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## Engineering for Grazed Systems

### Introduction

Fencing and water systems has always been a controversial subject since Joseph F. Glidden in 1874 invented the modern barbed wire. Land owners can now keep “free grazers” away from their range and water sources. To stop these range wars the states created fencing boundary laws which are continuously being changed even today. As we take a closer look into fence as something more than just boundary markers, we can find a management tool for improved calf performance, improved range/forage production and quality, and improved soil health. Fence product manufacturers have not been stagnant on the development of new and improved products. As livestock producers look into different types of grazing techniques and management, and also expanded grazing on to crop fields, it is time we take a new look at the fence and water source products that are now available.

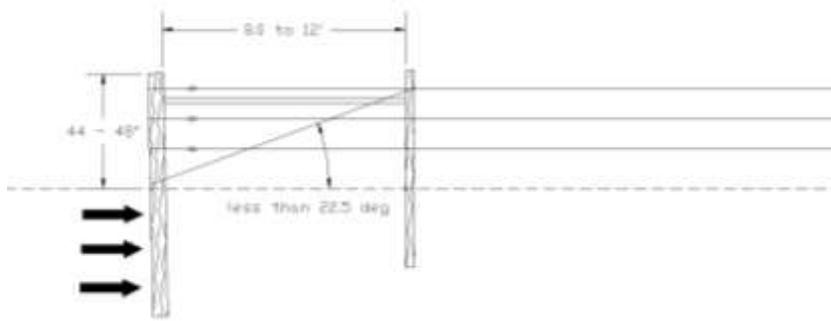
Fencing services several functions. It is a property boundary marker, a physical/psychological barrier, and a grazing behavior modification tool for livestock. Internal cross fences whether they are portable or permanent, function to work with the grazing behavior of cows or calves to achieve a desired result. Fences can also be used to determine the labor input. A continuous grazing operation will have the least amount of fence and labor input or an intensely managed system can have quite a bit of fencing and labor inputs. With so many options in fence type and construction, once a management style is in practice, the fence type can be selected.

This paper will briefly look at some of the more popular types of fence and construction methods and some new water delivery methods. Currently cattlemen are looking for new grazing opportunities and want to expand grazing on to forages in crop fields; fence and water systems will have to be adapted.

### Barbed Wire

Invented in 1874, it has been a standard fence since that time. Barbed wire construction uses 12.5 gauge barbed galvanized steel wire with either 3.5 inch or 4 inch x 6.5 foot creosote posts. Typical wire arrangements have been 4 to 6 wire.

Barbed wire has many advantages. It is a visual and physical barrier for humans and livestock. It uses simple construction methods and has over time proved its effectiveness. When using quality materials this fence can last many years. Most barbed wire fence uses a simple box corner construction (Figure 1) and post spacing at 16.5 feet (1 rod).



**Figure 1: Simple Box Corner construction used on barbed wire or permanent electric fence**

When building these corner systems it is important to use at least a 5 inch x 8 foot corner post, 4 inch x 6.5 foot brace post, and a horizontal brace length of 8 to 12 feet. When the horizontal brace is 8 feet or longer the bracing wire angle is lower than 22.5 degrees. This low angle assists the transfer of force from the wires which is applied to the top half of the corner post to a compression force applied to the soil in the lower half of the corner posts (see arrows). Box corners that have horizontal braces of 6.5 feet will have a brace wire angle over 24 degrees and it will tend to have a rotational force applied to the corner post as it pivots off of the brace post. Heavy wire loads and an inadequate box corner construction will start to tip the corner over, making it difficult to keep the wires tight.

There are some disadvantages to barbed wire. As the fence ages, maintenance will be an issue. Creosote posts at rod spacing give the producer many posts to check and replace as they deteriorate. Wildlife finds it difficult to pass through 5 and 6 wire fences and cause damage. Barbed wire also is susceptible to dynamic loads from snow, ice, and livestock pressure. The more wires the heavier the loads. In order to stabilize the loads, double box corners may be necessary. Using material cost at current retail prices from Tractor Supply Company in Bismarck, a 4 wire barbed wire fence will cost \$0.89 per foot.

#### Electric Fence

Permanent or semi-permanent electric fences along with portable electric fence will be the best option for cattlemen as they adopt high management grazing practices or expand their grazing into crop fields. Electric fences are more of a psychological barrier than a physical one. Since the wire is suspended under tension springs, the fence uses less posts. PVC coated fiberglass posts provide a lower cost and longer lifespan than creosote posts.

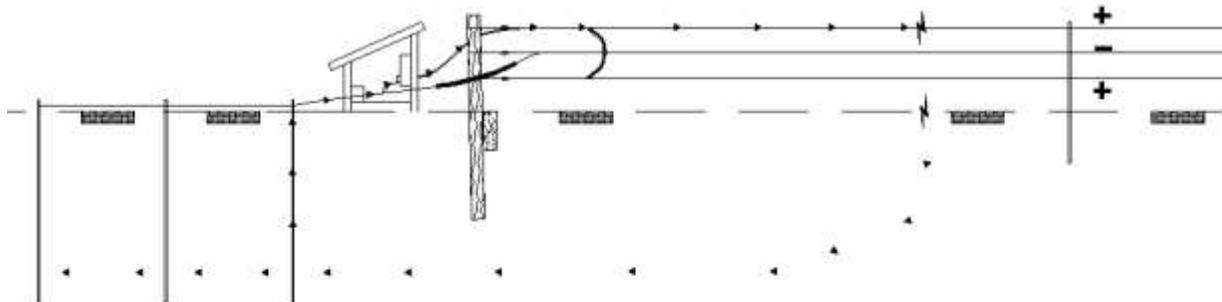
Over the past several years manufacturers have offered more options and more reliable components in the electric energizers. These energizers come in a wide arrangement of output power (joule output) and power supply. They can operate from 120 volt or 12 volt battery systems with solar recharging systems and some are remote controlled. Solar energizers that use the newest technology in solar panels and voltage regulator/controller can provide many years of reliable service. Some of the new controllers will identify the battery charge, self-diagnosis for problems, and equalize a flooded battery for longer life. Always follow manufacturer recommendations for energizer size and use.

The most challenging component of any electric fence is proper grounding. A rule of thumb is to use 1 – 8 foot ground rod per 5 joules of energizer output or a minimum of 3 – 8 foot ground rods spaced at a minimum of 10 feet apart. The fence ground has to be independent of other electrical grounds and the

fence should not run parallel or be 50 feet next to buried telephone lines. Only use galvanized ground rods for steel wire. Copper rods will cause electrolysis in the energizer.

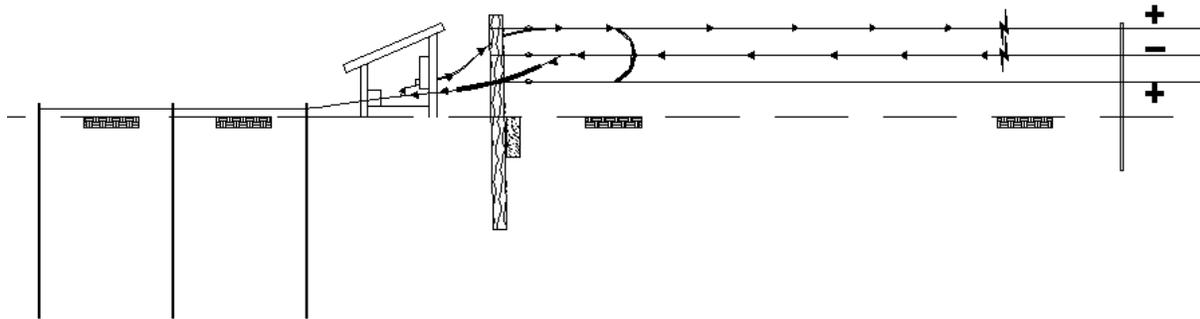
In order for the electric fence to be effective as a barrier to cows or calves the electric circuit will have to be closed by the cow touching the hot wire and the electrical current to pass through to the ground. This will give the cow the “snap”. Closing the circuit can happen through an earth return or a ground wire return.

In an earth return (Figure 2) the cow or calf touches one of the hot wires (+) and the current passes through them and into the soil. The current will travel to the nearest ground rod and back to the energizer to close the circuit. The cow will now feel a “snap”. Earth returns work well until the soil is dry. Under normal operation hot wire voltage should be above 3,500 volts. Dry soils have much more resistance than moist soils. The voltage loss can be so great that there will be a weak to no “snap”. Regions that are typically dry need to use at least a 2 wire fence where one wire is grounded. The wire should be grounded at the energizer and in multiple locations along the fence. One ground rod per quarter mile may be necessary. Now the current has a shorter route to reach a ground when the cows or calves are far away from the energizer. Also place ground rods in areas where the soils are normally wetter, such as in the bottom of a canyon or in a wetland.



**Figure 2: Earth Return**

A ground wire return fence will use a dedicated wire to close the electrical circuit (Figure 3). This wire will be grounded at the energizer and at multiple locations along the fence. The “snap” occurs when the cow or calf touches a hot wire (+) and the ground wire (-) at the same time. This closes the circuit with the least amount of resistance. All permanent electric fences in arid or semi-arid regions should have at least 1 ground wire.



**Figure 3: Ground Wire Return**

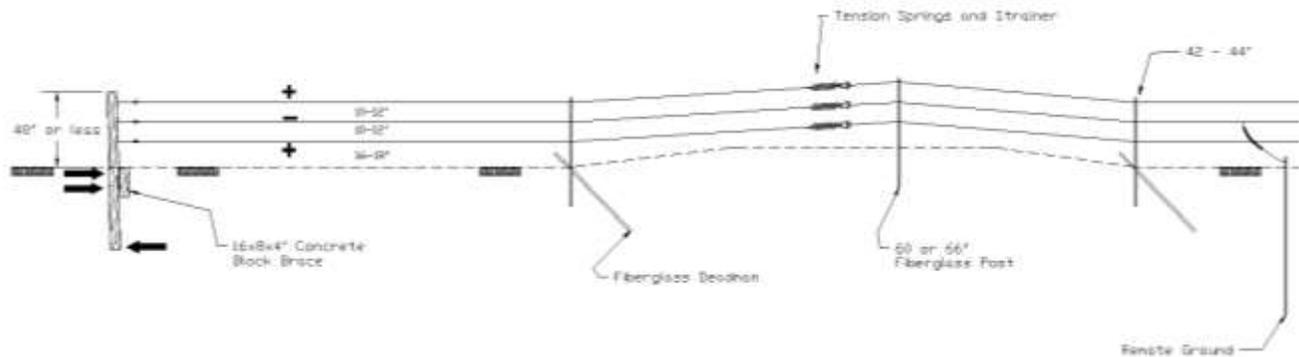
### 3 – Wire Permanent Electric Fence

The most common permanent electric fence is the 3 – wire (Figure 4). Two wires are hot and one is the ground. Generally the middle wire is ground but arrangement can be changed if all the wires are insulated. This fence uses 12.5 gauge high tensile wire (140,000 psi minimum), tension springs, 7/8 inch x 60 or 66 inch PVC coated fiberglass posts (pre-drilled), 6 inch x 8 feet corner posts, and 4 inch x 7 feet line posts. Fiberglass post spacing can range from 25 feet to 100 feet with a 4 inch line post every 300 feet. Post spacing is dependent on the terrain. Rougher topography tends to have closer post spacing. The coated fiberglass is smooth and easy to pull out of the ground. Areas in the fence where there is an upward force of the wire the fiberglass post must be supported by a dead man or replaced with a wooden line post. It is suggested to out a wooden line post at least every 300 feet in open and flat areas to help stabilize the fiberglass posts from heavy dynamic load caused by snow, debris (tumble weeds), and wind.

A great advantage of this fence is that top wire height is 38 or 40 inches and bottom wire height is 16-18 inches. This adequate to hold in cows and calves but allows antelope to pass under the bottom wire and deer and elk to pass over the top without much impact to the fence. Also the 18 inch bottom wire height allows room for a working dog to pass.

One key feature of a 3 – wire electric fence is its constructability. Fencing contractors that have skid loaders and wire trailers with multiple wire spinning jenny's can build this fence rapidly, which is a good value to the producer. A skid loader with a powered auger digger or post pounder is invaluable to fence construction. Also the loader and a bucket can be used to push in fiberglass post. A post height gauge can be made out of a 44" steel pipe. This helps set a consistent post height but also minimizes post shatter as it is pushed in the ground.

One important feature that can be used in 1 to 3 wire electric fences is block bracing (Figure 4). Fences with 4 or more wires should use the stronger simple box corner construction (Figure 1). The forces applied to a block braced corner in a 3 wire are normally not enough to tip the corner. A 16 x 8 x 4 inch solid concrete block is tightly placed between the post and the force. As the torque is applied to the post this gives a larger surface area to push on (see arrows).



**Figure 4: 3 – Wire arrangement with a block braced corner post**

When using a skid loader with a powered auger to build this fence, use the 12 inch auger bit for the corners and the 6 inch bit for the line posts. Set the corner where over 50% of its length is buried. If the top wire height is 38 inches, then set the corner at 44 inch in height. Place the block in the bore so that as the post is being pulled by the wire it pushes into the block. Tamp around the block and the back of the post well.

Table 1 is a materials list with their retail price from Tractor Supply Company in Bismarck, ND. This ½ mile fence does not include a gate or the energizer. Add \$ 0.2 per foot for a gate. A crew of two fence builders with a skid loader and ATV can build this fence in half a day.

**Table 1: Materials List for 3 Wire High Tensile 1/2 mile with No Gate**

2014 Prices from Tractor Supply Company from Bismarck, ND

<u>Part</u>	<u>Price</u>	<u># in Package</u>	<u>Price (ea)</u>	<u># Needed</u>	<u>Total Price</u>
6x8 Treated Post	\$15.99	1.00	\$15.99	2.00	\$31.98
4x6.5 Treated Post	\$8.99	1.00	\$8.99	7.00	\$62.93
7/8 x 66" FG Post	\$7.39	1.00	\$7.39	60.00	\$443.40
Concrete Block	\$1.20	1.00	\$1.20	2.00	\$2.40
Wire roll	\$99.99	4,000.00	\$0.02	8,000.00	\$199.98
Cotter Keys	\$4.90	50.00	\$0.10	200.00	\$19.60
Crimping Sleeves	\$4.29	25.00	\$0.17	25.00	\$4.29
Post Insulators	\$7.49	25.00	\$0.30	14.00	\$4.19
End Strainers	\$7.79	10.00	\$0.78	4.00	\$3.12
Strainers	\$4.79	1.00	\$4.79	6.00	\$28.74
Tension Springs	\$8.49	1.00	\$8.49	6.00	\$50.94
Ground Rods	\$17.99	1.00	\$17.99	3.00	\$53.97
Insulated Wire	\$16.99	50.00	\$0.34	20.00	\$6.80
					\$912.34 <b>Total</b>
					<b>\$0.35 per ft</b>

## Semi – Permanent Electric Fence

There is a class of electric fence that may not be permanent but it is not a portable or temporary fence. This fence looks similar to a permanent electric fence but it uses different wire and posts. It can be built quickly and with a little work it can be removed. A fence like this may be a perfect cross fence for rented property where the landowner is not interested in building fence infrastructure. The fence can remain personal property of the tenant and be removed when the lease is over. This fence also can be constructed as perimeter fence or cross fence in crop fields. It is stronger than single hot wire temporary and it is more wildlife proof. Another function of this fence or permanent electric is to work as an electric power and ground wire conveyance to the center of a pasture. The producer can tie off on this fence at any place to attach their poly wire. This can help minimize the length of the poly wire fence and provide a low resistance conductor and ground wire to the center of a pasture or paddock.

This fence is constructed using block bracing on the corners but the corner post can be 4 inch by 7 foot posts. Wood line posts can be 3 or 4 inch tops. Fiberglass posts can either be the 7/8 x 60 inch or the lower cost 11/16 x 54 inch post. For the wire use a 14 gauge galvanized steel wire with strainers and tension springs. This wire is not as strong as high tensile but it is easy to repair and roll back up. Generally this fence is a two wire, with the top wire hot and the bottom wire ground. Build the fence with both wires insulated so the polarity can be reversed to make the bottom wire hot or both wires hot. This is helpful to help teach baby calves about electric fence.

**Table 2: Materials List for 2 - Wire 14 ga Galvanized 1/2 mile, no Gate, Semi Permanent**

2014 Prices from Tractor Supply Company from Bismarck, ND

<u>Part</u>	<u>Price</u>	<u># in Package</u>	<u>Price (ea)</u>	<u># Needed</u>	<u>Total Price</u>
4x6.5 Treated Post	\$8.99	1.00	\$8.99	9.00	\$80.91
11/16 x 54 FG Post	\$5.50	1.00	\$5.50	60.00	\$330.00
Concrete Block	\$1.20	1.00	\$1.20	2.00	\$2.40
Wire roll (ft)	\$44.99	2,640.00	\$0.02	5,500.00	\$93.73
Cotter Keys	\$4.90	50.00	\$0.10	120.00	\$11.76
Post Insulators	\$7.49	25.00	\$0.30	14.00	\$4.19
End Strainers	\$7.79	10.00	\$0.78	4.00	\$3.12
Strainers	\$4.79	1.00	\$4.79	4.00	\$19.16
Tension Springs	\$8.49	1.00	\$8.49	4.00	\$33.96
Ground Rods	\$17.99	1.00	\$17.99	3.00	\$53.97
Insulated Wire (ft)	\$16.99	50.00	\$0.34	20.00	\$6.80
					\$640.00 <b>Total</b>
					\$0.24 <b>per ft</b>

## Portable Water

Cattlemen are increasing adopting a smaller paddock approach with more rapid moves in rotational grazing. This can lead to some issues with water supply. If cattlemen want to graze in crop fields there is also some trouble with water supply and with permanent tanks located in farm fields. Concern over the cost of a permanent installation and also over compaction around the tanks has deterred cattlemen from grazing these areas. One possible solution is to use portable stock tanks with moveable surface tubing (Figure 5).



**Figure 5: K-Line Irrigation's stainless steel stock tank**

Buried pressure pipelines and mounted tanks are a great grazing tool to provide water to livestock, but in multiple paddocks the amount of tanks and pipe can be overwhelming. Portable tanks and tubing allows for expanded water infrastructure without the expense. The tanks can be moved with the cow or calf rotation which will provide a water source near the livestock and minimize trampled areas that surround permanent tanks.

Portable tanks and tubing can be moved with an ATV. The K-Line Irrigation tubing is made to be moved and even though it is made from polyethylene. Its special fabrication allows the tube to not hold to a shape memory. The tube forms to the topography of the soil and extreme heat doesn't deform the tube. It is not frost protected and can only be used in times of above freezing temperatures.

Engineering and tube layout follows the same design criteria that buried PVC pipe has. Operational and static pressure at the hydrant must be carefully calculated so the water flow can overcome friction loss and elevation losses for the tubing. Well flow capacities need to be measured and matched to the number of livestock in the pasture. The tubing comes in rolls of 300 to 370 foot with tube diameters of 1 ¼ inch to 2 inch. Each roll is connected together with cam lock fittings. The producer can add to the line or shorten it as it is needed. Portable air / vacuum vents such as the Waterman AVP 1 can be installed in a K-Line Irrigation pod and can be connected though cam lock fittings along the length of the tube (Figure 6). In rough pastures the air vent can be placed at the ridge crests to protect the tube from air locks and vacuum problems. Depending on the water flow, pressure, and the topography 1,000 foot to 3,000 foot surface tubing is possible.



**Figure 6: K-Line 1 1/4" tube connected to water hydrant with an AVP 1 air vent in the pod**

Normally the tubing is connected and supplied from a pressured water hydrant, but it can also be supply as a gravity system. The tube can be supplied from a large tank or cistern. The cistern tank must be at least 10 feet about the highest crest of the tube and tank elevation. The tube will have to be well vented and the inlet riser from the cistern tank may need a gravel filter if there are excessive algae or debris.

The portable tanks do have limited supply of storage. In order for quick and easy moves with an ATV the tank only has 30 gallon water storage. The pasture systems will still require proper storage for a pump or well failure. Large permanent tanks should be located near the livestock somewhere in the pasture or field. For extra storage in pressure or gravity systems a portable cistern can be made from 1,000 or 1,500 gallon nurse tanks on running gear. These storage cisterns can also be moved with the cows and portable tanks.

#### Conclusion

The range and forage based grazing system's water and fence infrastructure is a large and necessary expense to any operation. Like most agricultural systems there are many options to choose from. If the grazing practice has frequent paddock moves and the cow or calf is in a low stress environment, then alternatives to conventional barbed wire fence and permanent stock tanks may be advisable. These alternatives are available and can be installed using simple construction techniques. The flexibility of electric fence and portable water can be adapted to crop field grazing and also be a complement to portable fencing and also barbed wire.