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Unit Standard 572

Fencing

Demonstrate knowledge of Electric Fencing Components and Systems

Version 4 Level 3 Credit 5

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Learning Objectives

Electric fencing is the most modern fencing method that is used to control the movement of livestock on farms. It differs from other types of fencing in that it provides a 'psychological' rather than 'physical' barrier. Livestock develop a fear of the fence as a result of the unpleasant electric shock they receive when they touch the fence.

Electric fences can be either **permanent** or **temporary** (portable).

When you have finished this module, you should be able to:

- identify electric fencing components
- know the animal containment properties of fences
- know about the performance characteristics of different types of electric fence energizers
- describe types of joule ratings and their applications
- describe safety considerations for electric fence earthing system installations

Introduction

Please take the time to view the 'Glossary' at the rear of this module. This will help you to understand the terms referred to throughout this electric fencing module.

Electric fence systems have a number of advantages over other fencing systems:

- They are lower cost and easily maintained
- When installed correctly, they have a long working life and are less prone to being damaged, they are also easily modified
- Animals are less likely to injure themselves also resulting in less damage to pelts and hides
- Help to protect valuable livestock
- A variety of electric fence systems are available for different classes of livestock
- They discourage predators and even trespassers
- Allow crops and pastures to be effectively rationed
- Areas, such as waterways, trees, roads, can be effectively fenced off

Electric fences are made up of three parts:

- the fence structure e.g. posts, insulators, switches
- the energizer
- the earthing system

Electricity

Firstly, to understand the construction of an electric fence, we need to have a basic understanding of how electricity flows. This will also help you to design and maintain an electric fence system.

The battery or mains power supplies the electrons which are moved along the wire by the energizer, just as the water is moved along a pipe by a pump.

The flow of electrons (called *current*) is measured in *amperes per second*, and the pressure of the electrons is measured in volts. *Insulators* prevent the *current* from leaking out.

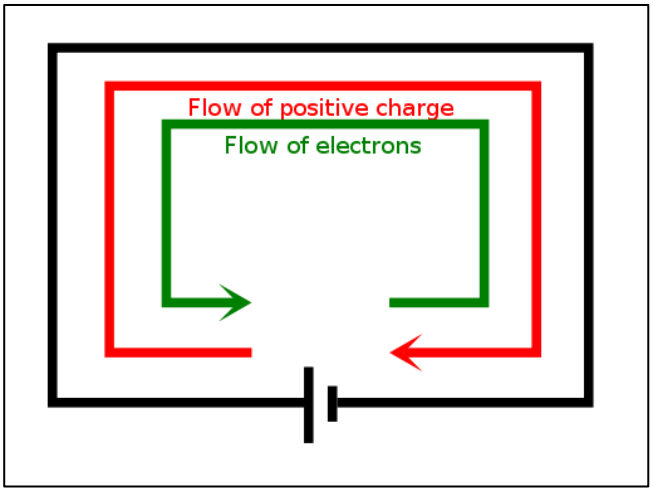


Figure 1 Flow of positive charge and electrons

Image retrieved from https://en.wikipedia.org/wiki/Electric_current#/media/File:Current_notation.svg Licenced under CC BY 3.0

Resistance (*Ohms*), is a measurement of a wires ability to conduct electricity (*current*). An increase in resistance will decrease the flow of current. Factors, such as these listed below, are examples of resistance to the flow of electrical current:

- A tree on the fence
- Crop touching the fence
- Stock on the fence
- Rusty wires
- Broken or missing insulators

A long run of fencing wire needs the electricity to have a *high voltage* (pressure) in order for the electricity to move along the wire. A high flow of current at a high voltage would be fatal to livestock and humans therefore the current is sent along the wire in *pulses*.

Electric fences are designed to act as a physiological barrier rather than a physical barrier. This will be discussed in more detail later in this module. There are two types of electric fencing systems used in New Zealand, the 'all live' system and the 'earth wire return' system.

The following diagram illustrates how the 'all live' (also referred to as the 'ground earth return' system) circuit functions and how it is constructed. This particular system is suitable for use in areas where conductivity is good and is the most common system used in New Zealand.

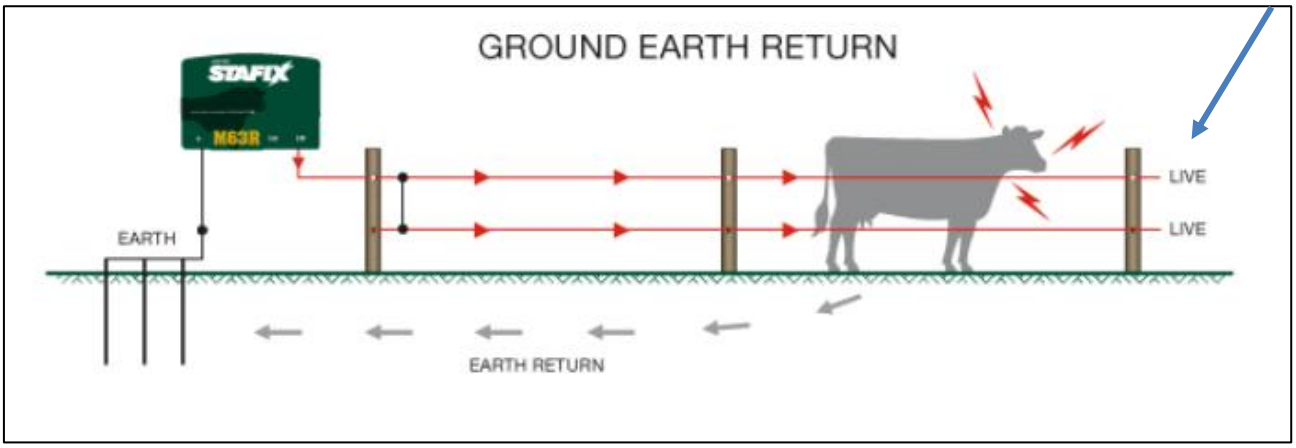


Figure 2 Ground Earth Return

Images retrieved from: http://www.stafix.com/en-us/helpful-information/grounding-your-energizer

'Earth wire return' systems are used in dryer areas where conductivity is poor. This system is more complex than that of the 'all live' system. It requires careful construction and must be well maintained (if the earth wire comes into contact with the live wire, the fence will become ineffective).

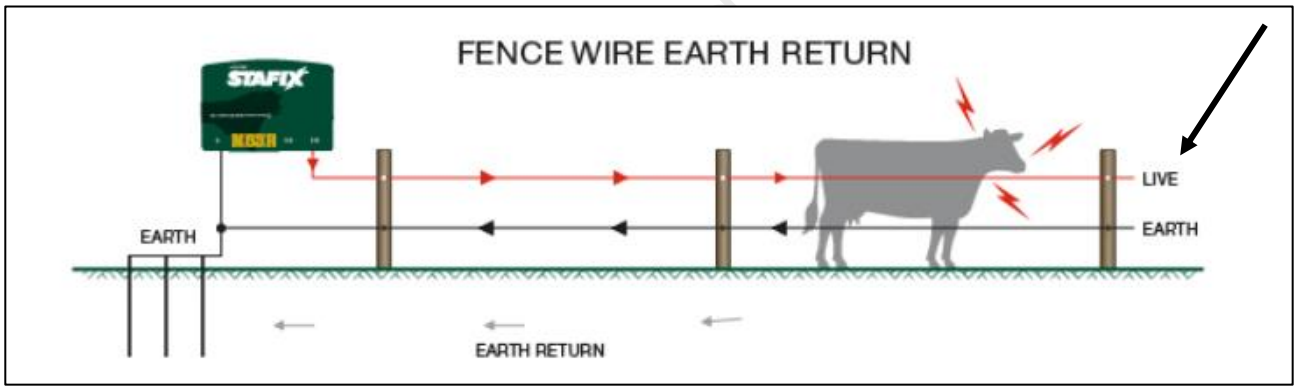


Figure 3 Fence Wire Earth Return

Images retrieved from: http://www.stafix.com/en-us/helpful-information/grounding-your-energizer

Electric Fence Components and their Functions

Posts

A wide variety of posts are available to be used in electric fences. Which ones to use depends on:

- whether the fence is permanent or temporary
- the contour of the fence line
- cost
- spacing along the fence line

The basic types of posts used to construct an electric fence are:

- fibreglass standards
- steel and plastic standards
- wooden posts
- concrete posts
- steel standards, often known as Waratahs or "Y" posts

Fibreglass

Fibreglass standards have the advantage of not needing insulators, as they do not conduct electricity. This makes them a cheap alternative and quick to install. Some fibreglass standards come equipped with wire clips which can be adjusted to the desired wire spacing. Fibreglass standards can be found on steep hill or high country areas, where fencing is difficult and are used to erect permanent or temporary electric fences. Their easy installation and light weight enables them to be installed in hard to reach areas. The can also be transported easily.

Steel and Plastic Standards

Steel and plastic standards, as pictured to the right, are more commonly used for portable/temporary fencing. They too do not conduct electricity (the steel standard has a protective non-conductive plastic cover), so can be easily manoeuvred for stock management (break fencing etc). They are installed using the foot tread and can be easily transported (light in weight) and come in a variety of lengths and styles to suit different stock types.

Wooden Posts

The most common post used to construct a fence with electric capability are wooden posts. Wooden posts are available in full rounds, half rounds or quarter rounds. The advantage of using a wooden post is that the wire can be attached to the post at any height. In contrast, a concrete post has prefabricated 'holes' for attaching wires. In most situations a wooden

Figure 4 Wooden Posts

Image retrieved from http://www.greatsouthern.net.nz/products/posts-and-strainers/sheep-and-cattle/sheep-and-cattle.aspx

post will be installed using a tractor and post driver. To attach electric wires, insulators will be required on wooden posts. Native totara was once popular for use as ground-durable wooden posts but most nowadays are treated pine (the majority radiata and some Corsican pine). You may still find totara posts in older fences still standing on farms – they may have softened near the soil surface but are still sound above and below ground.

Steel Standards

The most common steel posts are waratahs or Y-posts. Their name is derived from the "Y" shape of the cross section. Electric wires are attached to steel posts by using an insulator. Steel standards come in a variety of lengths (up to 2.6m for deer fencing) and have pre-fabricated holes for wires to be attached. These are suitable for areas where the soil is extremely hard, steep and a permanent fence is to be erected.

Figure 5 Steel Standards

Image by Liefting, 2009. Licenced under CC0 1.0

Concrete Posts

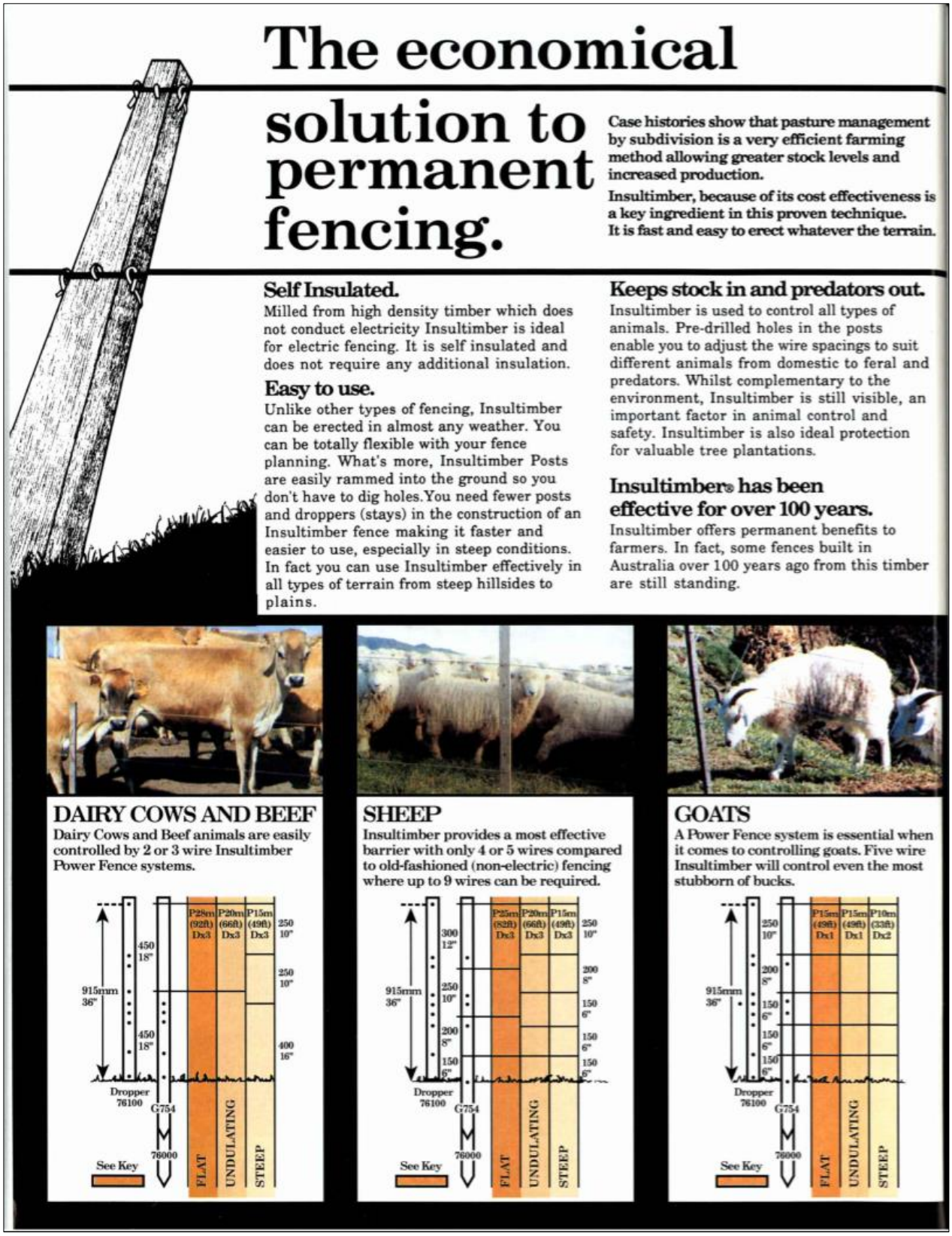
These are made from reinforced or pre-stressed concrete. Concrete posts are generally hardwearing however they may burst if water gets in and rusts the reinforcing. They are also relatively expensive. In most cases, concrete posts have prefabricated holes for attachment (using special long concrete post staples) or threading of fencing wires. When constructing an electric fence using concrete posts, insulators will be required to prevent the electric current being conducted through the post. Installation involves digging the post into the ground however some may be able to be driven with a post driver without breaking. They are heavy therefore their use is limited in particular on steeper properties

Figure 6 Concrete Posts

Image by Garratt, 2011. Licenced under CC BY-SA 2.0

Hardwood Posts or Insulating Timber

Hardwood posts (e.g. Australian Hardwood) are generally used for permanent electric fencing on hill and high country properties. Also, known as Insultimber (a registered Trademark product of Gallagher), hardwood posts are self-insulated therefore do not require an insulator. The following information is from the Gallagher website (www.gallagher.co.nz), an excerpt from the Insultimber brochure.



Insulators

An insulator is used to prevent electricity from flowing through the post and into the ground. The main types of insulator used on permanent electric fences are individual insulators or self-insulating posts. Insulators can be bought in a range of materials:

Insulator Materials

Porcelain

Porcelain strain insulators last a long time as they do not become waterlogged if well made, due to their smooth glazed surface. Porcelain insulators will however break easily when they are hit, and are more expensive than other insulators. They are known for their excellent insulating ability and are more reliable under high strain positions.

Figure 7 Porcelain Insulator

Image retrieved from http://www.stafix.com/en-nz/product/end-strain-insulator-porcelain

Insulating Timber

This is a special type of timber which does not conduct electricity, available as posts or droppers. Self-insulating timber eliminates the need to put individual insulators on each post - cutting both cost and time. They are strong posts and come ready to use.

Fibreglass

Fibreglass does not conduct electricity, so it is also a suitable material for manufacturing insulators. Fibreglass insulators are light weight therefore easily transported – great if you have to carry them some distance across steep terrain.

Plastic

These are the most commonly used post insulators today. They must be used on all live wires running past a post unless the wood is self-insulating. The most common form of plastic used for manufacturing insulators is a high density polyethylene which is UV resistant. Please note that if the insulator gets split or cracked, its performance will be compromised – by acting as a direct short when the insulator get wet or dirty.

Figure 8 Plastic Insulator

Image retrieved from http://www.grupacer.com/tienda/cerramientos/aisladores?page=3

Types of Insulators

There are many "types" of insulators available on the market. They have specialised designs to accommodate the type of post they are being applied to.

Insultube

Insultube is a small plastic pipe about 8mm in diameter. Insultube can be bought in 50m rolls or per cut in 100mm lengths and is stapled on to a post with a single staple over the tube. The wire is then threaded through the tube and tightened.

End Insulator

These are designed to prevent the electricity earthing out on the end post of a fence line. They also provide a straining point for the electric wire and are specifically designed to handle the tension of the strain. End insulators come in a variety of strengths (to handle permanent, semi-permanent or long, short strain fence lines) and are usually manufactured from polycarbonate plastic or porcelain.

Figure 9 End Insulator

Image retrieved from http://www.scruggsfarm.com/gallagher-super-strain-insulator-white-5-pack.html

Thread-through Insulator

Thread through insulators are nailed on to wooden posts or bolted to steel standards. The wire is then threaded through the insulators and tightened.

Wooden and Steel Post Insulators

These insulators are fabricated from plastic. Insulators attached to steel posts (such as "Y" posts of waratahs) usually have a pin system to attach the insulator through the prefabricated hole on the post. Insulators for wooden posts are attached with fencing staples. When required, these insulators can be individually replaced in comparison to a thread through insulator which is a more permanent fixture and is more difficult to replace individually.

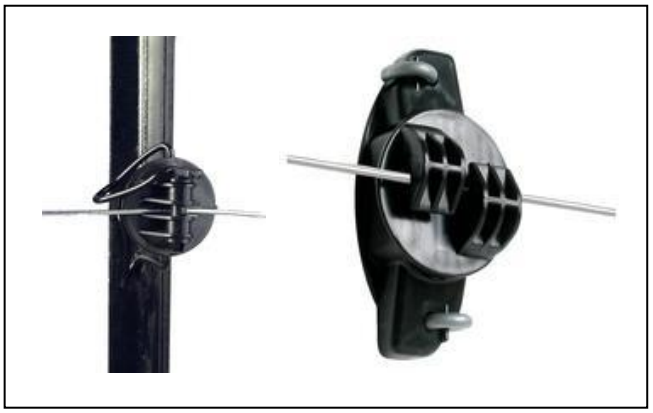


Figure 10 Wooden and Steel Post Insulators

Image retrieved from http://www.scruggsfarm.com/gallagher-w-wooden-post-insulator-25-pack.html

Concrete Post Insulators

It is less common these days for farmers to construct fences with concrete posts. There are many concrete post fences still around in some areas therefore it is useful to know that there are products available to repair or manage them. Concrete post insulators usually have two components; a wire post pin which attaches the insulator to the post itself, and the insulator itself.

Other Equipment

Cut-out Switches

The purpose of a cut-out switch is to isolate sections of a fence, so if there is a fault then the problem can be found without searching along the entire fence line. The switch can be used to turn off sections of a fence which are not in use.

Figure 11 Cut-out Switch

Image retrieved from http://www.stafix.com/en-nz/product/heavy-duty-cut-out-switch

Line Clamps

These are used to join two lengths of wire together along the fence. They should be made of galvanised steel to prevent degradation. When selecting a line clamp, it is important to consider one that will not impact on the efficiency of the electric fence – some clamps conduct electricity a lot more effectively than others.

Undergate or Underground Cable

This cable is wire which is double insulated with plastic. It is run through a plastic pipe buried under the gateway. It allows the power to run from one side of the gateway to the other. The following are examples of cable available from the Stafix range of products (www.stafix.com):

Extreme Underground Cable

2.7 mm aluminium coated steel for extreme conductivity. Delivers power effectively and efficiently over long distances. For under gate and lead out applications.

- Ideal for large properties with high powered energizers
- 2.7 mm (12 ga) aluminium coated steel for extreme conductivity
- 3 x more conductive than 2.5 mm (12.5 ga) premium cable
- Use with Stafix Joint Clamps
- Resistance of 11.5 ohms / km
- Easy to strip with soft steel core for greater flexibility
- Delivers more power over long distances.

Premium Underground Cable

2.5 mm galvanised steel for greater conductivity. For under gate and lead out applications.

- Suitable for all properties
- 2.5 mm (12.5 ga) galvanised steel for greater conductivity
- 3 x more conductive than 1.6 mm (16 ga) underground cable
- Use with Stafix Joint Clamps
- Resistance of 35 ohms / km
- Easy to strip with soft steel core for greater flexibility.

Underground Cable

1.6 mm galvanised steel. For under gate and lead out applications.

- Ideal for small properties with low powered energizers
- 1.6 mm (16 ga) galvanised steel
- Use with Stafix Joint Clamps
- Resistance of 90 ohms / km
- Easy to strip with soft steel core for greater flexibility.

Specialist Insulators

Reel insulators can be used on angles, such as a corner, and where the direction of the fence changes. They have a small wheel which the wire can move around so the fence's strain is maintained.

Outriggers

An outrigger holds an additional electric wire which is attached to the fence. It sits out from the fence itself, and helps stop stock from pushing against non-electrified wires. It will prolong the life of a fence considerably by reducing damage by stock. Outriggers, such as pigtails or wire outriggers, are designed to position the electric wire out from the fence, so the electrical current is away from the permanent fence. The picture to the right shows an outrigger with a porcelain insulator attached to a permanent fence.

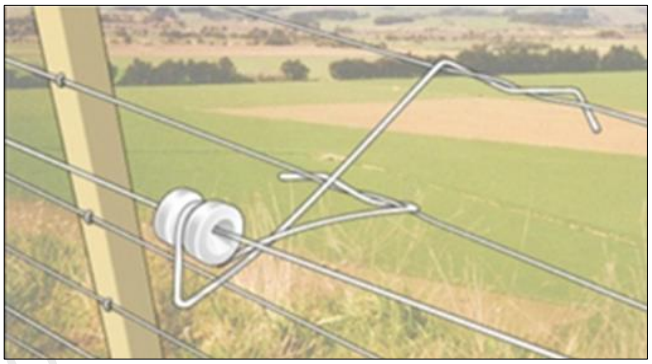


Figure 12 An Outrigger

Image retrieved from http://ricfeelectn.com/electric-fence-outriggers/.

Insulated Droppers

Along the fenceline, droppers are placed between posts. These can be self-insulating, eliminating the need for individual insulators on each dropper.

Earthing Materials

The materials used for earthing must be galvanised and unpainted, if not they may rust and create resistance. The earthing system is an important part of the electric fence system. The current of electricity moves along the wire from the energizer. When livestock touch the wire, the electrical current passes through them into the ground. In order for the livestock to receive a shock, the earthing system is required to complete the electrical circuit. The electrical current passes from the wire, through the livestock, into the ground, where it is passed back to the energizer via the earthing system. Earthing systems must be installed at least 10m away from any other earthing system (this includes phone lines, underground power lines or even house mains power). It should also be installed where stock cannot interfere with the connections but is still easily accessible for maintenance. Shady and damp areas are ideal (www.stafix.com).

Fence Energizers

Fence energizers are designed to convert power into electric pulses and send them along the fence line. Energizers are discussed in further detail in the next section.

Wire

For a permanent electric fence, it is recommended that 12.5 gauge (2.5mm) high tensile galvanised wire is used. For temporary or portable electric fencing, poly-wire or poly-tape can be used. Another form of highly conductive wire, available on the market in New Zealand, is aluminium coated wire. It is recommended for use in coastal regions and has three times the conductivity of 2.5mm high tensile wire (www.gallagher.co.nz).

Barbed wire should never be used for an electric fence. There is the danger of an animal or human becoming tangled in the wire and not being able to free themselves.

Electric Fence Testers

Also referred to as 'Fault Finders', testers can assist with measuring voltage and the current of the electric system. Some also have the added advantage of turning the energizer on or off from anywhere along a fence line. With the use of advanced technology, farmers are also able to switch fences on or off and locate faults remotely.

Gate Hardware

These products are commonly used on dairy farms throughout New Zealand. Electrified tape, springs or bungy cords are used across gateways to replace the traditional metal sheep and cattle or deer gates. The following examples are from the Stafix product range, www.stafix.com.

Tape Gate Hardware Kit

Contains all the components you need to create your own customised length tape gate - excludes the tape.

- For custom length gateways
- For use with Stafix Premium Gate Tape
- Versatile and easy to install
- Fully insulated, heavy duty handle with protective guards and non-slip grip.

Spring Gate

Versatile spring gate with a rust resistant galvanised spring.

- Electrifies gateways up to 8 m wide
- Versatile and easy to install
- Fully insulated, heavy duty handle with protective guards and non-slip grip

- Galvanised rust resistant spring.

Tape Gate

Electrifies gateways and is designed for maximum visibility with its 40 mm wide tape.

- Electrifies gateways up to 5 m wide
- Versatile and easy to install
- Fully insulated, heavy duty handle with protective guards and non-slip grip
- Designed for maximum visibility with 40 mm wide tape
- Tape contains 10 stainless steel strands for high conductivity

Self-Test One

Answer the following questions true or false:

1. An electric fence is designed to be a physical barrier rather than a psychological barrier.
   True/False

2. Resistance to the flow of electricity is measured in pascals.
   True/False

3. An insulator is designed to prevent electricity from flowing through the post to the ground.
   True/False

4. An earth is required to complete the electrical circuit of an electric fence.
   True/False

5. Fence energizers convert power into electric pulses and send them along the fence line.
   True/False

Electric Fence Energizers

The job of the energizer is to convert power (from the mains, battery or solar from light) to pulses and push them down the line. The difference between energizers is in their pushing power and energy i.e. how far can they push the pulse and at the same time maintain their voltage (www.electricfencing.co.uk).

A stronger energizer should be used when containing animals that are somewhat insulated, such as sheep (insulated by their wool). Horses are sensitive so they do not need as strong a shock to make them aware of the fence. Animals with wet noses also receive a stronger shock as the wet nose conducts electricity more readily than a dry one.

If netting is being electrified, a stronger energizer should be used as vegetation easily touches netting and will cause earthing and subsequent loss of power.

Battery Energizer

This energizer is basically the same as a solar powered energizer, but the difference is that it does not use solar energy to charge the battery. It is charged separately by connecting it to a mains power source.

This type of energizer ranges from a low power compact type unit for strip grazing, to a higher powered unit which is suitable for permanent electric fencing. An energizer with a high amount of output will require a large battery to be able to keep operating for a decent amount of time between chargings.

The advantage of a battery energizer is that it is portable therefore it can be relocated to where it is required.

Figure 13 A battery powered energizer

Image retrieved from http://www.abcustomfencing.com/shop/index.php?dispatch=products.view&product_id=29798

Mains Energizer

This form of energizer provides a reliable, consistent flow of electricity through the fence. It is the preferred energizer for permanent electric fences. It may cost slightly more than a battery powered energizer, but they often also have higher power.

They are easier and more economical to run, as there are no batteries to charge and maintain.

These energizers can range between 2.5 - 37 joules.

The sun (solar), wind and water are very similar as they are all natural ways of generating power. These methods of generating power are used to charge batteries, which in turn, power the electric fence energizer.

All three systems use the same 12 volt electric fence energizer, the only difference being the output of the energizer. These systems can be used in more remote areas where there is no mains power available:

Figure 14 A mains powered energizer

Image retrieved from http://gallagherelectricfencing.com/products/gallagher-mbx-2500.

Solar Energizer

This energizer uses the sun to provide energy. It then converts the energy into electricity to charge up its battery. It consists of a battery powered energizer, a battery to power the energizer, and a solar panel to use the sun to recharge the battery. These units are popular for use in remote areas which have no main electricity supply, and should be bought as a complete package. This ensures that the power available from the solar panel will match the power needed to operate the energizer.

When considering a solar energizer, it is important to analyse the sunshine hours it will be exposed to. These energizers are only as powerful as their battery.

Figure 15 A solar powered energizer

Image retrieved from http://ricfeelectn.com/solar-electric-fence-box/.

Wind Powered Units

Energy from the wind is harvested by a wind mill which in turn drives a generator to charge the battery that powers the electric fence energizer. Due to their reliance on the wind to charge the battery, wind powered units are only successful if there is regular wind to generate the electricity. During periods of no wind, the charge will decrease and gradually flatten the charge on the battery.

Water Powered Units

Water power is gathered in a similar way as hydroelectricity. Water energy is harvested from the water by diverting it over a small dam onto a water wheel. When the water turns the wheel, the wheel drives a small generator that charges the battery and furthermore powers the electric fence energizer. A constant supply of water is beneficial therefore consideration into its location is important.

Selecting an Energizer

When it comes to selecting the correct energizer for your farm, you need to consider the following:

- The class of stock you are trying to contain; farming type
- The distance the electricity has to run (size of the area)
- The source of power (mains, battery or solar, wind, hydro)
- Possibility of expansion
- The type of wire being used
- Whether your fence is permanent or temporary

Energizers are available in a variety of sizes. The following chart, from http://www.pel.co.nz/en-nz/helpful-information/choosing-your-energizer gives an indication of the size of energizer required to cover a certain area or distance, in joules.

It is important to note that the joule ratings vary between different branded energizers. Therefore, when considering what energizer best suits the needs of your farming system, also consider the fencing conditions and the type of energizer you will be using (solar, mains etc).

Energizer Selection Chart

	What distance/area do you want the energizer to power?	How will you power your fence?	Recommended energizer	Stored Energy (joules)	Maximum Output Energy (joules)
LARGE	**Up to 630 km** 850+ acres (350 ha)	Mains	863RS† / 863R†	97 J	63 J
	Up to 360 km 500 acres (200 ha)	Mains	836RS† / 836R†	54 J	36 J
	Up to 200 km 275 acres (110 ha)	Mains	820R†	34 J	22 J
MEDIUM	**Up to 180 km** 270 acres (110 ha)	Mains / Battery / Solar	418i†	24 J	18 J
	Up to 120 km 180 acres (70 ha)	Mains / Battery / Solar	412i†	16 J	12 J
	Up to 60 km 90 acres (30 ha)	Mains / Battery / Solar	406i / 406†	9 J	6 J
SMALL	**Up to 30 km** 45 acres (18 ha)	Mains / Battery / Solar	403	4.5 J	3 J
	Up to 20 km 30 acres (12 ha)	Mains / Battery / Solar	402	2.7 J	2 J
	Up to 10 km 15 acres (6 ha)	Mains / Battery / Solar	401	1.4 J	1 J
	Up to 5 km 8 acres (3 ha)	Mains / Battery / Solar	400†	0.7 J	0.5 J
	Up to 10 km	Battery / Solar	705S	0.63 J	0.5 J
	Up to 4 km	Battery	104B†	0.4 J	0.33 J
	Up to 3 km	Battery	103B†	0.29 J	0.23 J
	Up to 2 km	Battery	102B†	0.22 J	0.17 J
	Up to 2 km	Battery / Solar	702S	0.2 J	0.15 J
	Up to 2 km	Battery / Solar	101B	0.16 J	0.12 J
	Up to 1 km	Battery	5B	0.05 J	0.04 J

* = Europe Only † = Available in selected markets

NOTE: Area recommendations are a guide only and in multiple wire terms. Performance will be affected by the condition of your fence.

Design and Construction

There are many factors to consider when planning and designing an electric fence. They include:

- The location of your power supply
- Stock management
- Type of animals
- Distance and contour/geography of country being fenced
- Whether the fence is required for long term or short term grazing

How do you choose what type of fence is most suitable to your farming practice? The following chart from http://www.pel.co.nz/en-nz/helpful-information/selecting-electric-fence-type compares the three main types of electric fence structures:

Selecting an electric fence type

The best electric fence is the one that is suited to your requirements. Our table outlines the 3 main types of electric fence structures as a starting point to help you identify which fence type best suits your needs.

	Portable / Temporary	Semi-Permanent / Permanent	Permanent / High-Tensile
Length of Fence Placement	Short-moves frequently	up to 10 years*	20 years + *
Ease of Construction	Simple	Easy to medium	Medium Requires special tools or fencing contractor
Best Recommended for	Horses, cows, pets, domestic animals	Deer, horses, cows sheep, goats, pigs exotic animals	Deer, horses, cows sheep, goats, pigs exotic animals, predators
Containment Area	Short/Small	Unlimited	Unlimited
Primary Need	Temporary containment, stripgrazing	Pastures and internal fencing	Boundary and internal fencing
Key Benefits	Easy to install and relatively inexpensive. Offers greatest flexibility and portability	Can use any combination of post and wire types	Optimum strength for livestock management. Longer fence life with minimal maintenance.
Main Fence Components			
Post Type	Tread-ins, pigtails or fibreglass posts	Wood posts and battens, steel posts, fibreglass posts	Wood posts, steel posts
Wire Type	Poliwire, tape, rope or braid	Poliwire, tape or rope, steel or galvanised fence wire 2 mm (14 ga) - 2.5 mm (12.5 ga)	Galvanised high-tensile wire 2.5 mm (12.5 ga) - 4 mm (8 ga)
Energizer Type	Portable solar, small Mains / battery, Unigizer™	Mains, Unigizer™, battery, portable solar	Mains, Unigizer™, battery

*This timeframe also indicates expected fence life if using quality products and keeping fence maintained.

The design of a fence can mean the difference between it being a success or a failure. Please go to the following link to read an article from the PEL website http://www.pel.co.nz/en-nz/resources (Brochures and Fencing Manuals - PEL Electric Fence Manual), detailing how to plan the layout for a permanent electric fence.

There are three types of fence that are used for containing animals, poultry and ratites (emu, ostrich etc). They are multi-wire non-electric, multi-wire electric, and fabricated netting. The general properties of each for containing these animals are described below:

Multi-Wire Non Electric

This type of fence can be used for animals, poultry and ratites, but will require differing heights. Ratites need a high fence, and since the fence is not electric, some animals will try to jump over or push through the wires to get out.

Multi-Wire Electric

All animals can be kept behind an electric fence as they can be trained to respect it. Once an animal is trained to respect the fence, less voltage will usually be needed to control them.

The following table from the Lincoln University Farm Technical Manual (2011), illustrates the recommended number of wires and post spacing for permanent electric fences:

Table 1 Recommended number of wires and post spacing

Dairy Cattle	1 wire at 700-800mm height, posts spaced at 10-15m
Cattle and horses	2 or 3 wires, 900mm top wire height with posts spaced at 10-15m or posts at 15-30m with 1 to 3 droppers between
Sheep and pigs	4 wires, 900mm top wire height with posts spaced at 8-10m or posts at 15-30m with 1 to 3 droppers between
Goats, sheep and pigs	5 wires, 950-1000mm top wire height, posts and droppers as for sheep and pigs above
Deer	7 wires, 1500 top wire height, posts at 8-10m spacings

Note: The bottom wire height (from the ground) and the bottom wire spacings should be no more than 150mm, for sheep and goats.

Fabricated Netting

This fencing is ideal for use with poultry, ratites and sheep. When the netting is electrified, the stock are less likely to put their heads through the netting and damage the fence. The fence must be high for ratites as they can jump high.

Wire Recommendations

As discussed in the 'Other Equipment' section of this module, there are various wire options available when it comes to electric fencing:

The most commonly used for permanent fencing (cattle, sheep, deer, pigs etc) is high tensile 2.5mm wire. It is however, not suitable for horses or animals with thin skin due to the diameter being small resulting in poor visibility. When used for the construction of sheep and beef fences, it is recommended that battens be used. High tensile wire lasts for a long time, it is relatively easy to construct and is reasonably cost effective. Cattle can be easily contained behind one or two wires electrified, whereas sheep will require more.

Aluminium wire is mainly used as a lead out wire for permanent electric fences. It is highly conductive and is widely used on coastal properties as it is not as prone to corrosion as other wires. It can be used to contain sheep, horses and cattle.

The 4mm mild type wire is recommended for use on permanent fences constructed for thin skinned animals, such as horses. It is also very good visually due to its size. It also has a small amount of 'give' and doesn't tend to cut as much as a high tensile wire (including netting or barbed wire), should an animal get caught up in the fence. It is not as conductive as high tensile or aluminium wire.

The conductivity, or ability of wire to carry electricity, is measured in resistance (ohms). The following table illustrates the variations between different types of wires used for electric fencing:

Table 2 Differences between types of wires used

Wire Type	***Resistance (ohms/km)***	***Comments***
High Tensile 2.5mm	35 ohms/km	• a loose connection can be as much as 5,000 ohms • a dead short is zero ohms • aluminium coated wire has up to five times longer life and three times greater conductivity than 2.5mm HT wire
Aluminium 2.7mm	11.5 ohms/km	
4mm Mild	14 ohms/km	

Netting is used a lot on permanent fences for animals that tend to push or poke through for example, deer, cattle, sheep and lambs. Permanent netting is made with high tensile wire in contrast to the portable netting, which is made from poly-wire (which can be electrified). Where high tensile netting is used, it is recommended that outriggers or insulators are installed on a singular wire running above the netting itself. This will assist with keeping the animals off the netting fence protecting it and the animal from damage.

The recommended straining tension (kgf or kilograms of force) for a conventional fence constructed with 2.5mm high tensile wire is 150 kgf or 1,500 Newtons (Trafford, 2011). The full chart of recommended straining tensions for fencing wire can be view in Appendix 1 'Properties of Fencing Wire'.

The Earthing System

As discussed in the Electric Fence component section, an effective earthing set up is a vital part in the permanent electric fence system. Gallagher recommends the following when setting up an earthing system:

1. **"Soil conditions"**

Soil that is very dry, sandy or pumice will not conduct the electric current as effectively as clay or slightly damp soil. In these less than ideal conditions, it is more difficult to get an adequate earth system to ensure the animal receives the maximum shock. It is best to choose a damp area for earth installation where possible.

2. **The 3-3-2-1 earthing rule**

This general rule suggests you use a minimum of THREE galvanised stakes, placed THREE metres apart from each other, each TWO metres long (underground) and connected by ONE continuous wire." (www.gallagher.co.nz).

Please note, as mentioned above, this is the "general rule" for earthing systems. There are other systems which are just as effective. Some choose to place their galvanised pegs two metres deep and two metres apart, connected with a galvanised pipe at the top. There are also other products available on the market, such as the "Gallagher Super Earth Kit". This is recommended for use in areas with soils that are poor for earthing. Please go to the following link to read further:
https://am.gallagher.com/assets/Documents/76433.pdf

Other key points to note when setting up an earthing system:

- Install the earthing system as close to the energizer as possible
- The energizer earth (ground pegs) must be positioned at least 10m away from any other electrical (ground peg) system to reduce the possibility of mains (110V / 230V) power flowing consciously though any electric fence system
- Galvanised, unpainted earth pegs must be used. If they are not they will rust or corrode and will not work because they create resistance
- Do not allow bare wires or earthing materials to touch an iron clad or steel building
- Use double insulated cable to connect earth pegs
- Position at least 10m from metal pipes carrying domestic or stock water
- Position at least 20m from any dairy shed pipe work
- Materials must be protected from machinery and stock damage
- Positioned away from fertiliser, animal urine and manure (corrosion)

The earthing system requires a high standard of construction and must well be maintained because if live and earth wires come in contact, the fence becomes ineffective.

Lightning Diverters

"When lightning is about to strike in an area, it is attracted to the path of least resistance to earth. Often it is your fence that provides this easy path to earth. When lightning hits your fence, a surge of energy travels back to your fence energizer. It passes through your energizer, and into the earth electrode. After this event your fence energizer will probably need to be repaired.

A Lightning Fuse can divert most of this energy surge to earth. The Lightning Fuse is inserted between the energizer and fence. When the fuse "blows" the surge energy is directed to earth through the fuse unit - not the energizer. The electric fence energizer is protected and costly damage avoided" (www.sureguard.com.au).

The above paragraph describes the purpose of a lightning diverter as part of the electric fence system.

The best way to prevent lightning damaging the fence's energizer is to install these diverters at intervals along the fence line. A lightning strike is very high voltage and to ensure that the energizer is protected from damage, it is necessary to disconnect it from both the power source and the fence. But this is not always practical, as the farmer may be away at the time of the storm, and not able to reach the energizer in time.

For information on how to install a Lightning Diverter into an electric fence system, please go to https://am.gallagher.com/assets/Documents/Electric%20Fence%20Manual.pdf, section 4.3.2 "Install Lightning Diverters".

Supplying the Electricity to the Fence

Where the fence has the mains as the source of electricity, certain precautions have to be taken. The energizer should if possible be installed inside a building. The mains supply needs to be from a correctly fused and earthed electrical outlet. The feed out wires from the energizer outside to the fence can either be:

Overhead on Poles

This is a common system where a single wire is carried on poles from the energizer to the fence. The best system which helps to reduce the voltage drop is to use three wires, 300mm apart.

On an Existing Fence

A supply wire can be run on an existing fence. An existing wire is converted to carry electricity. This requires either outriggers being installed onto the fence or hardwood battens bolted onto the posts. The top wire of the fence is electrified and the intermediate battens are cut short.

Underground

This requires having the supply wire (usually double insulated wire) being carried inside a 12mm polythene pipe which has been buried to a depth of between 300-600mm. The distance of wire that can be buried underground should be no more than 100m.

Stock Management

Keeping Stock In

Farmers in New Zealand use electric fences to keep stock in an area to be grazed or to keep stock out of an area where they do not won't stock in (for example waterways, roads). They are particularly useful for separating different classes of stock (i.e. the ewes from the rams or bulls from the cows). When constructing fences in general, consideration should be given to the class of stock. A dairy farm will not require the same fence structure as a sheep breeding farm.

Portable electric fences are ideal for temporary grazing situations such as the grazing of winter crops or controlling pasture intake (for example reducing the amount of intake for in-calf heifers, overfeeding may increase the size of the calf resulting in birthing difficulties). These portable fences can be powered by battery or mains powered units. Larger paddocks can also be sub-divided by using temporary electric fences at a low cost yet providing effective stock control.

Stock must be trained to the electric fence. The Lincoln University Farm Technical Manual (2011) suggests the following:

"Select a small well fenced, holding paddock and place offset wires on this at about two thirds the height of the animals to be trained. Earth the remainder of the fence to the energizer earth and electrify the offset wires with the strongest possible pulse. The minimum training time required is 12 hours and most animals will be fully trained in 48 hours. The aim is to have stock approaching the fences with caution".

Keeping Predators Out

New Zealand electric fences have been used overseas to help keep predators away from domestic stock. These fences are purpose built and may carry a higher voltage than allowed here in New Zealand.

Physical and Psychological

An electric fence is as much a psychological barrier as a physical one. Once an animal has received a 'shock' from the fence, they tend not to forget and gain a 'respect' for fences. Although a single wire across a paddock is no physical barrier - stock that have been trained to electric fences will not cross it. Even though these animals haven't had a shock off this particular fence they still see it as a physical barrier. Stock that haven't been trained to using an electric fence generally do not show much respect for them.

Avoiding Damage

If a fence has been constructed poorly, for example, with incorrectly tensioned wires, not enough droppers, or it is too low, there are numerous problems which can arise.

Firstly, if the fence is not of strong construction or the electrified wires are not going, then stock will soon discover this. They will eventually try to escape or use it as a scratching post. Stock graze pasture right up to the fence, and will occasionally touch it by mistake. If they discover that the fence is not turned on, it is low, or weak, then they will simply attempt to push through or jump the wires. This extra strain on the

wire from the animal straining against it can break or weaken it. In portable electric fences, the wire will often break.

Results of a poorly constructed electric fence:

- Wire damage is a result of poor fencing, as is damage to posts and battens/droppers from the impact of the animal
- Extra strain on wires from animals pushing against it could weaken or even break the fence
- Injury to animal while trying to push through or jump wires in a permanent electric fence; animals may cut themselves or catch a leg in the fence. This can lead to nasty cuts or broken bones if the animal falls. Animals can also damage their wool, skin or pelt
- A temporary electric fence can become tangled around the animal and give them not only repeated electric shocks, but the wire/tape gives nasty burns and cuts when it is moving at speed along the skin
- Large animals could become stuck or tangled in netting fences
- The fence has poor containment properties resulting in stock management issues.

All of these issues are costly to the farmer – not only in time but also money. It is important to construct both permanent and temporary electric fences effectively to avoid damages occurring.

Portable Electric Fencing and Strip Grazing

Strip grazing is a grazing management system where temporary (portable) electric fences are used, ahead of and behind the animals, to 'ration' the feed which is available. It is a popular form of grazing in times of low feed. It is often called 'break feeding' when stock are being held on a forage crop in the winter, and the electric fence is referred to as the 'break'. The fence is moved a small distance further out into the crop each day, giving animals a small amount of access to the new feed. The same method is often used for grass also.

Figure 16 A single wire portable fence used to strip graze dairy cattle

Image retrieved from http://www.teara.govt.nz/en/photograph/15306/break-feeding.

The portable electric fence is ideal for strip grazing purposes, and is widely used. Stock soon learn that the fence is electrified and respect it, even though it is not a strong fence in terms of an actual barrier. These portable fences can be run off a mains electric fence, or from a battery powered energizer. Rather than using high tensile wire as in a permanent electric fence, tape or special poly wire is used. The wire can be used on multi-wire or single wire fences, but if higher visibility is required (as with horses), tape can be used. This tape is either white or coloured, and can be seen more readily.

The wire or tape used for a portable electric fence is wound onto a reel. The reel is either attached to something solid or a reel stand. Many reels can be attached at once to a reel stand, meaning that it is easy to create a multi-wire fence. The wire/tape is then wound out from the reel to the opposite end of the intended fence line, and a tread-in standard is placed approximately every 20 metres. The wire/tape is threaded through the standard to erect the fence and hold the wire/tape in place.

The following diagram is from the 'Gallagher Power Fence Systems User Manual', Please go to the following link for a reading on detailing the construction of a temporary/portable electric fence for both sheep and cattle: https://am.gallagher.com/assets/Documents/Electric%20Fence%20Manual.pdf, section 5.1.

Self-Test Two

Answer these questions based on the previous sections:

1. From what sources can electricity for an electric fence be obtained?

2. What are energizers designed to do?

3. What properties should wire for electric fences have?

4. What is the reason for having insulators in an electric fence?

5. List the main types of insulators available to farmers.

6. What materials can posts for an electric fence be made of?

Joule Ratings

There are two measurements of joules when it comes to electric fence energizers; output and stored. A joule is a unit of energy referring to the energy level of the energizer and the amount of electricity "felt" in the pulse. Energizers with a high wattage deliver more joules per second on the fence line. Therefore, when considering an energizer, compare the number of output joules rather than the stored joules.

When comparing output joule ratings to determine the best option for controlling livestock, there are many things to consider such as:

Variations in Climatic Conditions

Rainfall, humidity and wind can influence corrosion of the fence components. Therefore, the energizer would have to have a relatively high joule rating, to make sure the fence is still being electrified through the corrosion and through the varying climatic conditions, at a high enough joule rating to control the livestock present.

Significant Geographical Features

The joule rating in this situation would need to be moderate-high, as it needs to power every point of the fence. The steep sloped gullies cause the joule rating needed to be slightly higher than if the fence was just on an even surface.

Multiple Energizers

It is important to note that no more than one energizer may electrify any one fence line at any one time. It is also not recommended that a portable unit is attached to a mains unit earthing system at the same time.

The following chart contains information complied on Gallagher electric fence energizers. Please note, there will be a variation in Joule rating between different makes and models of energizers. The purpose of this chart is to show the output requirements for different classes of stock.

Output Ratings for Stock Classes:

Table 3 Output ratings for stock classes

		Sheep	***Dairy***	***Horses***
Output Rating (Joules)	Mains Energizer	4.5-57.0	0.7-57.0	0.7-57.0
	Solar Energizer	2.1	1.3-10.6	1.3-10.6
	Battery Energizer	1.1	0.09-2.0	0.09-2.0

Finding Faults

When a fault occurs in any part of the electric fence, there will be a loss of electricity. This will occur where electricity finds a pathway to earth instead of along the wire(s). This is known as leakage. Usually this will be caused by vegetation coming into contact with the fence. The best way of testing for leakage is to use a voltage tester. Where a fault occurs, it will show up as decreased voltage on the voltage tester.

Faults caused by factors other than vegetation can be difficult to find. The only way to find these faults is to walk along the fence line, take voltage measurements, and make a visual inspection of the fence.

Performance Checklist

When your electric fence is not performing, use the following checklist to help identify the issue. Check:

- The earth is functioning correctly
- The connections may be corroded or worn
- The distance of the wire is too long for the size of the earth or the energizer itself
- The electric fence wire may have corroded, causing rust
- The insulators may need replaced (or one may be damaged causing the current to leak)
- Excessive vegetation may be touching the fence (a tree down in strong wind or crop touching the wires of a portable fence)
- The phone line may be too close to electric fence system
- The connections or knots in the wire itself may not be adequate
- The source of the electricity is faulty

The following link may also be useful for identifying the source of a fault: https://am.gallagher.com/assets/Documents/Electric%20Fence%20Manual.pdf, page 39 “Fence Fault Finding Chart”.

Safety Considerations

Within this module we have already discussed the safety procedures around the use of earthing systems and lightning diverters. The following is information about keeping safe around electric fences, how to prevent radio and telephone interference and the placement of caution signs. With the high voltages often used in some electric fence systems, the design and construction of the electric fence components is strictly controlled. For example, telephone interference will make a ‘tick-tick’ noise on the phone, and can disrupt data transmissions such as faxes therefore there are guidelines in place to control these. Please go to https://am.gallagher.com/nz/products/electric-fencing/power/power-system-accessories/safety-and-protection for more information.

The link above is an outline of the safety requirements for electric fencing. It also details the requirements around signage and the installation of fences for areas where radio interference is a concern.

Manufacturers of electric fence systems provide installation instructions with all energizers sold. They take into consideration the earthing materials to be used, the placement of pegs (mains electricity only), the use of multiple energizers and the type of wire being electrified.

Other key points to note:

- Never load wires beyond their straining tension
- Consider the class of stock being fenced i.e. single wire electric fence would not be suitable for containing sheep or goats
- Never electrify barbed wire
- For boundary fences, build permanent electric fences. They are much stronger than portable, temporary electric fences.

Self-Test Three

Answer these questions based on the previous section.

1. What shape is ideal for paddocks with electric fences?

2. In hill country how should electric fences be planned?

3. What type of wire is best for electric fences?

4. How should live and earth wires be handled at gateways in the fence?

5. What tension is required for the wire of an electric fence constructed with 2.5mm high tensile wire?

Self-Test Answers

Test One

1. *F*
2. *F*
3. *T*
4. *T*
5. *T*

Test Two

1. *Mains and batteries*
2. *Apply a large voltage to the fence for a short period of time and generate enough power to give an electric shock to any livestock which touches the fence.*
3. *Strength*
   Convenient and safe to handle
   Resist corrosion
   Low resistance
4. *To prevent the flow of electricity through posts to the ground*
5. *Moulded plastic*
   Ceramic
   Self-insulating fence support
6. *To prevent the energizer being damaged by a lightning strike*
7. *Treated wood, steel, plastic, fibreglass*

Test Three

1. *As square as possible*
2. *To follow the contour of the hill*
3. *2.5mm high tensile wire*
4. *Be buried under the gateway*
5. *150kgf or 1500N*

Appendix 1: Properties of Fencing Wire

tension is most important. *Table 9.1* shows the properties of some common fence wires plus recommended straining tensions. Refer below for a description of how wire tension can be measured.

Table 9.1: **Properties of Fencing Wire**

Wire Diameter (mm)	*Length per 25 kg coil (m)*	*Approx. yield Point (kgf)*	*Breaking load (kgf)*	*Recommended straining tension (kgf)*
High Tensile				
1.6	1584	150	220	80
2.0	1013	270	395	110
2.5	648	430	620	150
3.15	408	580	840	200
3.55	321	840	1225	250
4.00	253	980	1410	300
Mild Steel				
1.6	1584	65	90	40
2.0	1013	100	140	65
2.5	648	150	215	80
3.15	408	250	365	150
3.55	321	320	460	200
4.00	253	400	600	250
4.50	200	510	745	315

Note: The units used in *Table 9.1* and elsewhere in this Section for force, load and tension are kgf (kilograms force). In the SI metric system, Newtons (N) is the unit for force and 'kilorights' should be used to express yield point, breaking load, tension, etc, as it is in some other publications. However, kgf is used here because it is likely to be more meaningful to those using this information. To convert kgf to N, multiply by 9.81: i.e., kgf x 9.81 = N

Example: The recommended tension in a conventional fence is 150 kgf.

150 x 9.81 = 1472 (N) or approximately 1500 N.

Figure 17 Properties of Fencing Wire

Source: Trafford, G. (2011). Lincoln University Farm Technical Manual

References

Gallagher online www.gallagher.co.nz:

- “The economical solution to permanent fencing”
- “The Power Fence Systems User Manual”
- “Fault identification chart”
- “Permanent Electric Fencing Needs”
- “Super Earth Kit”
- PEL online www.pel.co.nz
- “The PEL electric fencing manual”
- “Selecting an electric fence type”
  Trafford, G. (2011). Lincoln University Farm Technical Manual.
- www.electricfencing.co.uk

Glossary

a.c.	Alternating current as from a mains power supply (i.e. 110/120v or 220/240v)
Amp (Ampere)	Unit of flow of current. Calculated as watts divided by voltage
Capacitors	Energizers use capacitors to store energy. This energy is released through the output transformer in the form of a high energy pulse
Conductor	A material through which current will readily flow. All metals are conductors
Current	It is the current, the duration and rate of its flow which causes the shock. Increasing the voltage increases the current whereas increasing the resistance decreases the current
d.c.	Direct current (from 12v battery input)
Ground	The rods in the ground which are connected to the ground terminal on the energizer. The ground collects the pulse through the earth when an animal touches the live wire and completes the circuit
Impedance	Total effective fence load. This is made up of Capacitance, Inductance and Resistance. In terms of the energizer, low impedance means low internal resistance of the energizer resulting in more power on the fence
Induction	In terms of the fenceline, this is the transfer of power without physical contact, from an electrified wire to a non-electric wire or gate. This is usually noticed by touching a wire on the conventional fence (or gate) and finding it "live". This phenomenon is more noticeable in damp weather conditions
Insulator	A material which resists the flow of current
Joule	Unit of energy. A joule is one watt for one second. There are two measurements of joules when it comes to electric fence energizers; output and stored. A joule is a unit of energy referring to the energy level of the energizer and the amount of electricity "felt" in the pulse
Leakage	Small losses of energy from the Fenceline to earth. These losses can be caused by seasonal vegetation growth, faulty insulators etc
Lead out wire	"The lead out is the high conductive insulated cable or wire that connects the energizer
or Feed out wire	to the fence. It is important to have a lead out that is able to deliver the full power of the energizer to the fence. If the fence is several hundred meters from the building where the energizer is installed cable should be used to get the power to the outside of the building' www.gallagher.co.nz
Live wire	The wire connected to the energizer power terminal which carries the current

Ohm	Unit of resistance
Resistance	Anything that causes a loss of power on the fence. This is often referred to as "the load" and is measured in ohms.
Short	A large loss of voltage from the fenceline to the ground. This can be caused by live wires touching the ground or ground wires
Volt	Unit of electrical pressure which creates the current flow
Watt	Unit of power