ground by the end brace. The ultimate strength of the end brace depends on the soil conditions, post size and type of brace used. Brace failure can be avoided by using proper design, proper brace location and the correct wire tension.

Soil failures occur when the load applied to the soil is so large it causes the end brace to move. To eliminate this problem, use larger posts or large plates to increase the soil bearing area.

An end brace turns horizontal wire forces into vertical forces on the posts. A short end brace will pull out of the ground more easily due to these forces. Lengthening the end brace reduces the pull out forces to the point where the end brace does not fail. A good rule of thumb to remember when constructing end braces is the brace assembly must be at least two and one half times the fence height. End braces must be square with the fence to develop their strength. Distances between end braces can be up to 500 metres, depending on terrain.

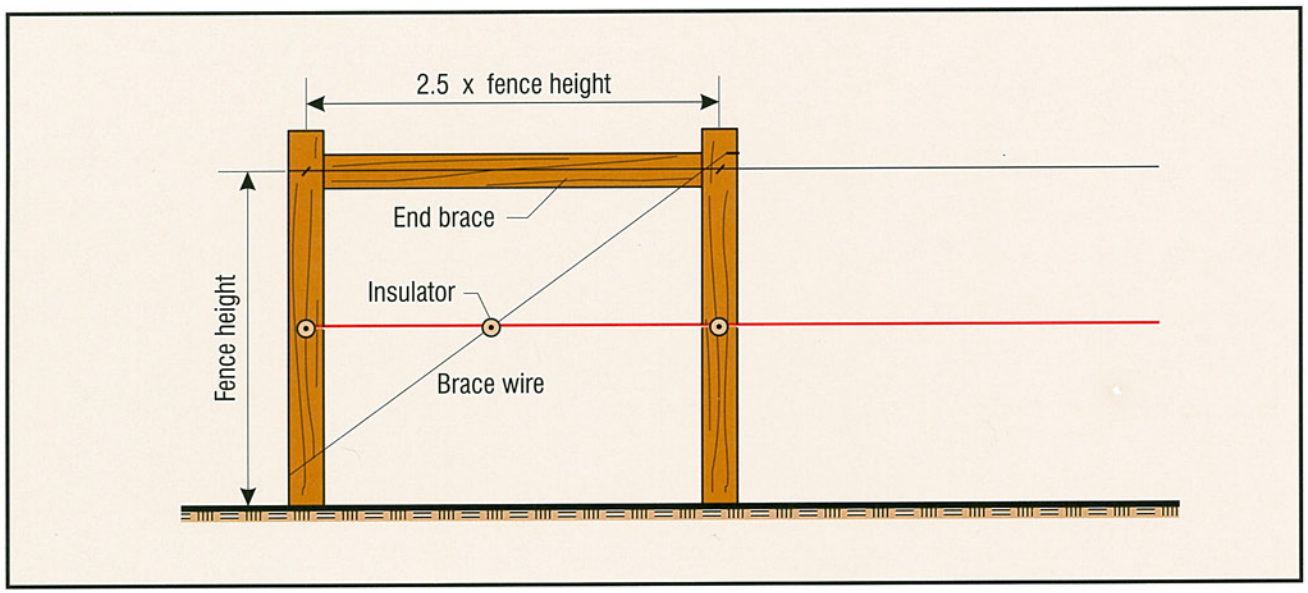


Figure 1. Calculating end brace length

Single Post End Brace

A single post, at least 150 mm in diameter, is the simplest type of end brace. The strength of the post depends on the diameter of the post and the depth it is embedded into the soil. The larger the post and the deeper it is set, the stronger it is. Generally, a single post is the weakest type of end brace.

Single Post End Brace with Deadman Anchor

A deadman anchor is placed into the ground at a 30 to 45° angle. The brace wire is secured to the anchor and wrapped around the fence post. This system absorbs the endload, thus replacing the need for an end brace.

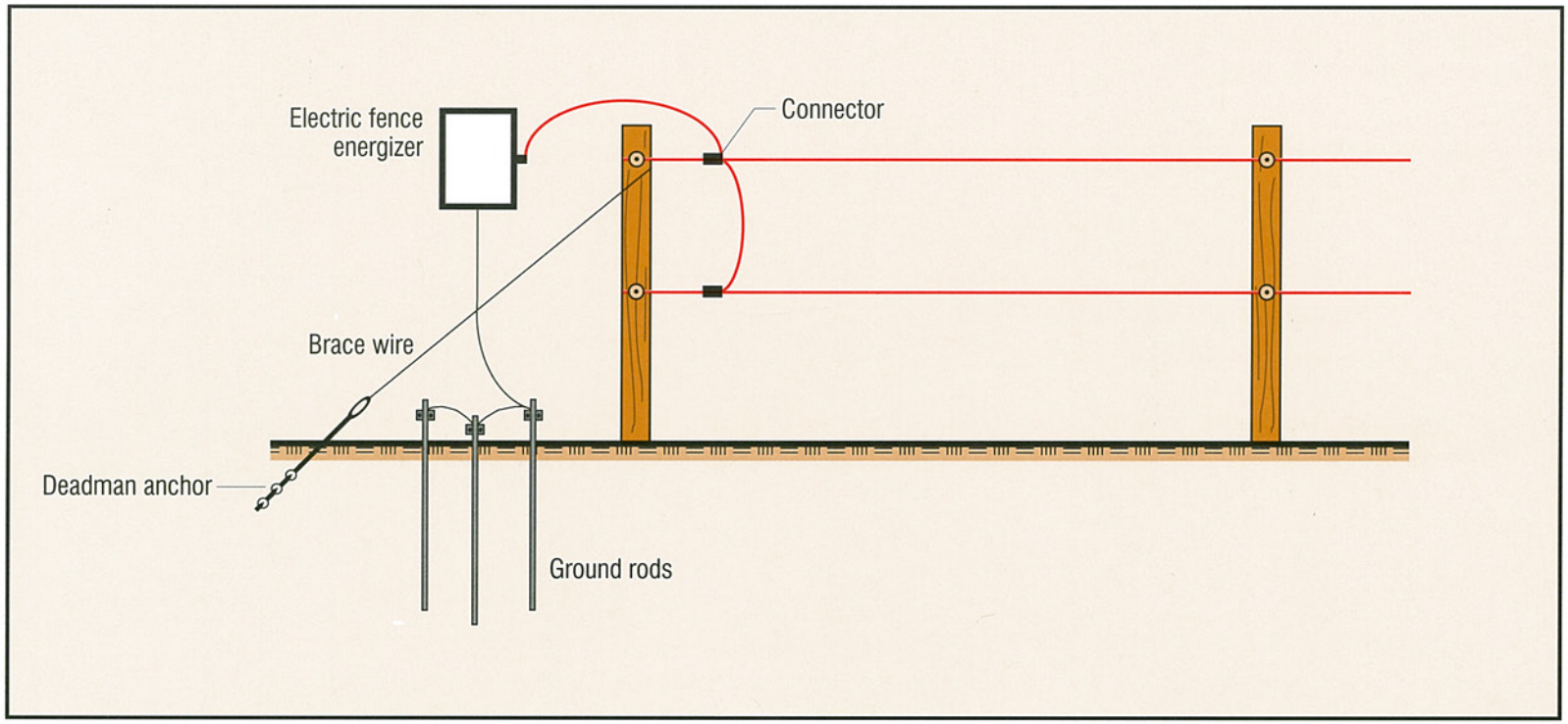


Figure 2. Post with deadman anchor

Diagonal End Brace

A diagonal end brace is constructed of two 150 mm posts spaced three metres apart. A square, pressure-treated, 150 x 150 mm timber is run diagonally from the bottom of one post to the top of the other post. A brace wire is run on the opposite diagonal and tensioned.

There is one important point to remember with all end braces: the brace wire often contacts the live and ground wires, thus shorting them out. Any contact between the brace wire and the live or ground wires must be eliminated, or an insulated section of brace wire must be used to prevent wire contact.

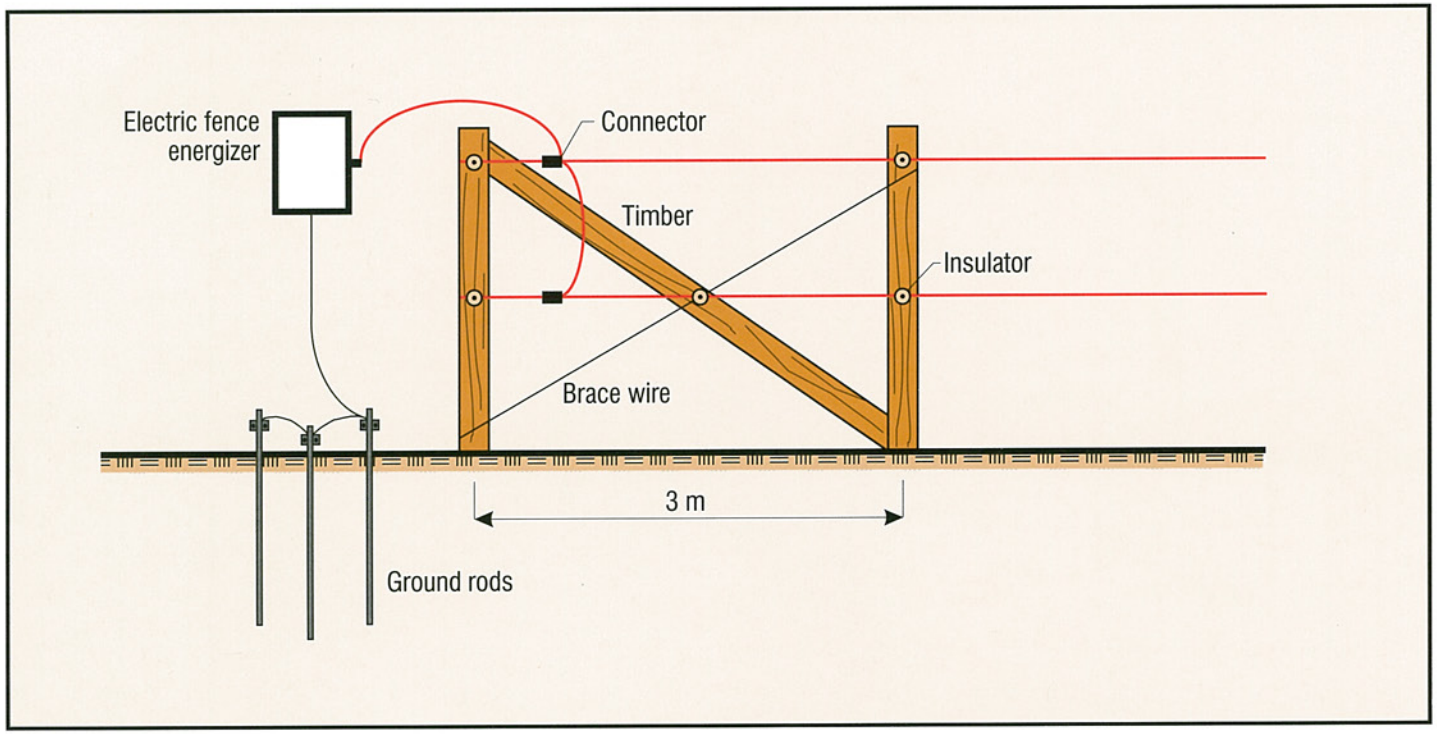


Figure 3. Diagonal end brace

Horizontal End Brace

A horizontal end brace is constructed of two 150 mm pressure treated posts set 3 metres apart. A 150 x 150 mm square pressure treated timber brace is placed horizontally between the top of the posts. A tensioned brace wire is used to preload the brace.

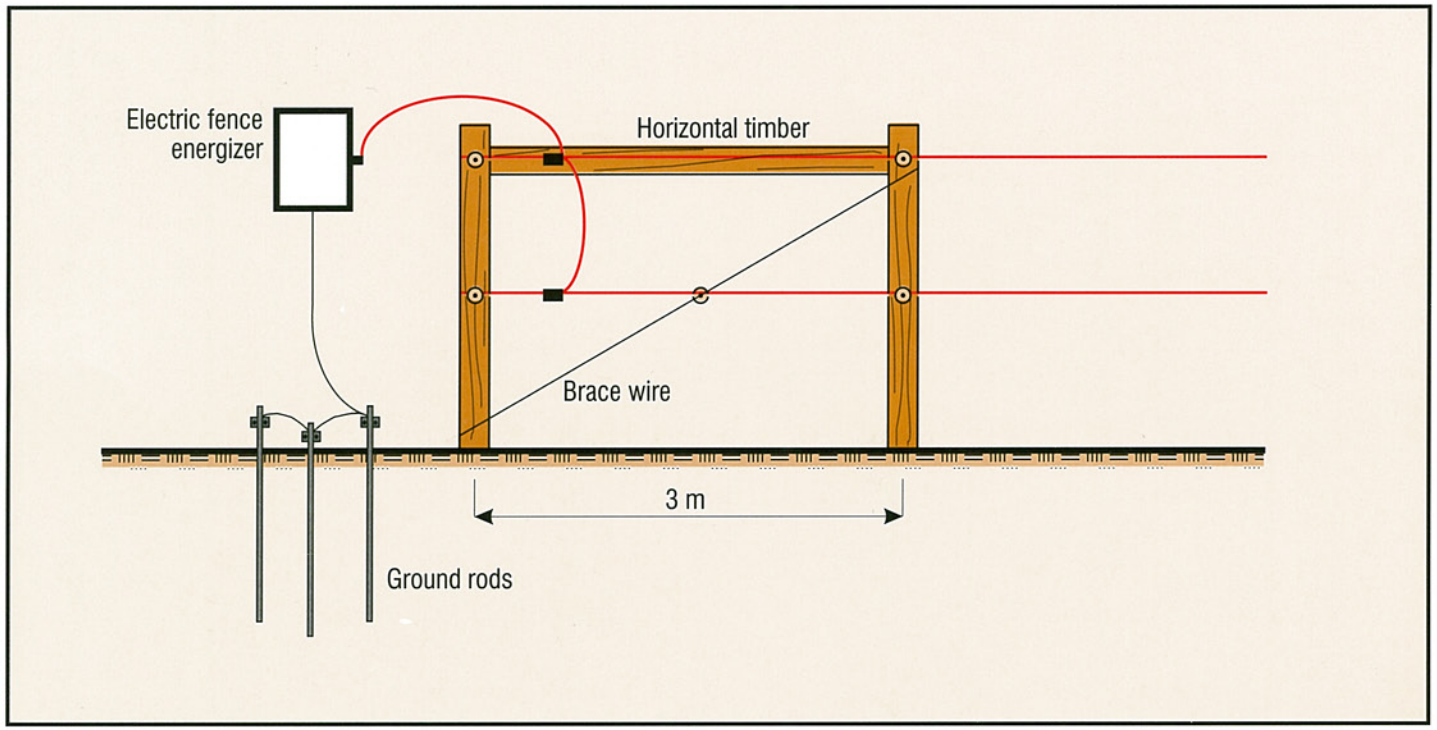


Figure 4. Horizontal end brace

Fencing on Uneven Ground

When fencing on uneven ground, an end brace is required on each change in the ground slope. Posts are placed perpendicular to the ground. Note the wire configuration shown in the diagram below. The wires run through the end brace and must be connected by insulated jumper wires. By connecting all the live wires and grounded wires, jumper wires even out the electrical flow, ensuring a continuous electrical circuit.

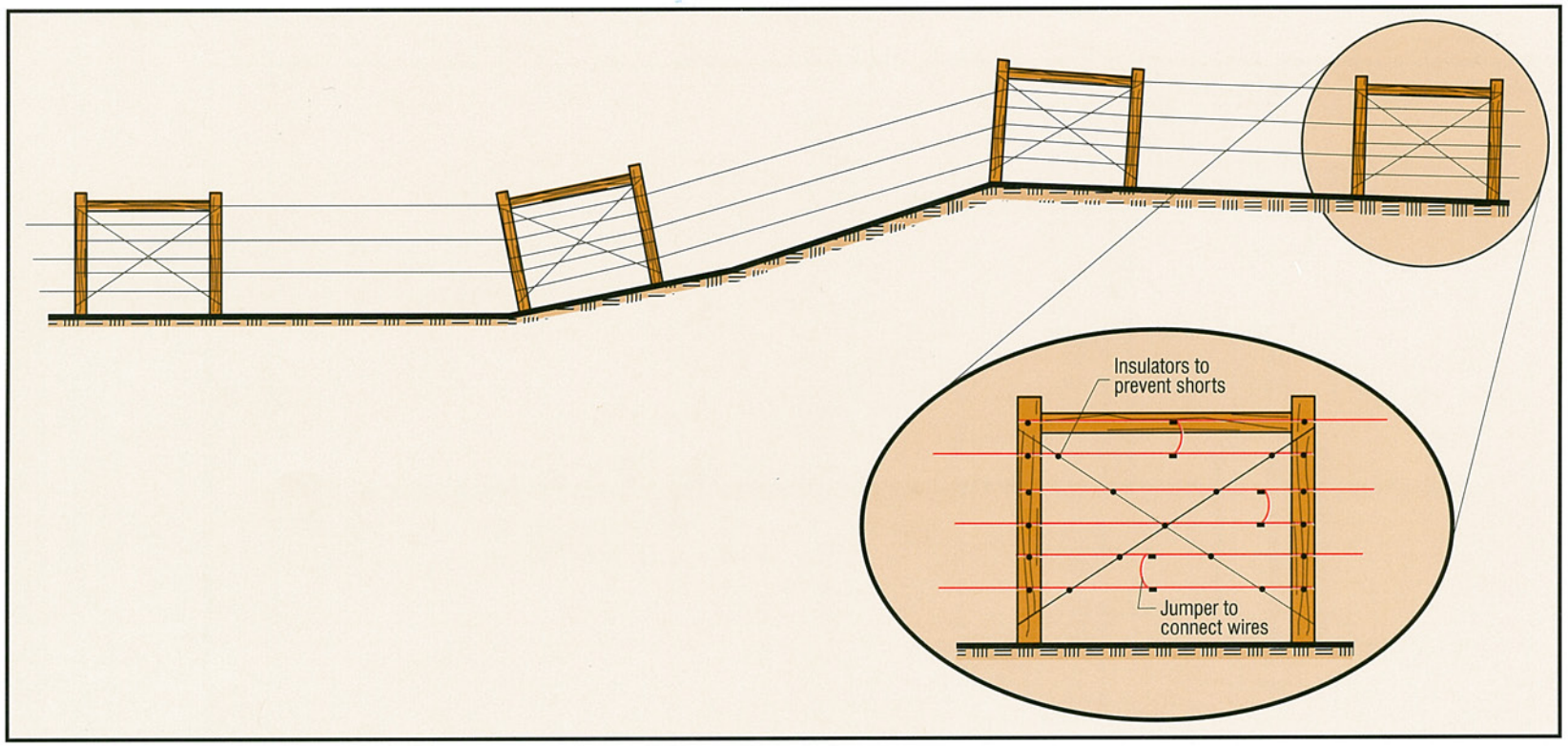


Figure 5. Fencing on uneven ground

Angle End Brace

An angle end brace is constructed of one 150 mm pressure-treated post and a 150 x 150 mm square pressured-treated timber. The timber runs from the top of the post to the ground, where it is supported on a piece of pressure-treated planking. Run a horizontal brace wire from the bottom of the post to the angled member to provide structural strength.

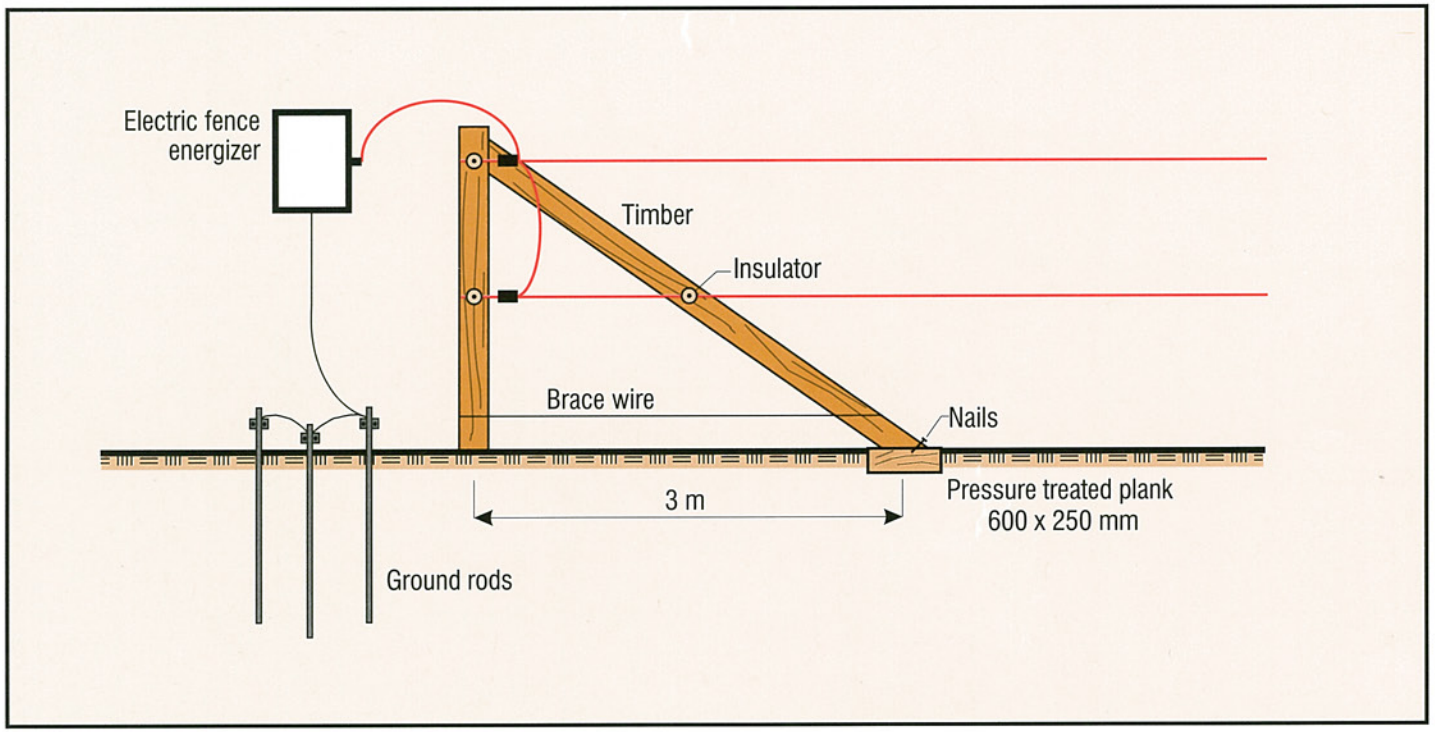


Figure 6. Angle end brace

Insulators

Insulators prevent electrical leakage by resisting the flow of electricity. In electrical fencing systems, insulators prevent live wires from grounding out. Most modern high-energy electric fence energizers can energize short, uninsulated fences; however, insulators are required to get the full benefit of your electric fence energizer. Insulators are available in a variety of materials.

Porcelain has been used as an insulator for years. It is an effective insulator but tends to develop cracks that fill with dirt and moisture, thus reducing its insulating qualities. Porcelain insulators, if you can find them, are expensive.

Plastic insulators come in a variety of designs and plastic formulations. Better quality plastic insulators provide a wide gap between the post and the wire. High-density, ultraviolet-resistant plastics are a good choice. (Ultraviolet rays in sunlight tend to make plastic brittle as it ages.) Choose a plastic insulator that will not break or shatter in cold weather.

High strain, wrap around tube insulators, with metal inserts, are another durable insulator. However, they have been found to collect dirt and insects, resulting in electrical leaks.

Other materials, such as fibreglass, may also be used to manufacture insulators.

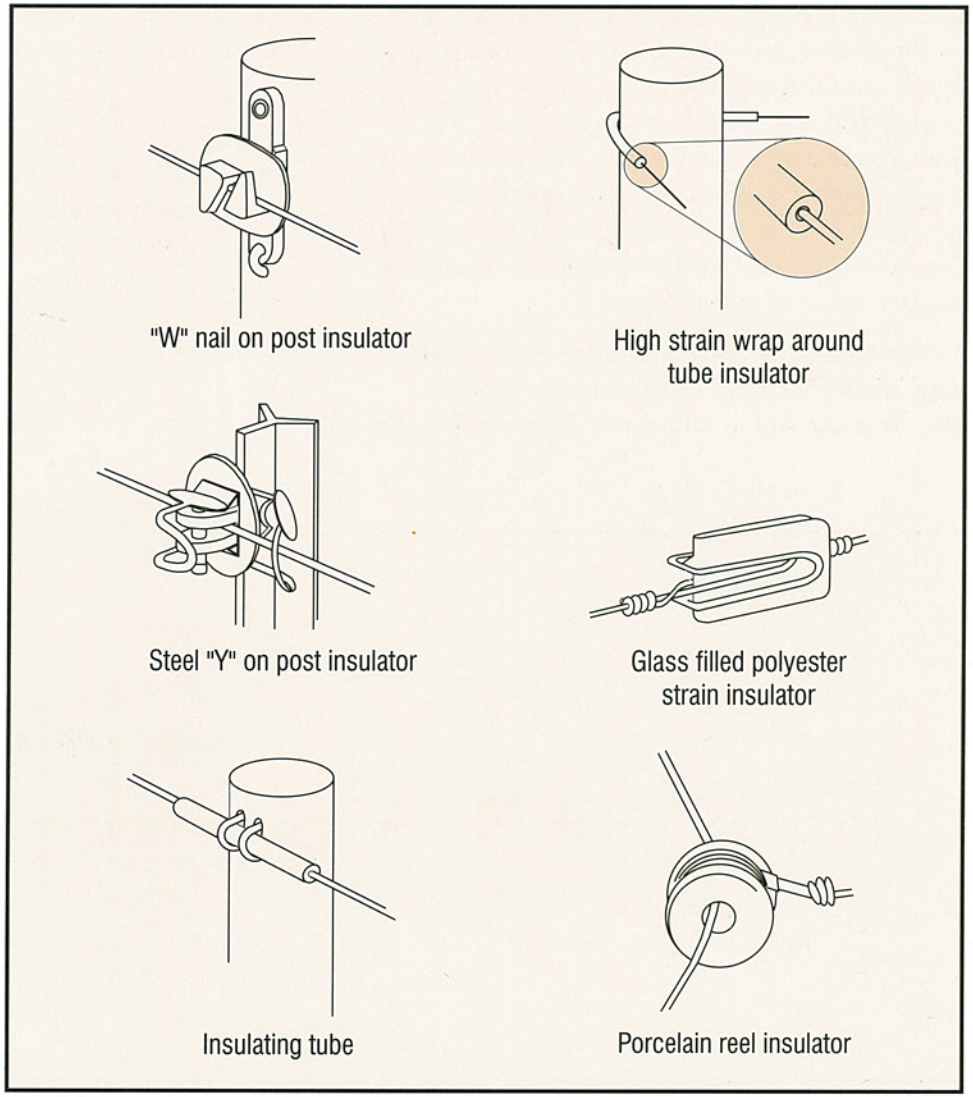


Figure 7. Types of insulators

Grounding

Grounding is the most important, and often the most neglected, part of the fence. The electrical capacity of the ground must exceed the total of all the electrical leaks and shorts in the fence. The ideal ground consists of three or four ground rods, two to three metres long, spaced 3 metres apart, and driven into an area of permanently moist soil. Connect the ground rods with ground rod clamps and galvanized wire (See Figure 8).

In drier areas, additional ground rods are required. Long, multi-wire fences need additional ground rods placed at 400 to 800 metre intervals along the fence and connected to the ground return wires. This ensures that a reliable shock is produced.

Galvanized ground rods are generally used because bare steel rods will corrode and lose their ability to ground. The fence ground must be separate from all other electrical equipment grounds and never be connected to well casings or water pipes. This is to ensure electrical safety.

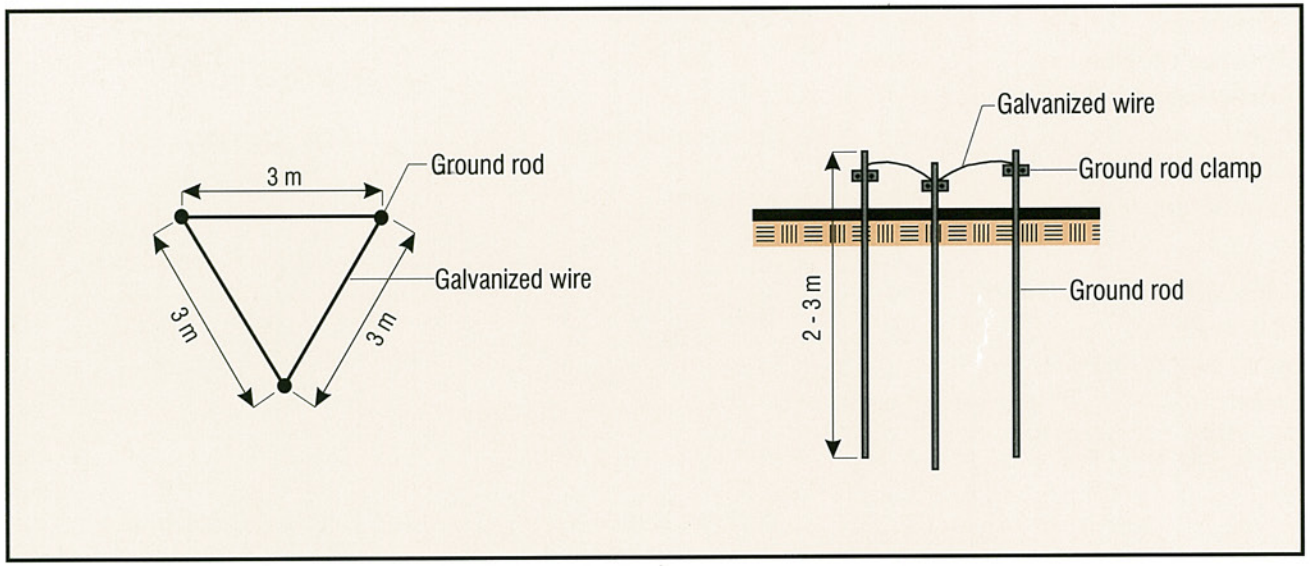


Figure 8. Basic ground rod configuration

Testing the Ground

Before testing the ground, check all connections to make sure that they are tight, clean and corrosion free. One method for checking the ground is with a peak reading digital voltmeter or a special electric fence voltmeter is as follows:

❶ Measure the voltage between the ground terminal of the electric fence energizer and a metal probe, such as a screwdriver (minimum 0.3 metres in length), that is placed at least 1.5 metres from any existing ground rod. The voltage should read less than 400 - 500 volts. If the voltage is greater, more ground rods are needed.

❷ Measure the ground performance under adverse conditions. Turn the electric fence energizer off. At a point approximately 100 metres down the length of the fence, place a series of metal posts against it. Turn the electric fence energizer back on. This will short out the fence. Repeat the measurement taken in Step 1. The voltage should read 400 -500 volts or less, if not, more ground rods are required.

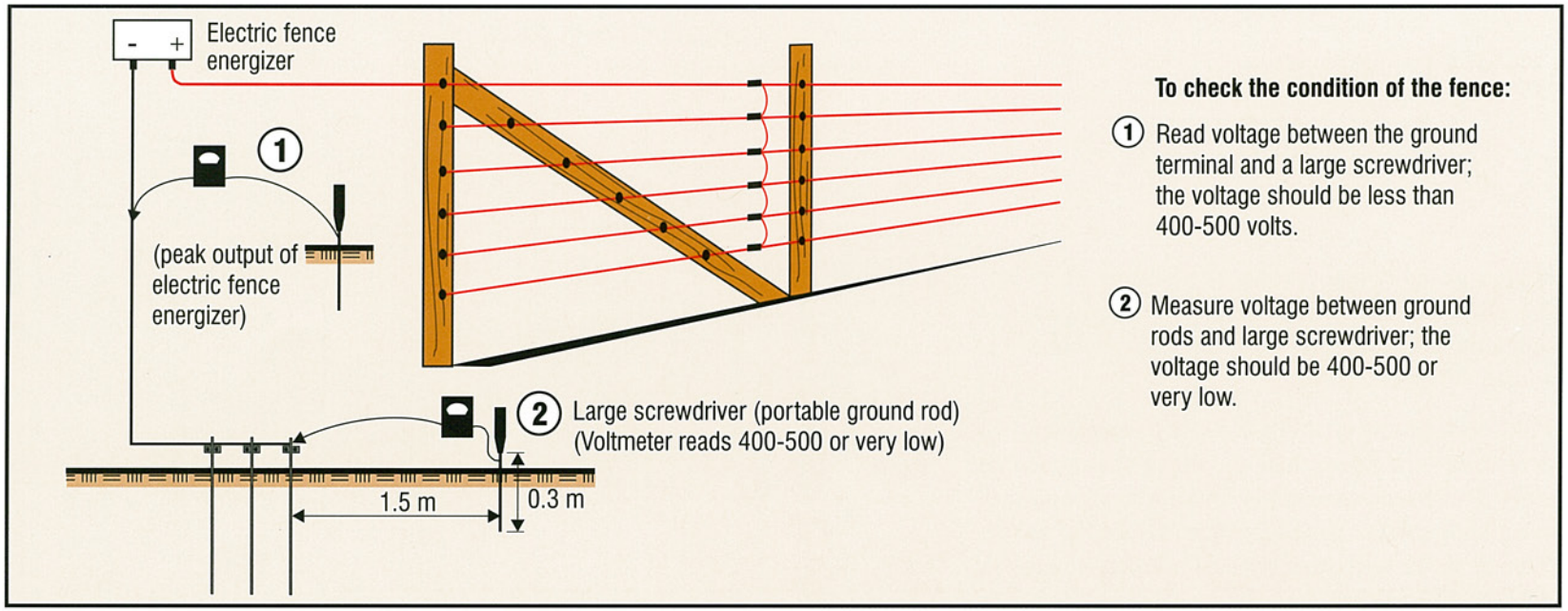


Figure 9. Testing the ground

Type of Animal Controlled

The type of animal to be controlled has a direct effect on the design of the fence and the choice of electric fence energizer. The number of wires and their spacing is determined according to animal size and physiology. The voltage required for the fence depends on the insulating qualities of the animal's coat. This voltage is known as "guard voltage".

To be effective, an electric fence must maintain a minimum guard voltage along its entire length. The minimum voltage required varies according to the type of animal:

- **short-haired (e.g., pig) – 700+ volts**
- **longer-haired (e.g., cow) – 2000+ volts**
- **long-haired (e.g., sheep) – 3000+ volts**
- **elk and deer – 3500+ volts**
- **predators – 5000+ volts**

Higher guard voltages are needed when the soil is dry or frozen. Voltage is not a measure of the shock the animal feels, it only ensures that the animal will feel a shock.

The shock intensity of the electric fence system determines the strength of the shock that an animal feels. This shock strength is difficult to measure, but a high current usually indicates a strong shock. A small shock will cause a small burning or tingling sensation at the contact point. A large shock will cause involuntary muscle reactions. An even larger shock will kill!

From an electrical safety point of view, a very short duration shock is the most desirable. It will cause pain, but will not interfere with the respiratory or circulatory systems or cause electrical burns. The interval time between shocks allows the animal to pull itself away from the fence. A typical electric fence energizer has a shock length of 3/1000 of a second and will repeat this shock 45 to 80 times per minute. If the shock intervals are more than two seconds apart, animals will get through the fence during that time.

Training Animals

The easiest way to train animals is to enclose them in a small electrified corral and let them come into contact with a charged electric fence. Most animals are curious and when confined to a small area they are more likely to touch the wire, get a shock, and learn to avoid wire contact. Domestic animals generally require two or three days for training. For wildlife and predators, use an odor or taste attractant to encourage contact with the charged wire.

Planning the Electric Fence

What are the boundaries of the field that is being fenced?

Legal boundaries (property lines) can be marked by a surveyor. Natural boundaries, such as lakes, streams, and roadways also determine the location of the fence.

What hazards will be encountered?

Contact the local utility companies to locate underground cables, pipelines, etc. Alberta First Call at 1-800-242-3447 provides assistance in the location of underground utilities.

Does the fenceline need to be cleared of brush and debris?

Prepare the fenceline by removing trees, shrubs, and other vegetation. Smooth the ground surface and fill all hollows that animals can crawl under and trim all high spots that might ground the bottom wire. Controlling vegetation along the fenceline reduces the electrical drain, making the fence more effective.

What type of animal is to be confined (or kept out)?

This will determine the number and spacing of wires and the configuration of energized and grounded wires.

What is the basic fence layout?

Fence in a "circle" whenever possible. This simply means that the energized wire is looped back to the electric fence energizer and connected to the energized terminal. If the wire breaks or there is a bad connection, the two portions will still be energized from opposite ends of the line. Also, higher guard voltages can be maintained on a given length of wire as compared to connecting only one end to the electric fence energizer. Plan the layout so the system can be turned off when not in use. This will also make it easier to isolate trouble spots when problems occur.

How many kilometres of electrified wires are there?

Add up the total length of all electrified fence wires. This number will determine how large an electric fence energizer is required to energize the fence. Most suppliers can provide this information.

What conditions will the electric fence be working under?

A single-wire electric fence relies on the animal touching the fence and the soil to receive a shock. If the soil is dry or frozen, the electrical circuit will not be completed and no shock, or only a small shock, is received. Under poor grounding conditions, a ground wire or multiple live and ground wires are required.

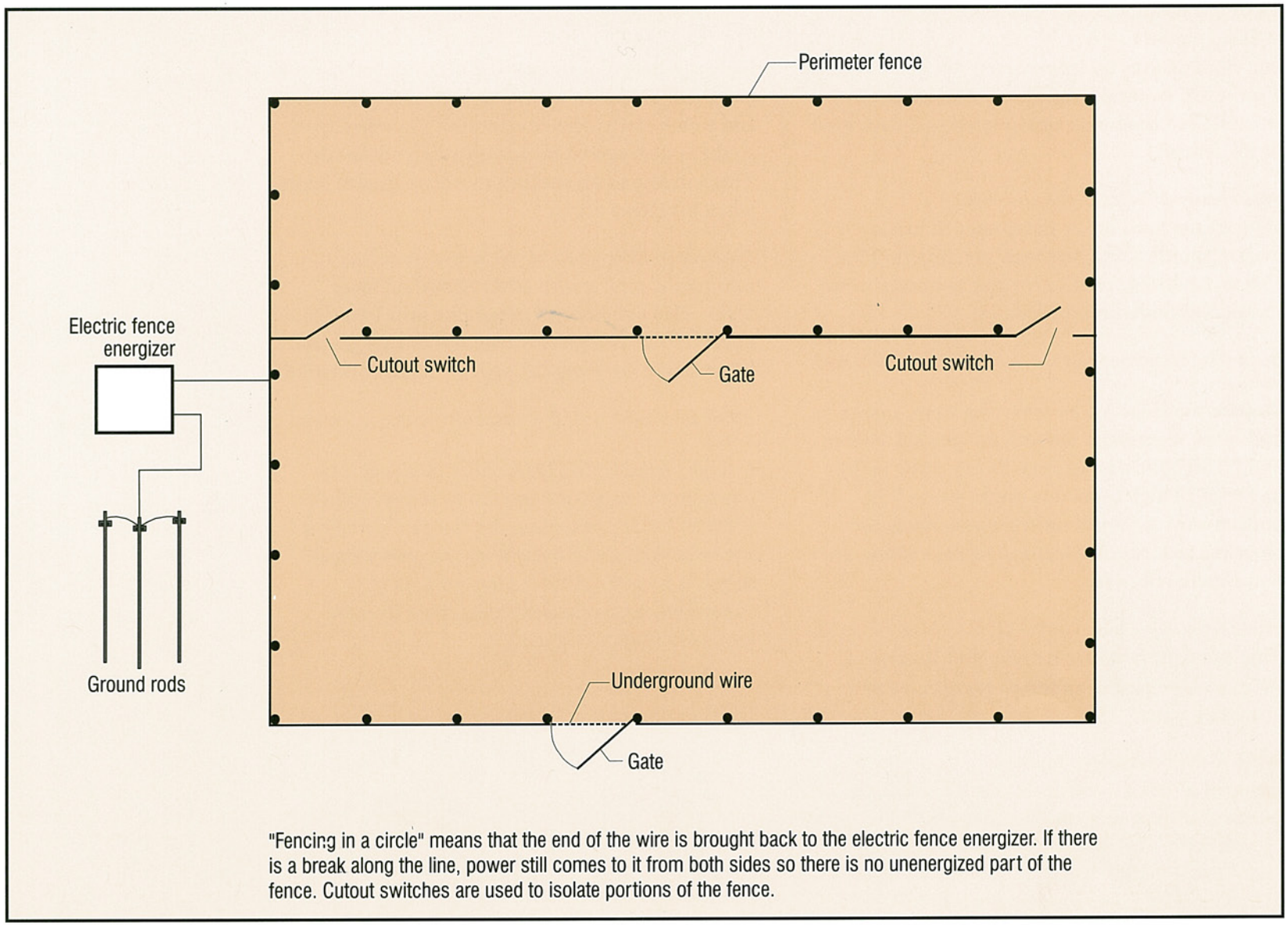


Figure 10. Fencing in a circle

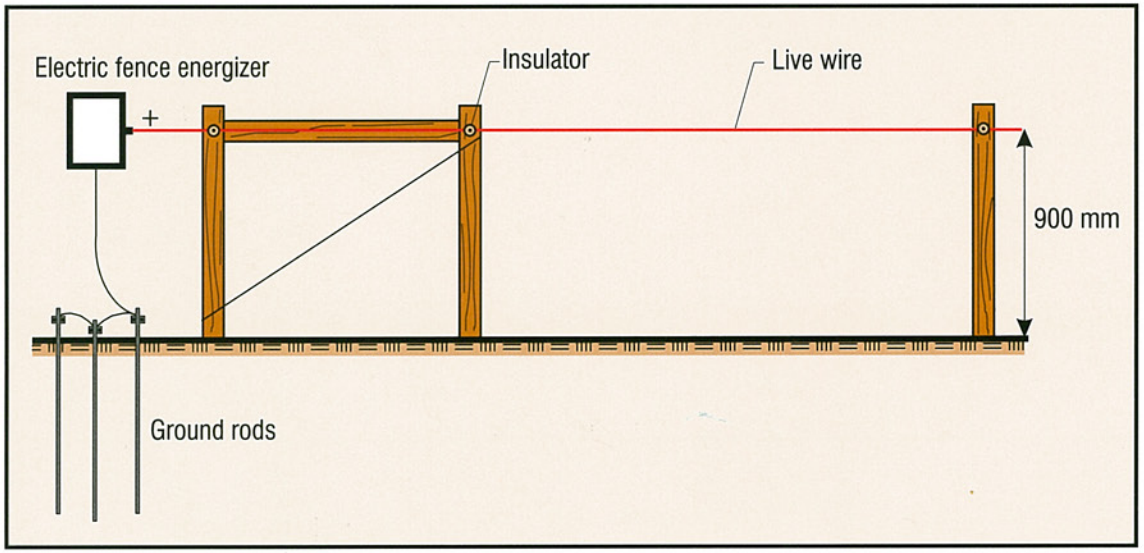
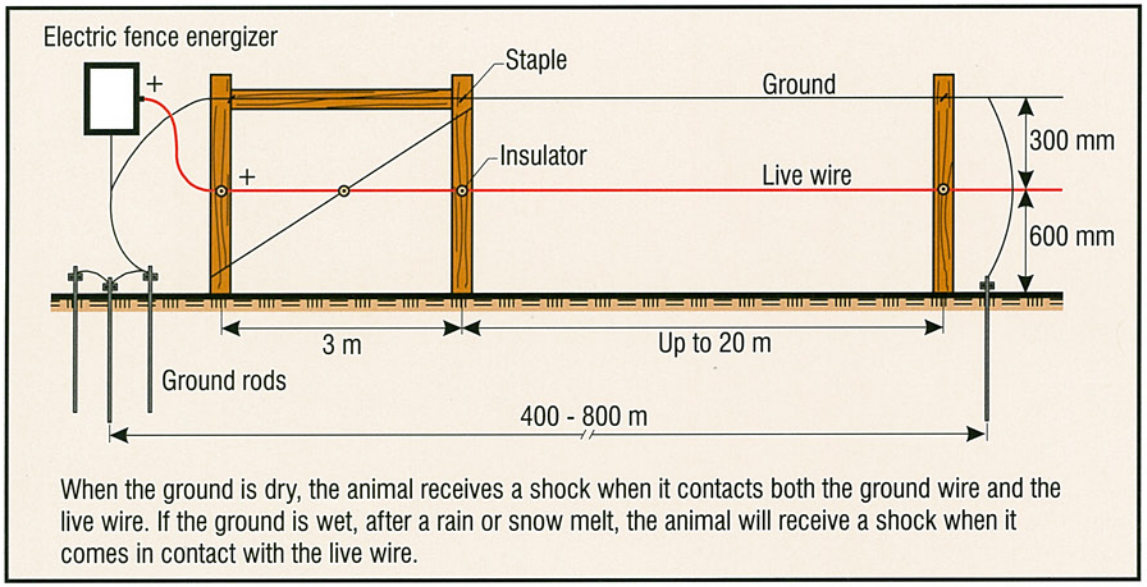


Figure 11. Normal ground grounding (wet soil)



When the ground is dry, the animal receives a shock when it contacts both the ground wire and the live wire. If the ground is wet, after a rain or snow melt, the animal will receive a shock when it comes in contact with the live wire.

Figure 12. Dry soil grounding

Types of Electrical Fences

Single-wire Fence

The single-wire electric fence, shown below, consists of a single live wire placed 900 mm above the soil. This type of fence requires wet soil conditions to produce a shock when an animal touches the live wire. It can also be used as a permanent pasture dividing fence. This type of fence does not work well if the soil is dry or frozen.

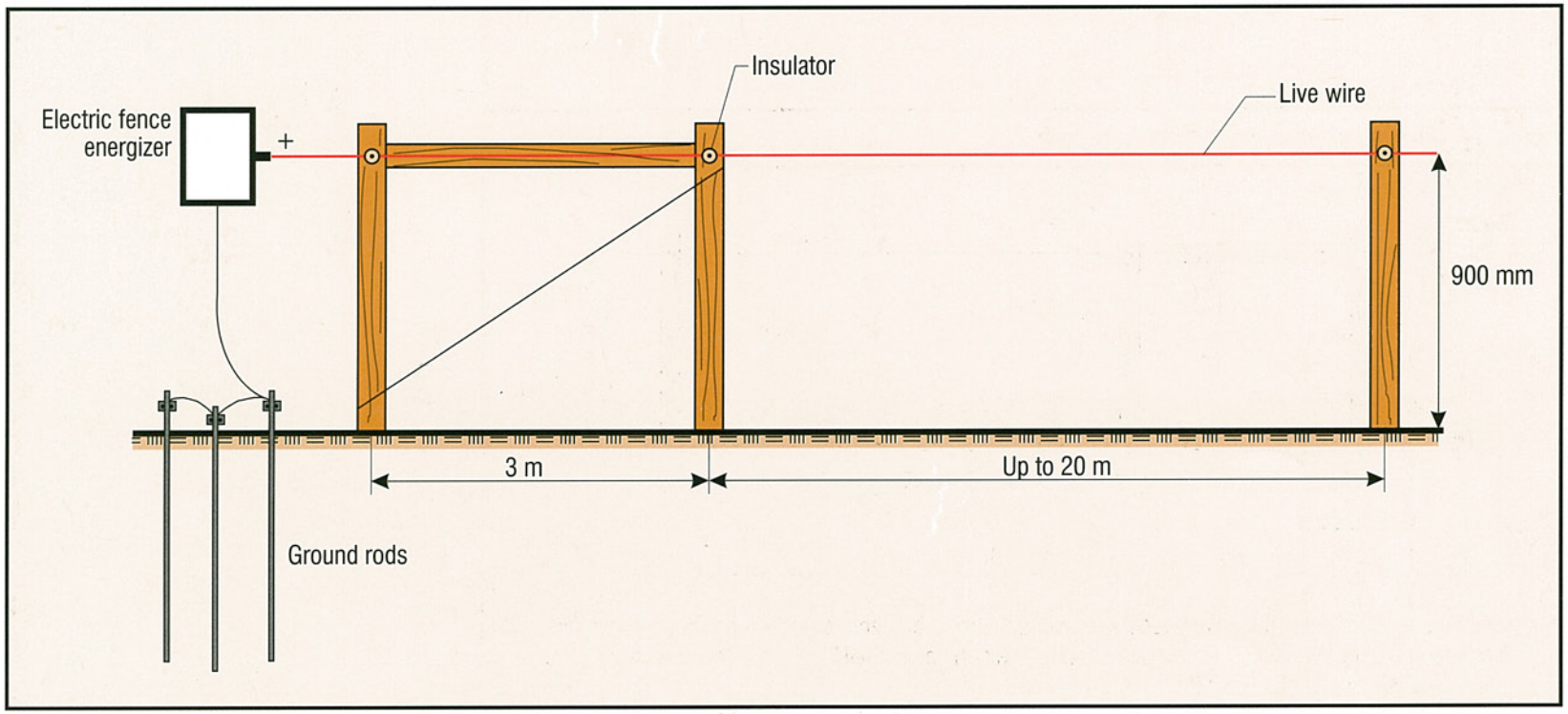


Figure 13. Single-wire fence with ground return

Two-wire Fence

The two-wire, bipolar fence uses a bipolar electric fence energizer with both a positive and a negative terminal that produce a negative live wire and a positive live wire. An animal receives a shock when it contacts either the positive (+) live wire or negative (-) live wire and the soil. The animal will also receive a shock if it simultaneously contacts the positive (+) live wire and the negative (-) live wire.

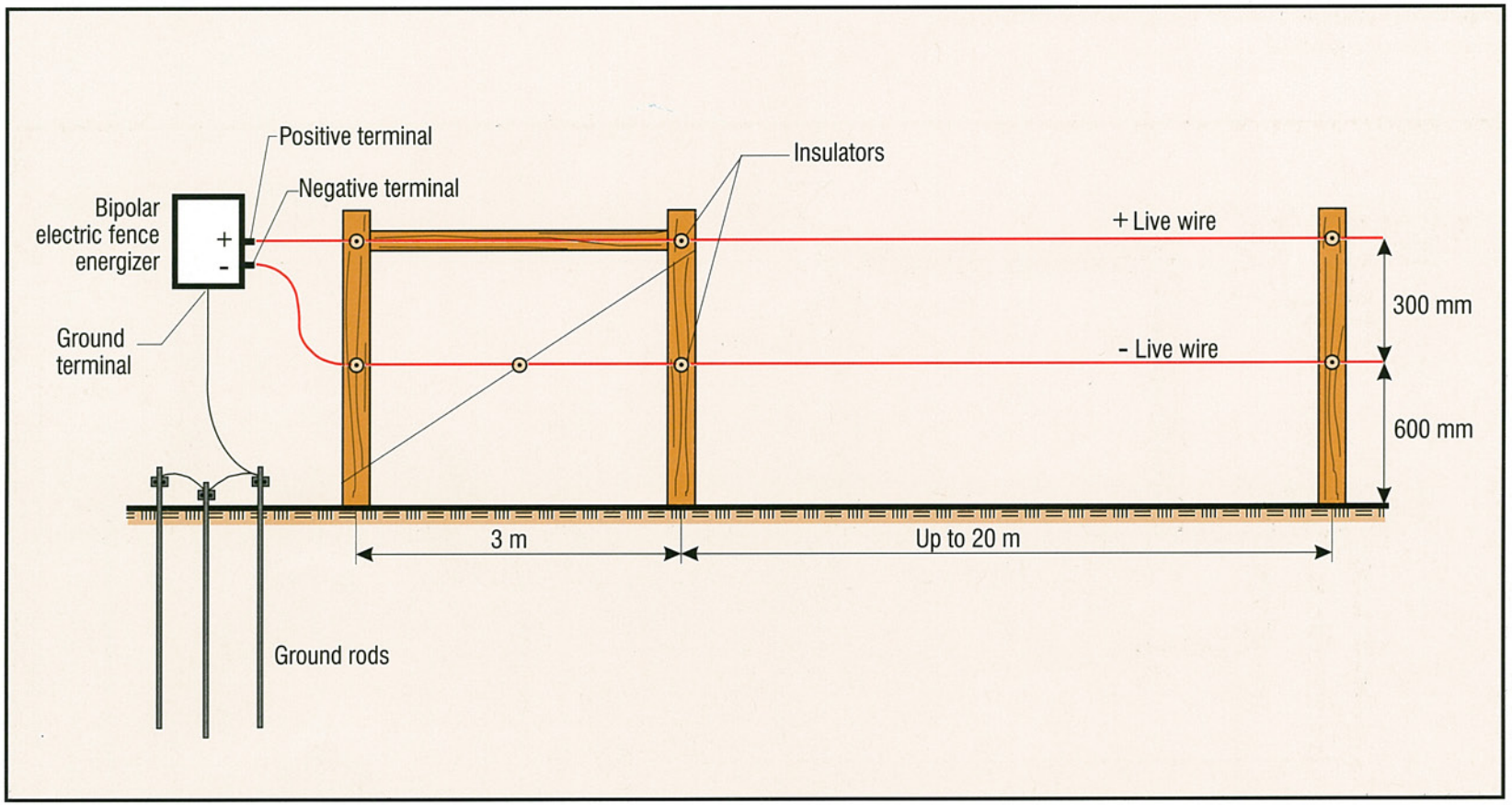


Figure 14. Two-wire fence, bipolar

Figure 15, illustrates another kind of two-wire fence. It has a positive (+) live wire and a ground wire. An animal receives a shock when it touches the positive (+) live wire and the ground wire, or comes into contact with the positive (+) live wire and the soil. In areas where the soil is often dry, attach extra ground rods to the ground wire to create a better ground.

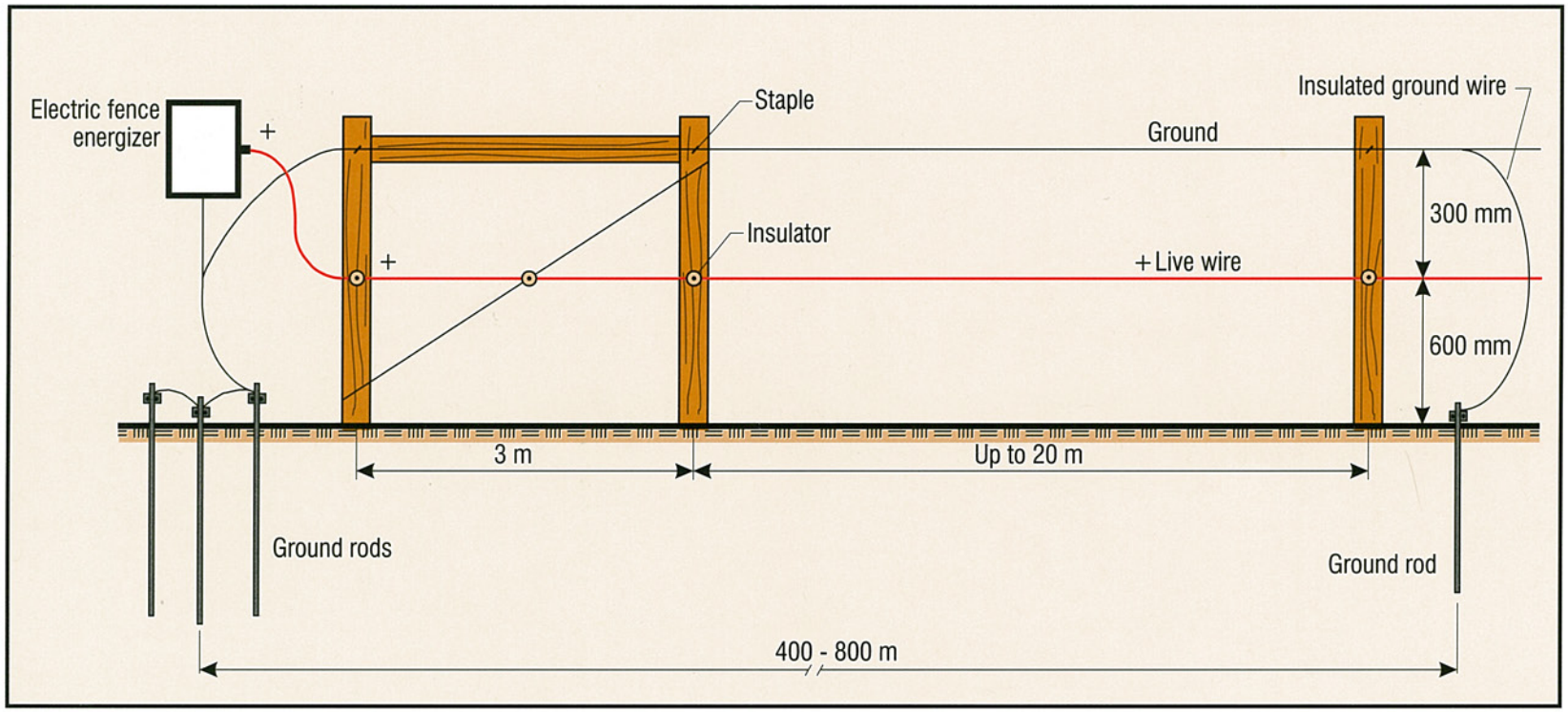


Figure 15. Two-wire fence: one live wire, one ground wire

Three-wire Fence

The three-wire electric fence is primarily used to contain dairy and beef cattle. It has a ground wire located between two positive (+) live wires. Animals will receive a shock when they come into contact with all three wires, or by contacting any of the positive (+) live wires and the soil. Place extra ground rods at 400 to 800 metre intervals along the fence to provide a better ground where the soil is dry. Insulated jumper wires are used to connect both positive (+) live wires and are placed at intervals along the fence to ensure a continuous circuit should a wire break.

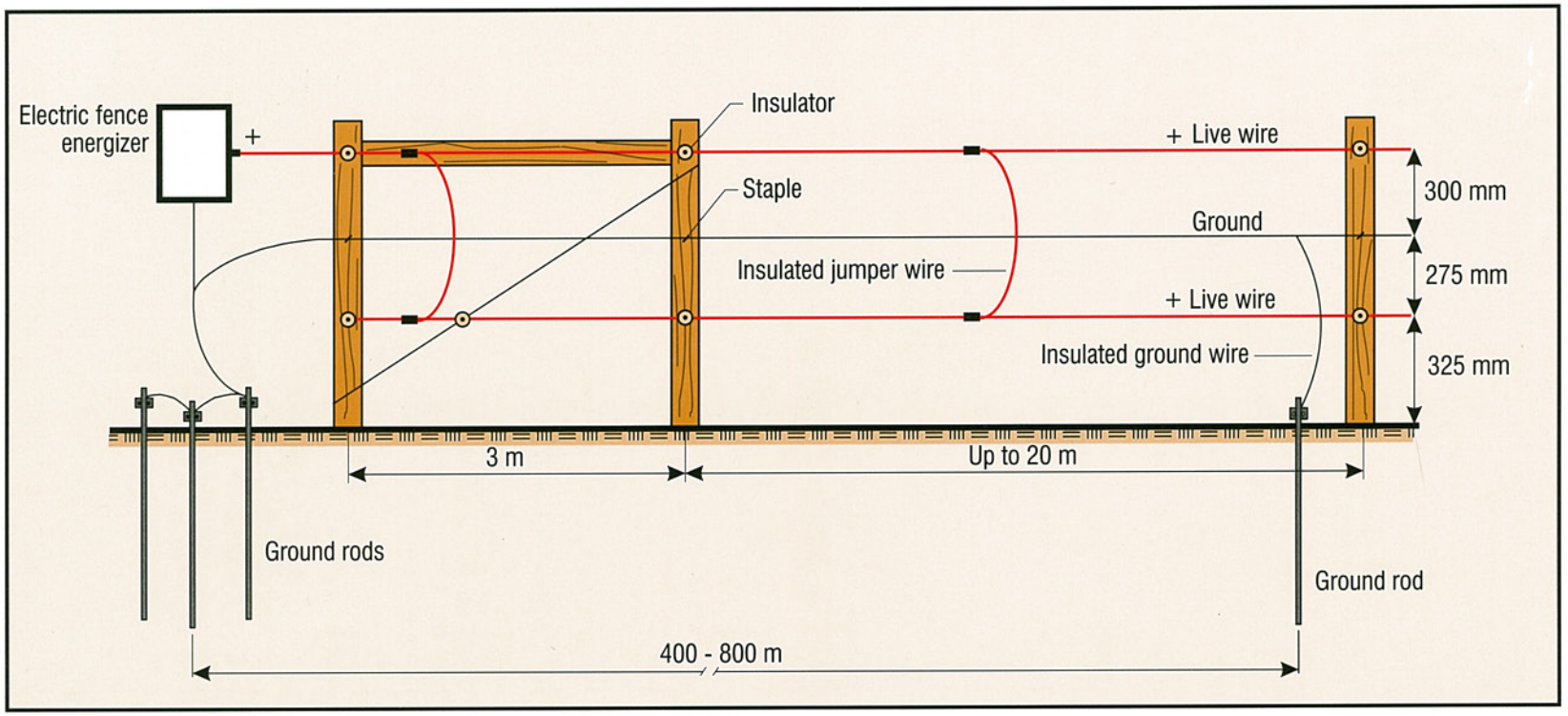


Figure 16. Three-wire fence – dairy and beef cattle

The three-wire electric fence for hogs is the same as the fence for dairy and beef cattle except for the wire spacing. The first positive (+) live wire is placed 150 mm above the soil to prevent hogs from escaping under the fence.

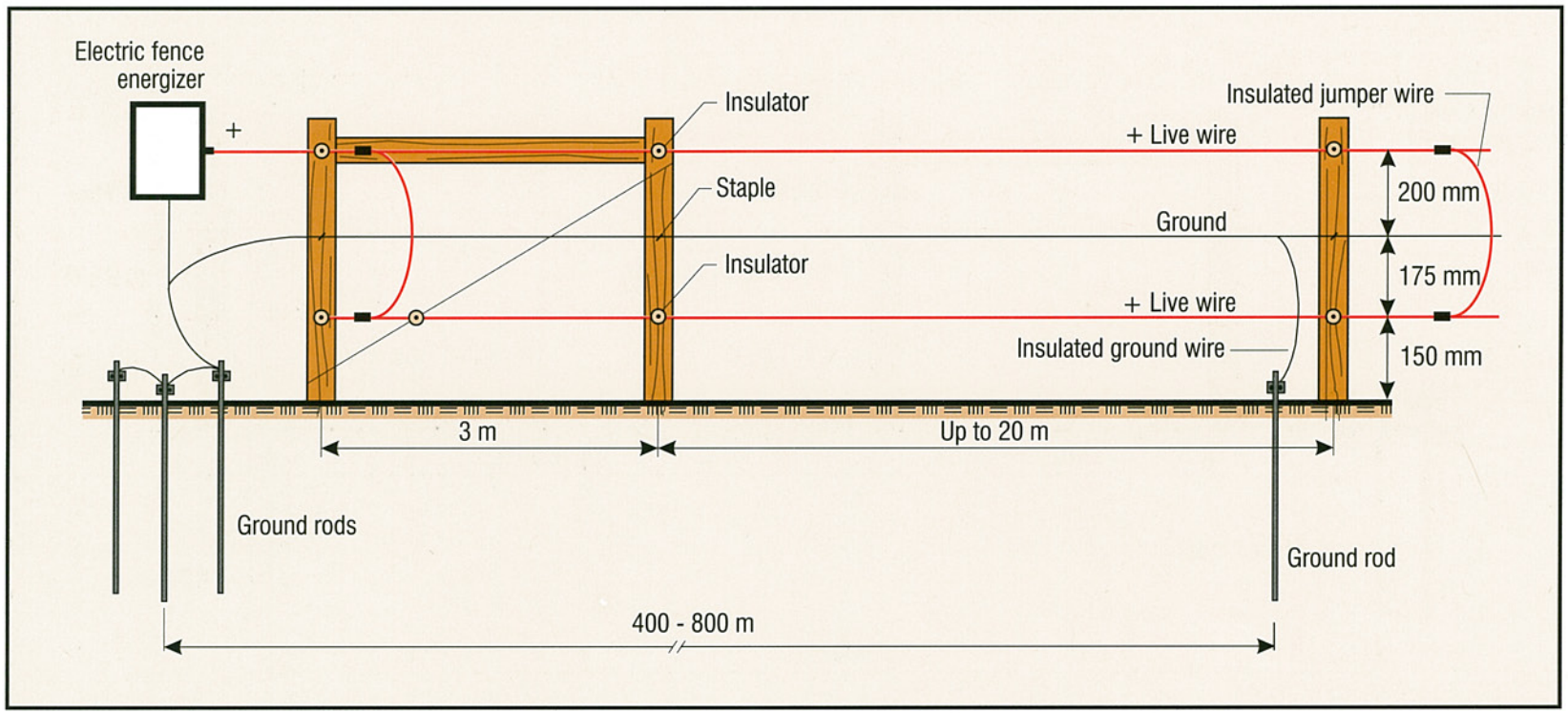


Figure 17. Three-wire fence – hog

Four-wire Fence

Cattle and horses are usually contained with four-wire electric fences. These fences consist of two positive (+) live wires and two ground wires. Extra ground rods are positioned along the fence at 400 to 800 metre intervals. Insulated jumper wires are used to connect the positive (+) live wires and the ground wires to each other. The animal will receive a shock by touching the positive (+) live wire and the ground wire, or the positive (+) live wire and the soil.

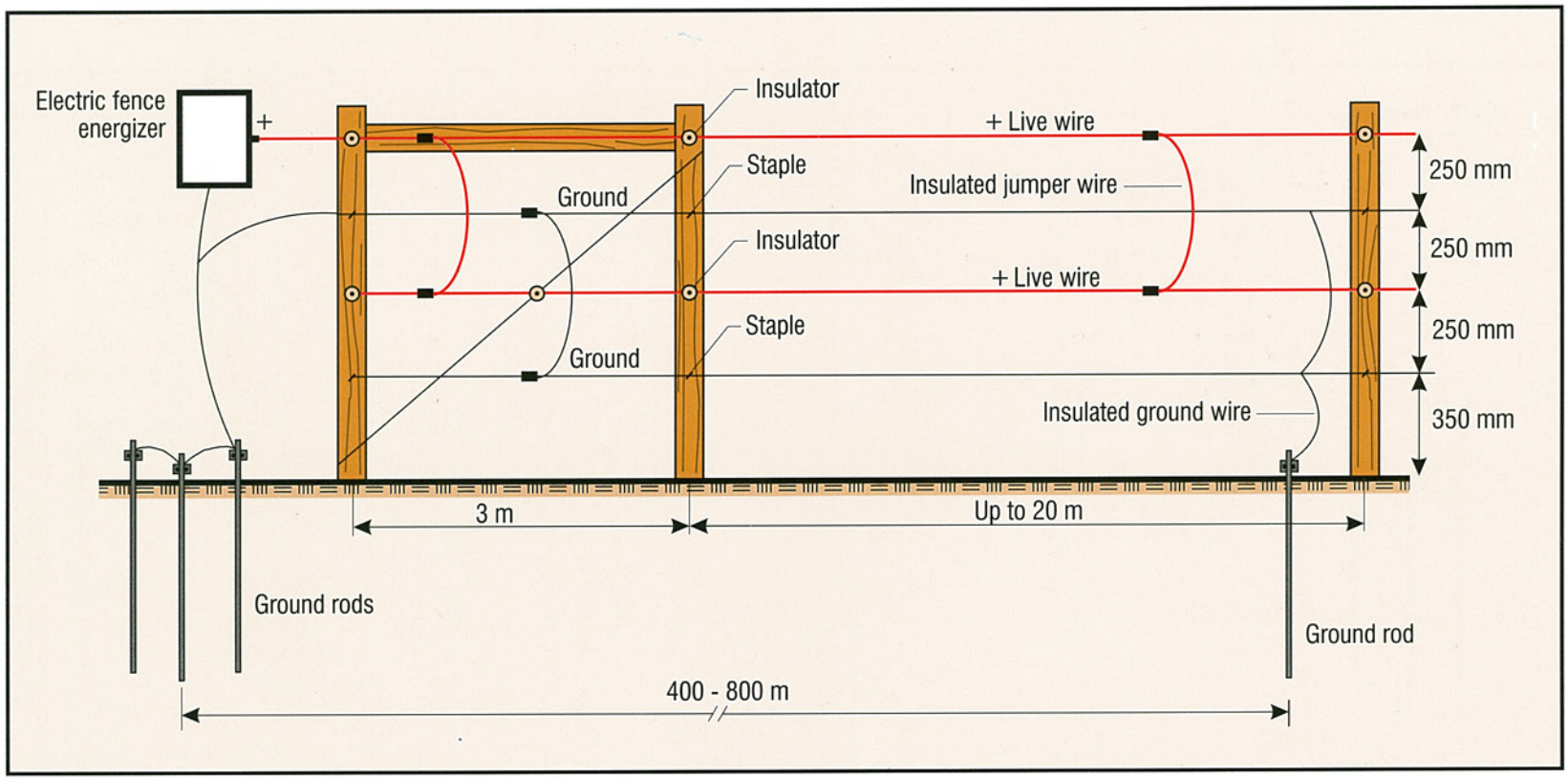


Figure 18. Four-wire fence – cattle/horse

Five-wire Fence

Five-wire electrical fences are the most effective fences for containing sheep and goats. They consist of three positive (+) live wires and two ground wires. Insulated jumper wires connect the three positive (+) live wires and the two ground wires. An animal receives a shock when it contacts a positive (+) live wire and a ground wire, or when it contacts a positive (+) live wire and the soil.

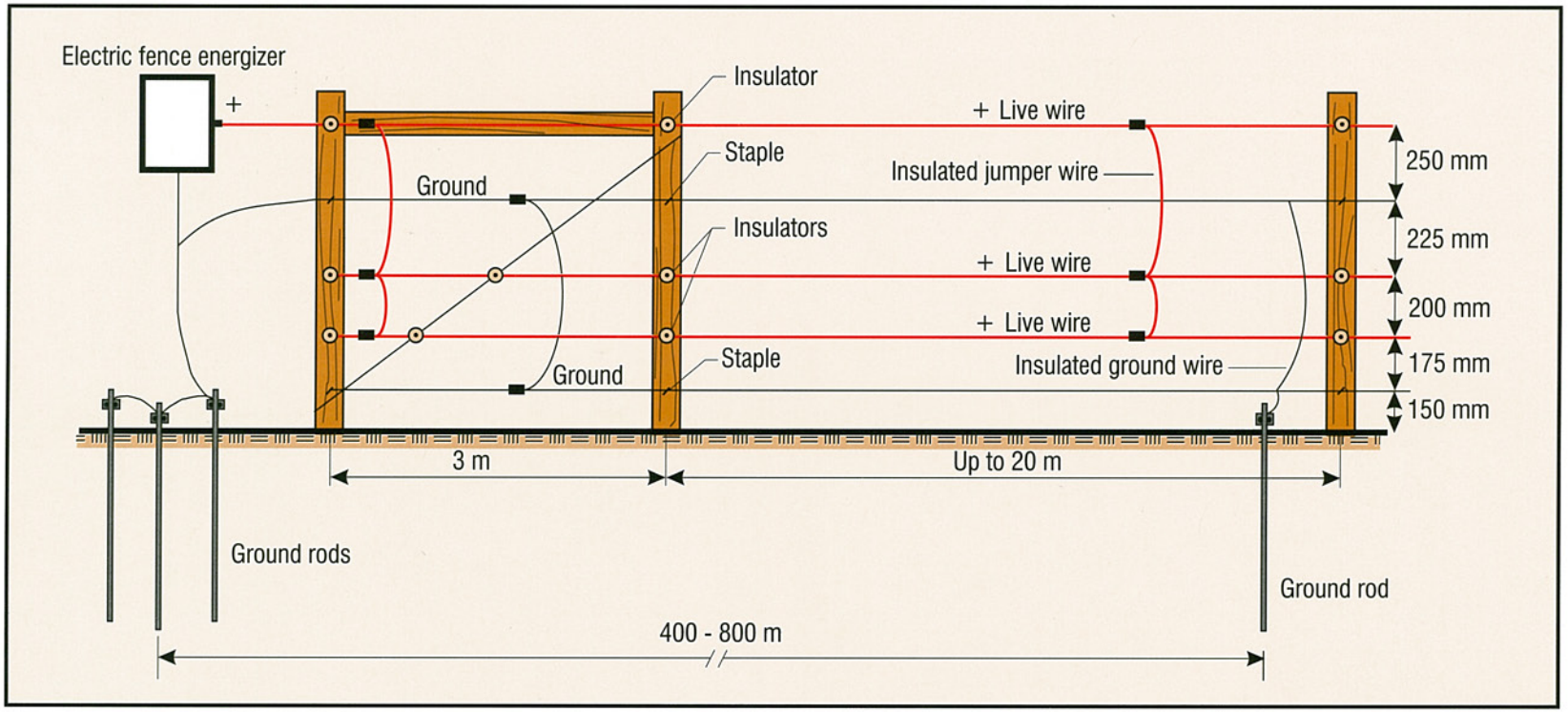


Figure 19. Five-wire fence – sheep/goat

Predator Fencing

Electric fences are also used to control predators such as the coyote and bear. A nine-wire electric fence of 12.5 mm high-tensile smooth wire is the most effective predator fence. It is vital that electrified predator fences are constructed using insulators. This fence may be bipolar or have alternate live and ground wires. All common wires are connected at 500 metre intervals along the

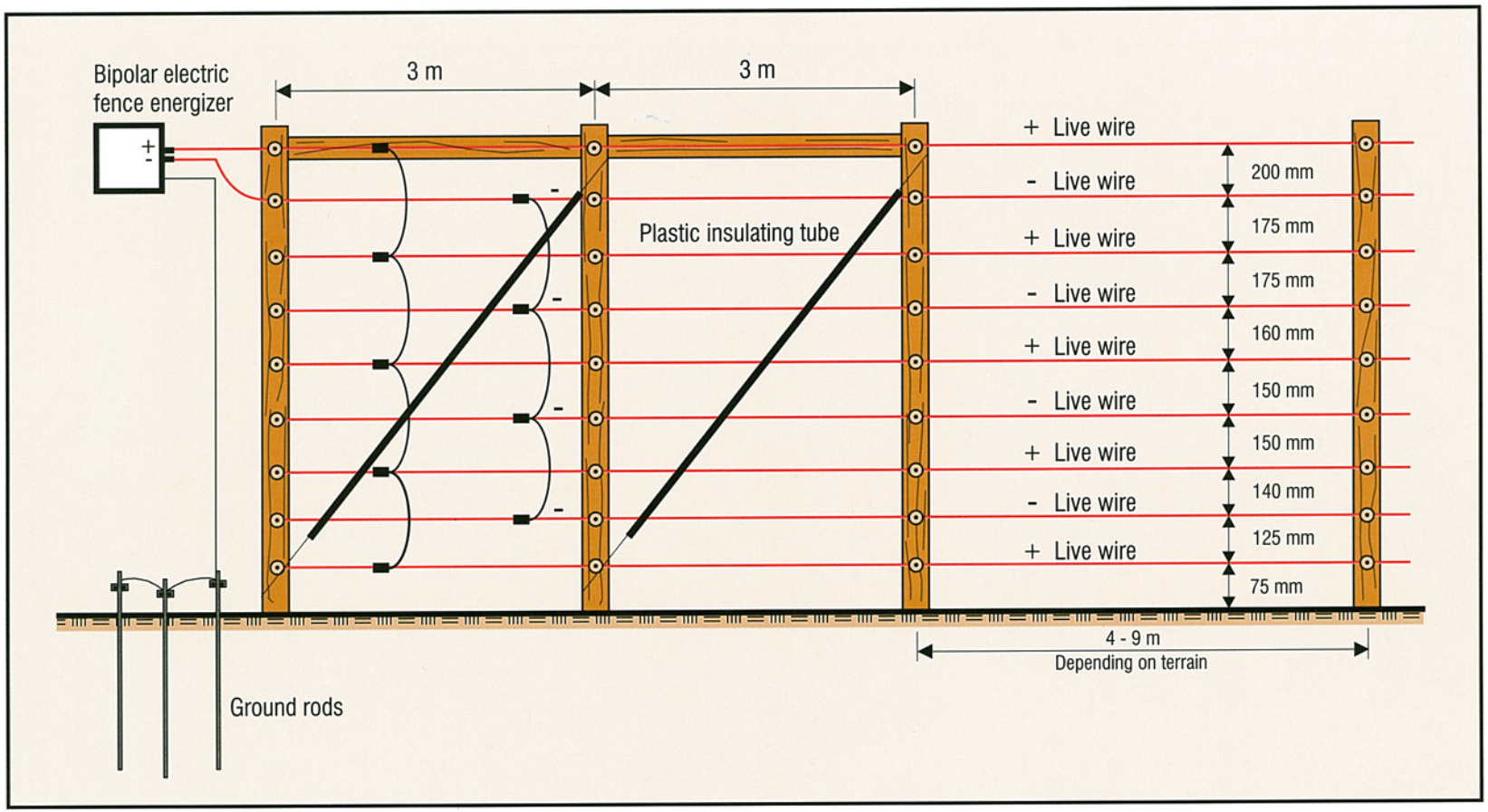


Figure 20. Nine-wire predator fence

fence. Ground wires are connected to ground rods every 500 metres.

Conventional 810 mm woven wire sheep fences can also be electrified. Two or three strands of high-tensile smooth wire are added 150 - 175 mm apart, above the woven wire. The top and bottom of these wires are charged to keep coyotes from jumping the fence. Add a charged wire, or wires, to the bottom of the fence to prevent coyotes from digging under it. Place this wire 150 mm above ground and 100 to 200 mm out from the fence bottom. If the fence posts are 100 mm in diameter or larger, the charged wire can be placed in insulators attached to the posts. For smaller posts, use offset brackets.

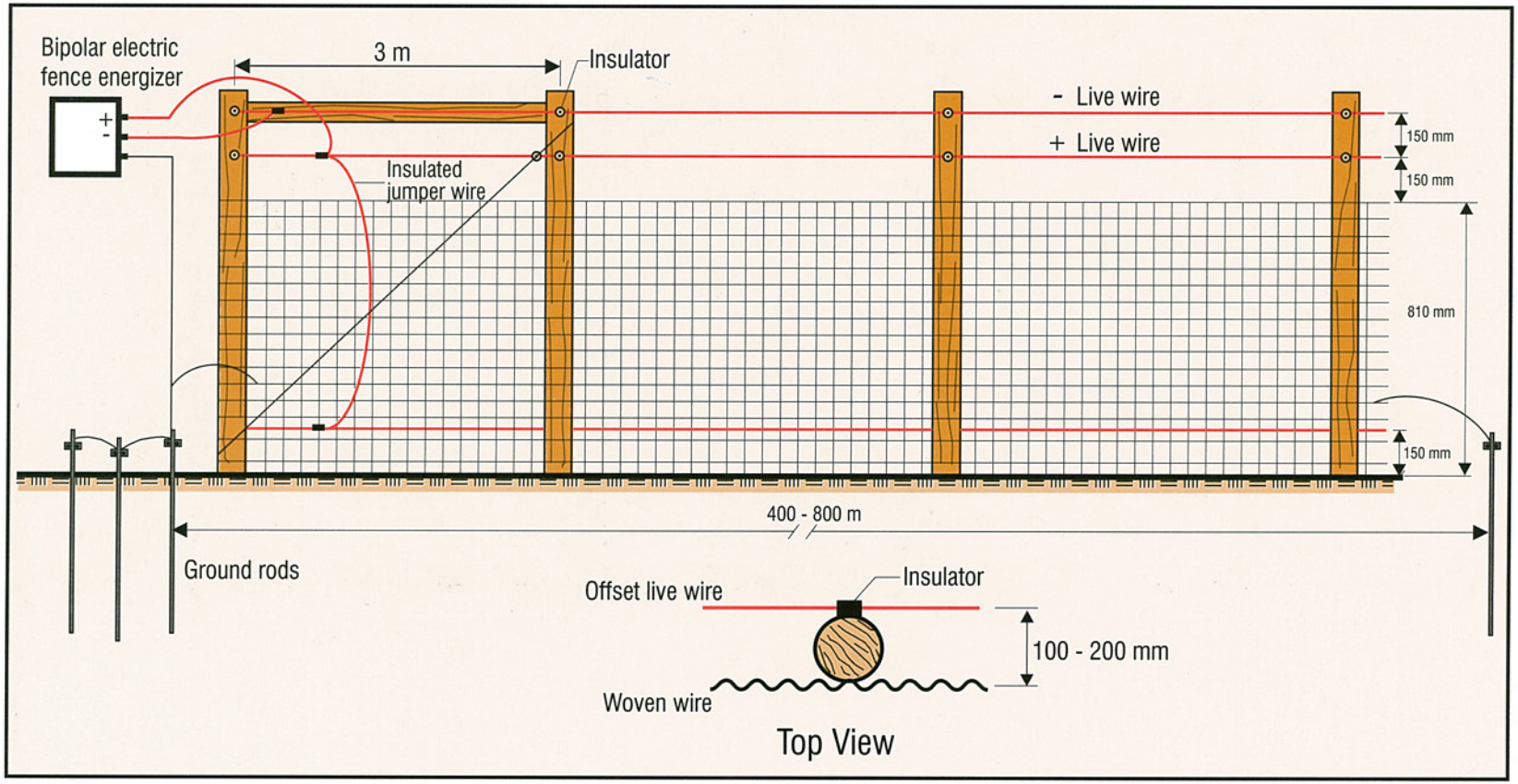


Figure 21. Modified woven wire fence

Bear Fence

Electric fences are often used for bear control around bee hives. They consist of a five-wire fence with all live wires. The bottom wire is placed 200 mm above the soil, and the remaining wires are 175 mm apart.

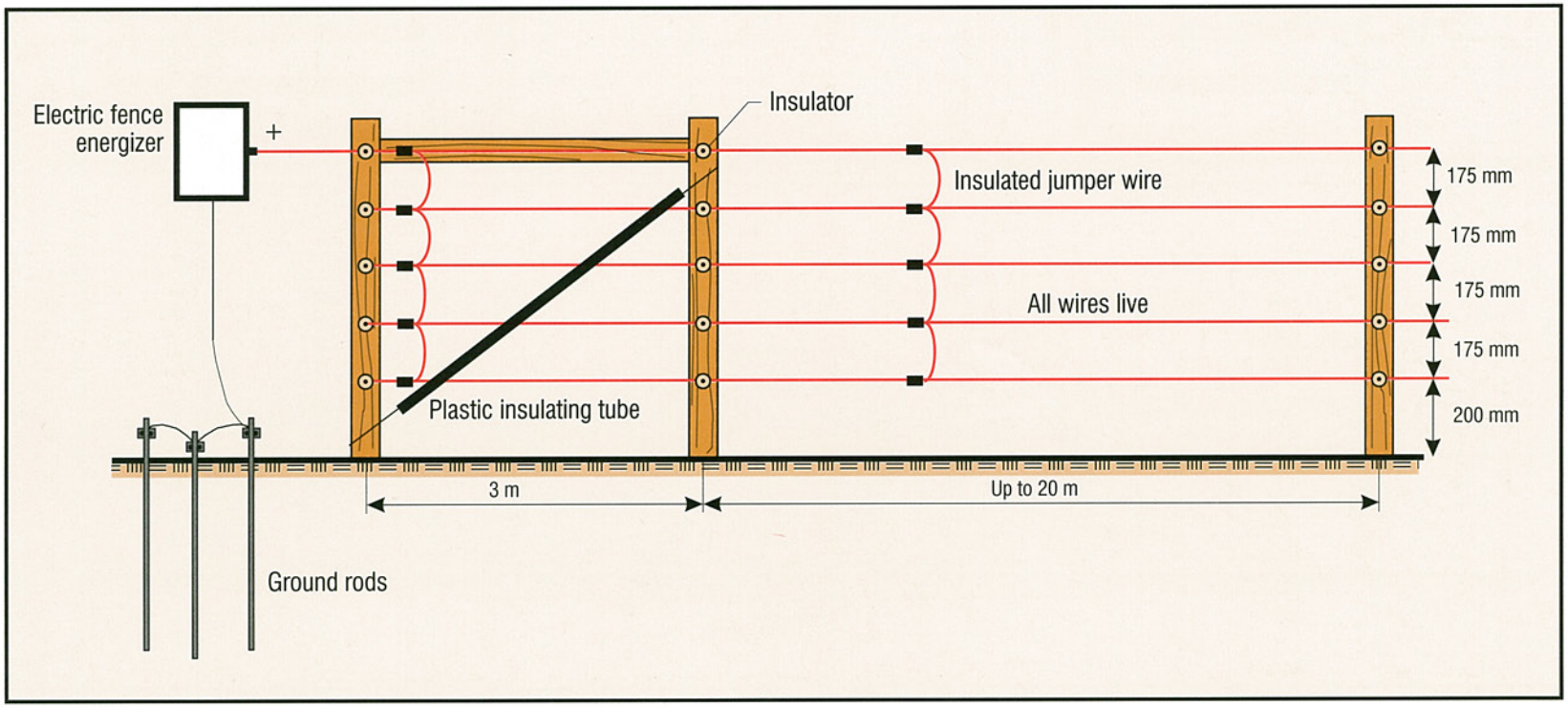


Figure 22. Bear fence

Gateways

Once trained, animals shy away from electrified fences. They will even hesitate to cross where electrified fences once were. When installing a gate in an electric fence, the animal must be able to visibly distinguish the difference between the gate and the fence. For example, a plank or metal gate can be used in a short section of plank fence. Another alternative is a lightweight gate made of plastic snow fence.

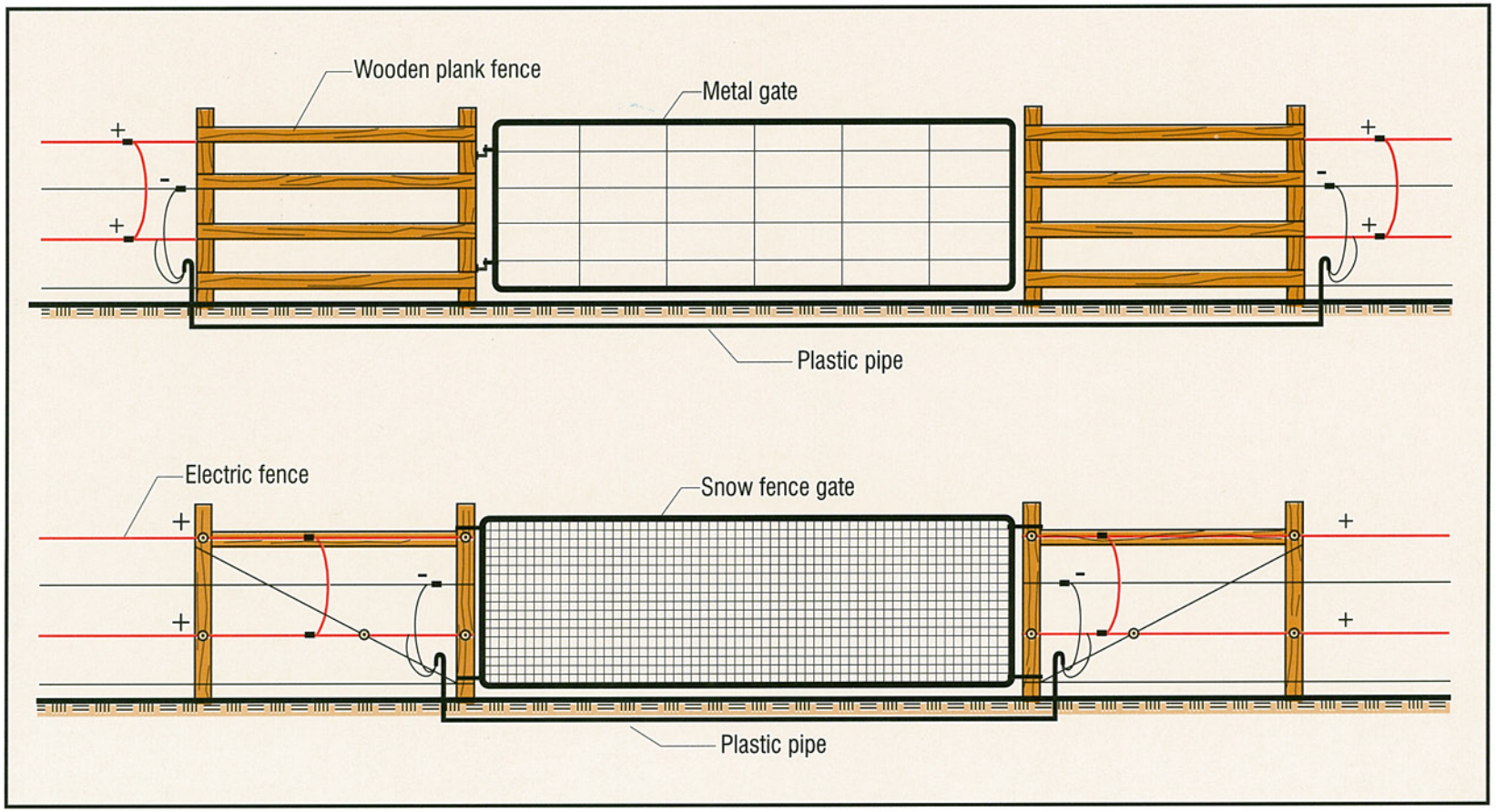


Figure 23. Gates in electrified fences

Undergate cables are used to maintain a continuous charge to wires on either side of the gate. They are made from PVC conduit, complete with service entrance fittings. Insulated wire is run through the pipe, connecting the charged wires on both sides of the gate.

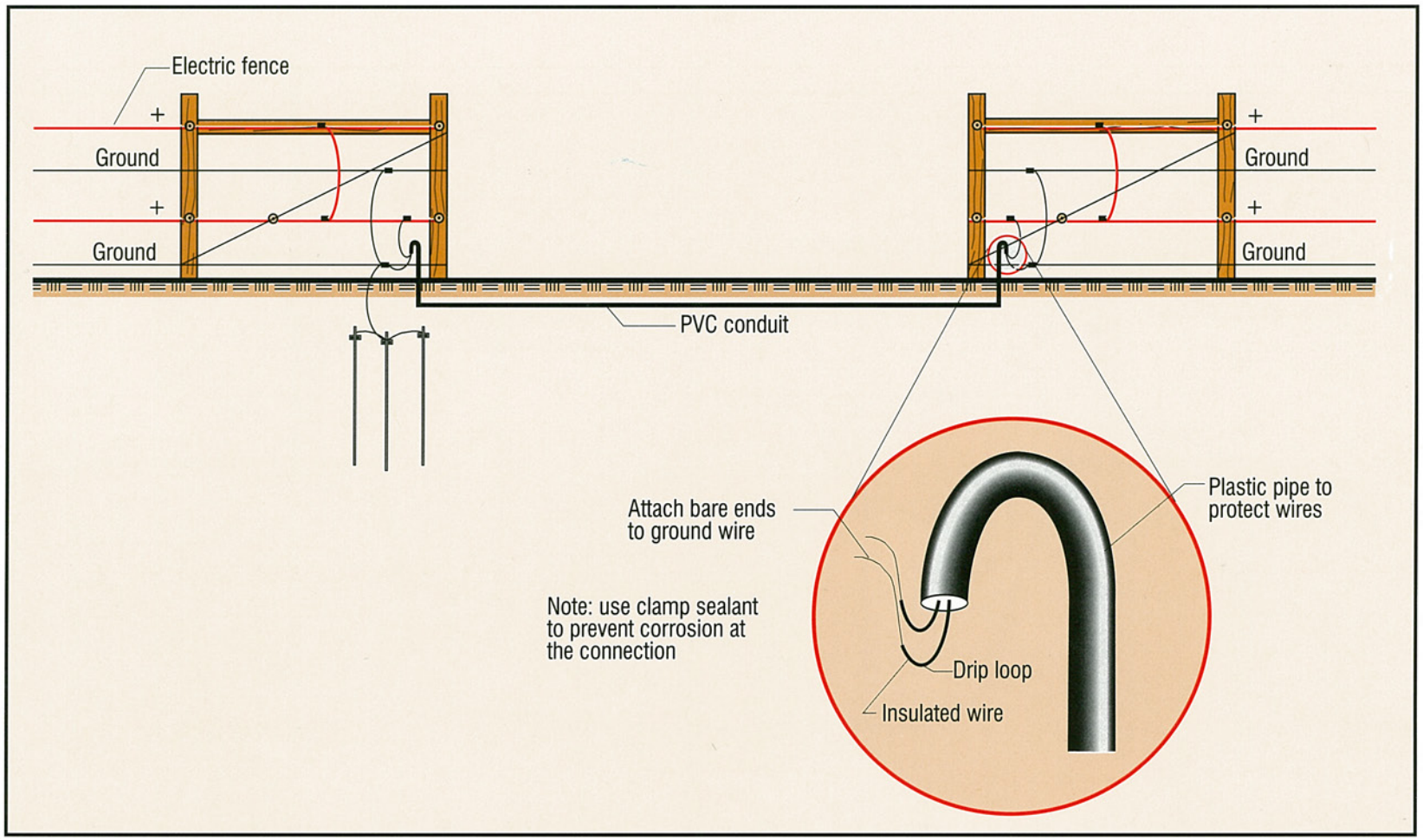


Figure 24. Undergate cable

Electrified flood gates are used when the fence has to cross a stream or a gully. When the water rises and comes into contact with the galvanized chains, the flood gate controller automatically shuts off the energy to the flood gate.

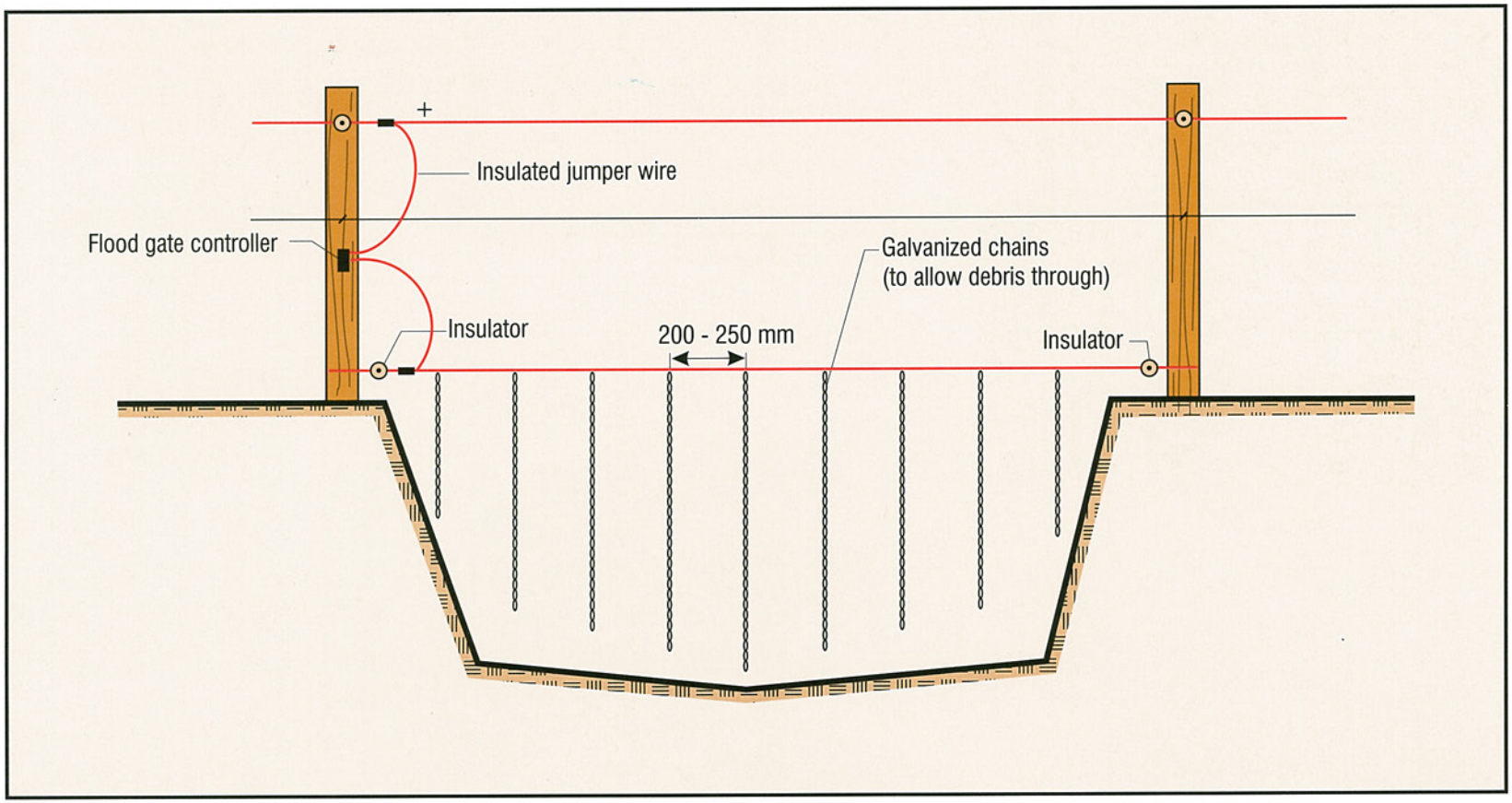


Figure 25. Electrified flood gate

Gates in Predator Fences

Conventional metal or wooden gates are also used for electrified fences. To ensure they are predator proof, there can be no opening larger than 100 mm. Gates must be high enough to prevent predators from jumping over them and kept closed so predators cannot walk through them. The area under the gate should be filled with a hard material such as packed soil, gravel or concrete to prevent an animal from digging under the gate. A wooden sill embedded into the soil is another deterrent to prevent digging by animals.

Lightning Protection

Electric fences must be protected from lightning strikes to minimize damage to the electric fence energizer. This is done by using a lightning protector and a coil of wire or a choke. The coil of wire, or choke, increases the line resistance to the lightning strike, diverting it to the ground through the lightning protector. This system of lightning protection does not interfere with the operation of the fence.

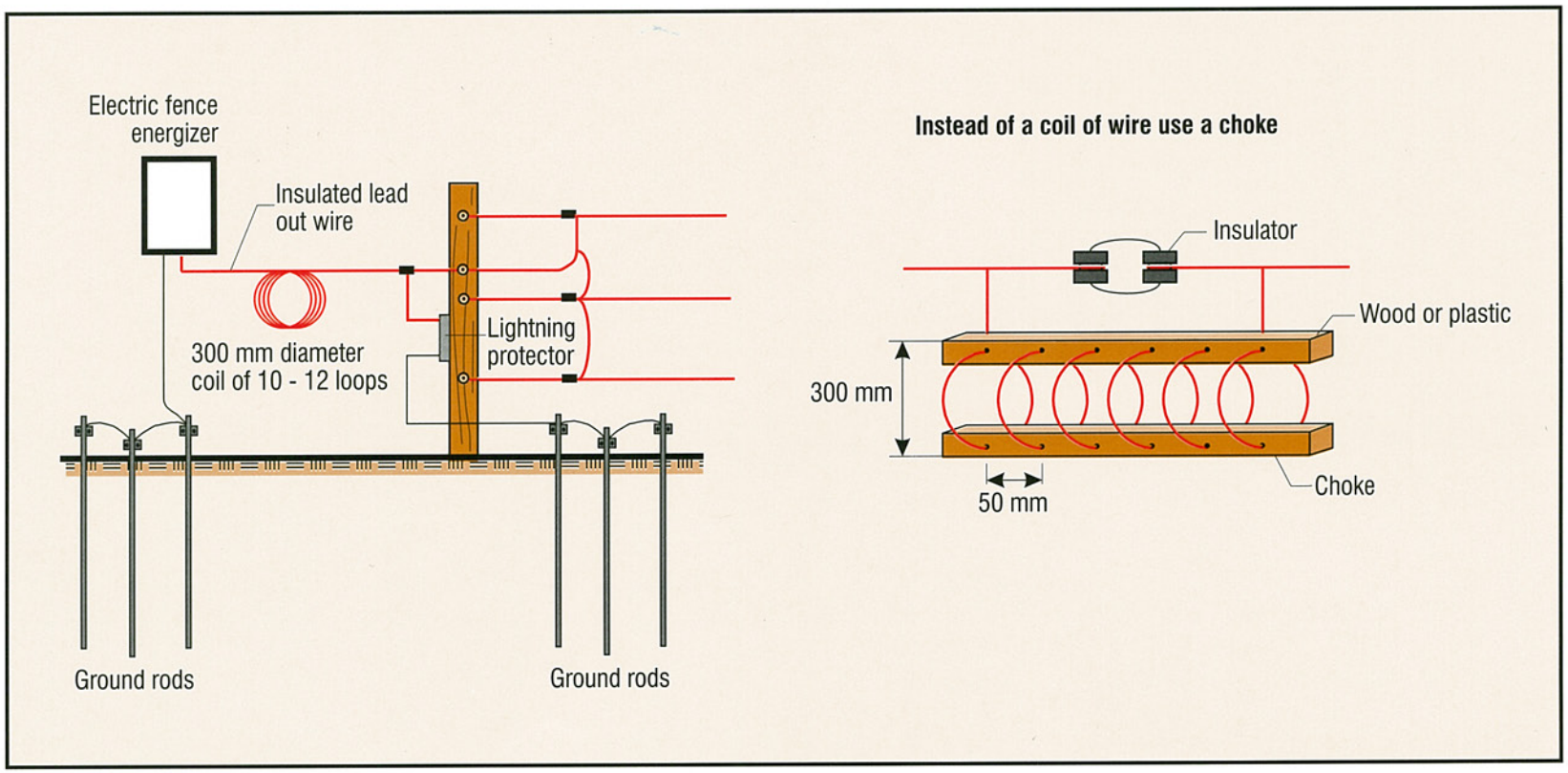


Figure 26. Lightning protection for electric fences

Electrifying Existing Fences

The life of existing non-electric fences can often be extended by electrifying them. Offset brackets are ideal products for this. The fence must be in reasonable repair and free of trees and vegetation in order for this alternative to be successful. Offset brackets are attached to the existing fence and projected outward at a distance of 350 to 400 mm. An electrified wire is placed into the insulator. Projecting the wire away from the fence guarantees that the animal will touch the live wire first.

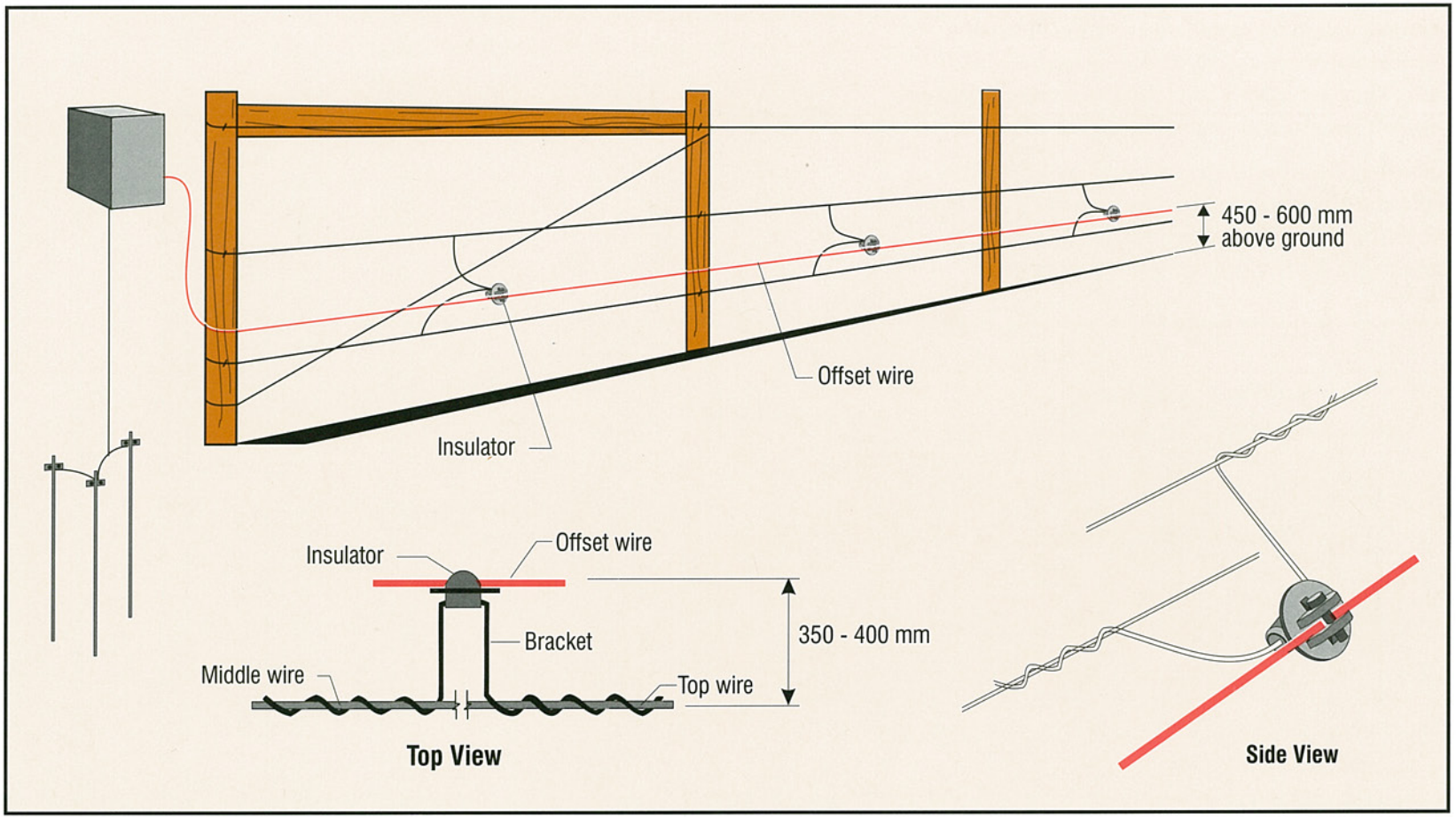


Figure 27. Electrifying existing fences with offset brackets

Wire Connectors

When joining wires, it is important to make a proper connection. The "reef knot" and the "figure-eight knot" are recommended (See Figure 28). Wire splicing is done by using the "western union" splice or crimping sleeves and other special fittings.

A special crimping tool is needed for correctly attaching **crimping sleeves** to the wires. Properly crimped wires are usually as strong as the wire itself. They are mainly used for connecting joints or tying off wire at end posts (See Figure 29).

Line clamps and **solderless clamps** are easy to use and are a quick way to attach a lead-out wire to the live wires. To prevent corrosion at the joints, use a non-drying sealant and wrap the clamps with electrical tape. A "cold-galvanizing" paint can also be used.

Flexible connectors and cutout switches can be used to supply power to sections of a fence. They make it easy to disconnect fence sections from the main fence for troubleshooting and maintenance.

Gate handles are spring-loaded plastic insulators, attached to gate posts. They allow you to safely open gates of electrified fences without receiving a shock.

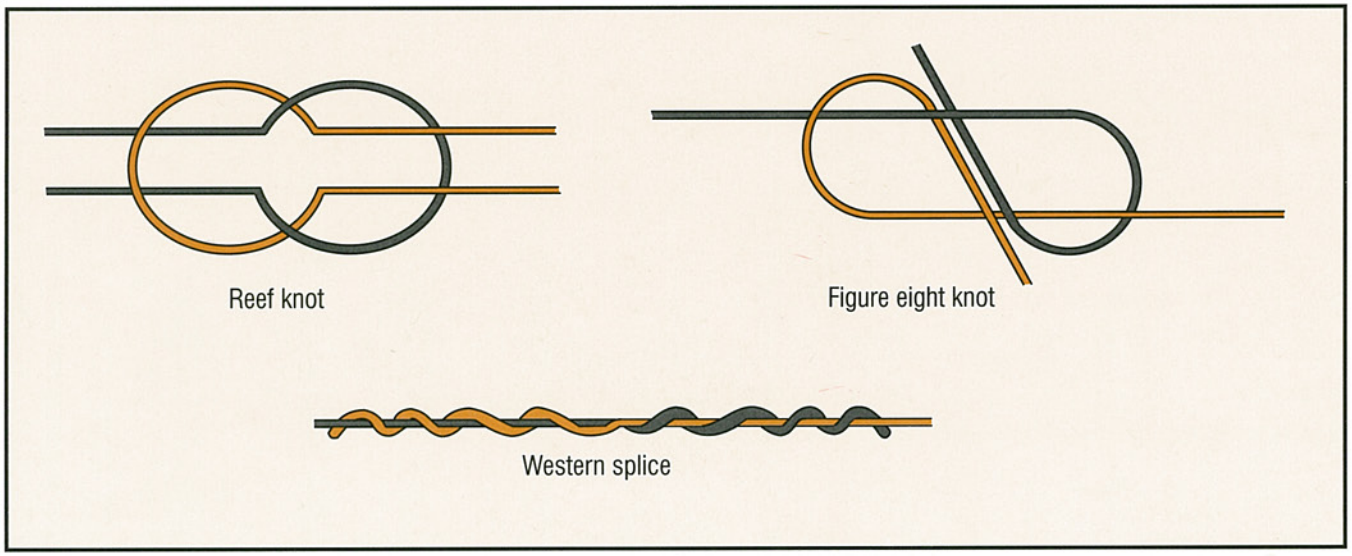


Figure 28. Wire splices and knots

Connecting Dissimilar Metals

When it is necessary to connect dissimilar metals (e.g., copper and steel), special clamps and joint compounds are available. These products prevent massive corrosion at the joint, which would result in a poor electrical connection (no current flow). Avoid using dissimilar metals in the fence because corrosion may occur even when joints are properly made.

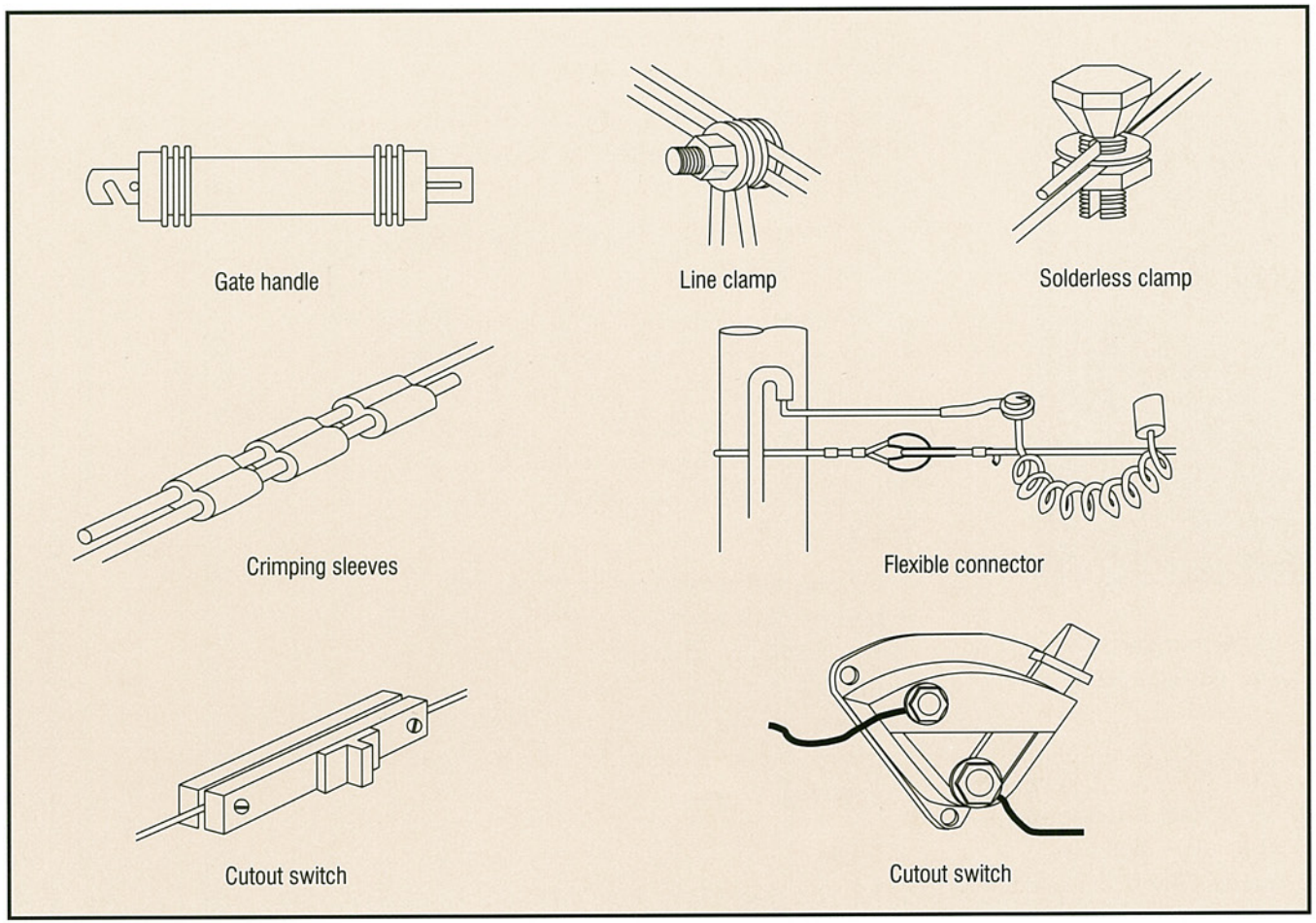


Figure 29. Gate handles, connection clamps, cutout switches

Fence Safety and Maintenance

- Always turn the electric fence energizer off before servicing the fence or provide plenty of cutout switches.
- Use only one electric fence energizer at a time.
- When testing an electric fence with a voltmeter, wear rubber gloves or rubber soled shoes to minimize any electrical shocks. Electrical shocks are intensified by wet, sweaty hands and feet.
- Be careful when working around overhead or underground power lines.
- Do not work or stand beside a fence during an electrical storm.
- Never grasp an electric fence with a closed hand.
- Mark the electric fence with warning signs every 100 metres.
- Never attempt to service the electric fence energizer. If it fails, send it to the manufacturer for servicing.
- Keep all electrified wires tight and free of fallen trees and debris.
- All electric fences require regular maintenance. Check the voltage daily. Visually inspect the fence on a regular basis. Look for broken wires, broken insulators, loose wires and any object that may have fallen across the fence. Thoroughly check the fence after rainy or stormy weather.
- Fenceline maintenance is important. All vegetation that could come in contact with the fence should be removed. Any vegetation that contacts live wires will allow electrical current to go to the ground, reducing the effectiveness of the fence. Control vegetation with herbicides or by mowing.

Troubleshooting Electric Fences

Electric fences must be maintained regularly to function at peak efficiency. Electrical shorts due to cracked or broken insulators, vegetation, poor connections and broken wires must be found and repaired. Electric fence problems are often due to bad connections or bad grounds.

If there are no bad connections or broken wires, over 90 per cent of electric fence problems can be traced to a bad ground.

Three items are needed to check an electric fence:

- a peak-reading voltmeter or an electric fence voltmeter,
- a large screwdriver or short piece of rod to use as a portable ground rod,
- a portable AM radio.

To Isolate a Problem

- Disconnect the electric fence energizer and check to see that it meets the manufacturer's voltage output specifications. If it is battery operated, check the condition of the batteries and the battery connections. Repair and replace as required. Always return a faulty electric fence energizer to the manufacturer for repair.
- Many electric fence problems are due to bad grounds. Check ground connections to make sure that they are clean and free of corrosion. A quick check of the ground can be made by holding one hand on the ground rod with the other hand touching the soil. If a shock is felt, the ground is bad. (See testing grounds on page 15.)
- If you have fenced in a circle, disconnect one end of the wire from the electric fence energizer. Check voltage to ground at both ends. If there is a short in the fence, the end of the wire will have low or no voltage and the beginning (close to the electric fence energizer) will have a high voltage. Leave the wire disconnected and walk the fence, taking periodic voltage readings to the ground. The voltage will drop as you approach the short. Once past the short, the voltage will be low or zero.
- If the fence has been designed to isolate areas, the fence can be broken into sections using cutout switches or splices on the live wire. As each splice or switch is disconnected, the section still connected is checked. If the voltage is adequate in the section being checked, the short is further down the fence. Move down the fence, disconnect the wire, and check it again. If the voltage has now dropped, then the problem is in the section between the "breaks."
- Splices can also be checked. Connect the positive (+) probe of the voltmeter to the wire on the "electric fence energizer" side and the negative (-) probe to the other side of the splice. Fix the splice if the voltage drops more than 100 volts. A portable AM radio can also be used to find bad splices. Tune the radio to a point between stations, adjust the volume so that a "click" is heard, and walk along the fence. The "click" will increase in volume as you approach the arcing connection.

References and Further Information

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Further Information

Most manufacturers of electric fence energizers have excellent fencing manuals. These manuals cover the layout and construction of electric fences in detail.

Examples are:
Pel Electric Fence Systems Instruction Manual
7th Gallagher Power Fencing Manual
Everything You Should Know About Electric Fences and Fence Controllers, published by Shur Shock
Baker 500 Bi-Polar/Uni-Polar Electronic Fences

Available from Alberta Agriculture, Food and Rural Development are:
Wire Fences For Livestock Management, Agdex 724-5
Electric Fences For Livestock Predation Control, Agdex 684-7
PAMI Evaluation Report 618

Appendix A

Worksheet for Sizing Solar-powered Fencing System Components

Step 1: Estimate Your Power Needs (Watt-hours/day)

The rating of a fence controller is commonly given in Joules, a measure of the energy in a pulse.

Total Daily Load: (Wh/day) = Controller Power (Joules) x Pulses/minute x 0.4

Note: If pulses/minute is unknown, use 60, which is a typical value.

Example:

Total daily load (Wh/d) = _____ (Joules) x _____ (pulses/min) x 0.4 = _____

Step 2: Determine Approximate Hours of Peak Sunlight

In Alberta use the following typical values:

	Hours of Peak Sunlight	
	Summer use*	All year use
Peace Region	4.0	2.0
Peace Boundary to Red Deer	4.5	2.2
Red Deer to Lethbridge	5.0	2.5
South of Lethbridge	5.6	3.0

*Summer use means from April to the end of September

Step 3: Estimate the Required Photovoltaic Module Size (peak watts, Wp)

$$\text{Module Size (Watts)} = \frac{\text{Total daily load (Wh/day)}}{\text{Peak sunlight hours} \times \text{Eff}_{bat}}$$

Note: Eff_{bat} is the battery efficiency, which is typically 75 to 90%. Use 80% or 0.8 when specifications are unavailable.

Example:

Module size (Watts) = _____

Step 4: Estimate the Required Battery Capacity (Amp. Hours)

$$\text{Battery Capacity (Ah)} = \frac{\text{Total daily load (Wh/day)} \times \text{(Days of storage)}}{\text{Battery voltage } (V_{bat}) \times \text{Eff}_{bat} \times \text{DoD}}$$

Notes:

1. Days of storage: a good rule of thumb is four days
2. Battery voltage: 6, 12, 24 volts, etc.
3. DoD, maximum depth of discharge of battery. This ranges from 10 to 70%. For automotive batteries, use 10%. For deep discharge batteries, such as RV batteries, use 30% when manufacturer's specifications are unavailable.
4. Battery capacity (Ah) is given in ampere-hours.

Example:

Battery capacity (Ah) = _____

Appendix B

Types of Batteries

A battery should be selected based on usable capacity and economics. The amount of usable energy capacity is the product of the depth of discharge and the total energy capacity (Ah, ampere hours). The depth of discharge is the percentage of the total battery capacity that is available during normal cycle use without causing permanent damage. Select a battery that will be the most economical over the long run. Factors to consider are the battery's efficiency, cycle lifetime, self-discharge, maintenance requirements and cost.

	Approximate Cost[1]		Cycle life	Depth of discharge (%)	Normal self-discharge (%/month)
	$/kWh	$/kWh/cycle			
Lead-acid (automotive)[2]	70	0.35	150-250	10	7-50
Low antimony (RV)[3]	85	0.28	200-400	50	7-50
High-antimony (electric vehicles)[4]	95	0.05-0.09	1,000-2,000	up to 80	7-50
Pure lead (photovoltaic)	140	0.05-0.14	1,000-3,000	30-50	2
Lead Calcium (photovoltaic)	200	0.03-0.10	2,000-6,000	20-70	1
Nickel Cadmium (pocket plate)[5]	400-1,200	0.14-0.80	1,500-3,000	80	5
Lead-acid (gel cell)[6]	555	0.56-1.11	500-1,000	up to 80	7-50

Notes

1. Actual costs change with time. Use these figures to compare relative costs of different types of batteries.
2. The common automotive battery is **not** recommended for photovoltaic (solar) systems. It is not tolerant of overcharging or deep discharging. It also tends to lose up to 50% of its energy through self-discharge each month, depending on the age of the battery.
3. Similar to automotive (starting) batteries, but with slightly thicker plates, containing some antimony.
4. Designed for use in golf carts, fork lifts. Characterized by their massive size and weight. Usually 6 volts.
5. Ni-Cad batteries have excellent low-temperature capacity characteristics.
6. Gel cells must not be charged or discharged too rapidly.

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