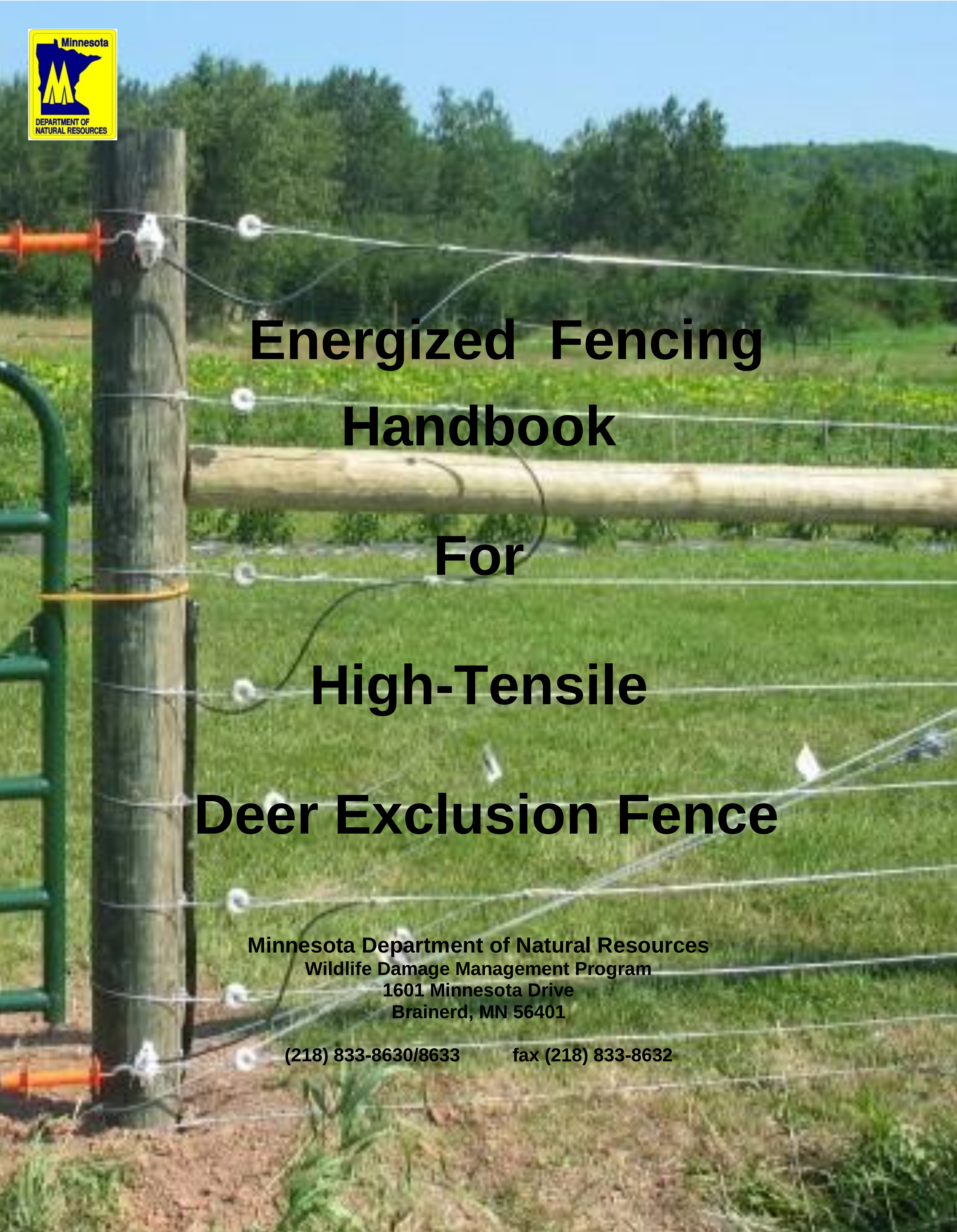

Energized Fencing Handbook

For

High-Tensile

Deer Exclusion Fence

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Energized Fencing for Deer

For commercial growers in a moderate to high deer density situation, energized fencing may be the method of choice for wildlife damage abatement, particularly when larger acreages are involved, making woven-wire fencing cost prohibitive. A properly installed and maintained energized fence can virtually eliminate deer depredation. It is important to remember that an energized fence is **not** a physical barrier against deer entry as is woven-wire fencing. An energized fence acts as a psychological barrier that deer will continually test for an entry location. Therefore, it is extremely important that all aspects of an energized fence be monitored and maintained on a regular schedule. An energized fence system should operate 24 hour per day throughout the entire year to be effective.

Figure 1. Vertical energized fence

There are two styles of energized fences commonly used for deer abatement; vertical and slant. The eight wire vertical fence is described in this handbook. The slant fence has been used to some degree in Minnesota but is more commonly used in eastern states. Minnesota depredation specialists have found it to be more difficult to install as well as maintain and it seems more prone to failure. The slant style is very adaptable to hilly sites with frequent grade changes.

Figure 2. Slant style energized fence.

A pictorial glossary is located in Appendix A for further explanation of the fence components and the tools discussed in this manual.

General fence specifications

Purpose

To construct a deer-resistant exclosure fence that will reduce or eliminate access by white-tailed deer to prevent the depredation of agricultural crops.

Description

An electric fence, approximately six ft. in height, comprised of a pressure treated wooden post frame supporting eight strands of 12.5 gauge, smooth, high-tensile wire. The energizer may be powered by 110/220v AC current or 6/12 volt DC battery. DC powered systems may incorporate solar power as part of the recharging system for the battery. All wires are energized except for the bottom wire, which is part of the grounding system. Spacer battens are placed at 15 ft. intervals along the fence line, to ensure proper wire spacing throughout the fence.

Planning & Design

Thoughtful planning in the design and layout of the fence regardless of type can reduce material cost; save time during installation; encompass more area; and ease maintenance. In short, it will provide a more cost effective and efficient use of your resources. The following steps will help you in your planning process:

1. Check local laws and zoning regulations regarding fences and electricity, especially in urban areas.

2. Determine the size enclosure you need for efficient operation. Allow adequate space for equipment to maneuver around obstacles and provide sufficient clearance to avoid the fence (especially watch corners). Plan for the future. Determine if roads or equipment will need access around the outside and inside of the enclosure. This is a good time to mark the proposed corners with a stake and flagging.

3. Locate all hazards and obstacles (e.g. power lines, hills, dips, water, underground utilities, etc.). **Be sure to call Gopher One (1-800-252-1166) to locate all underground utilities prior to digging.**

4. Areas that are square are the most cost efficient in terms of area enclosed per lineal ft. of perimeter fence. Strive to keep the perimeter simple by eliminating as many corners as possible. Remember that it is less costly to enclose a rectangular area than it is to enclose an "L" shaped area of the same perimeter length (due to the higher cost of corner assemblies).

   Layout comparisons. Area A has the same perimeter length as Area B yet it has two more corners. Area B will enclose more surface area for less total cost and is an easier installation. Keep this in mind when obstacles such as buildings, wetlands, or hills are factors in your design. It may be more cost effective to enclose a small pond or structure rather than fence around it.

5. Try to avoid rapid changes in grade and avoid crossing ditches and low wet areas as much as possible. These areas are hot spots for future maintenance issues, and are more easily penetrated by deer. They can also increase costs through the need for additional brace assemblies or other physical barriers.

Gates should be located on level ground. If earth work is required to prepare a level area; complete this prior to the fence construction. Changes in grade will impact post elevations and it is much easier to accomplish the grade changes without working around the fence as an obstacle.

6. Determine the number of gates necessary for efficient operation, using as few gates as possible. Keep in mind that corner and gate assemblies are the most expensive and labor intensive components of the fence. Locating gates next to corner brace assemblies where possible will save on the cost of additional brace assemblies.

7. Determine the desired width of gate openings. Make sure they are adequate for the largest piece of equipment you will be using. If in doubt, go larger. Gate openings can vary in width from 4' to 32'. Keep in mind however, that the gates are the weak point as far as the security of your enclosure. **The same bracing is required regardless of the size of the gate.**

8. Prepare a sketch of the layout of the fence, highlighting the perimeter dimensions; locations of corner and brace posts; as well as gates and gate assemblies (**Fig.3**). Indicate any features or obstacles to be avoided, such as utilities.

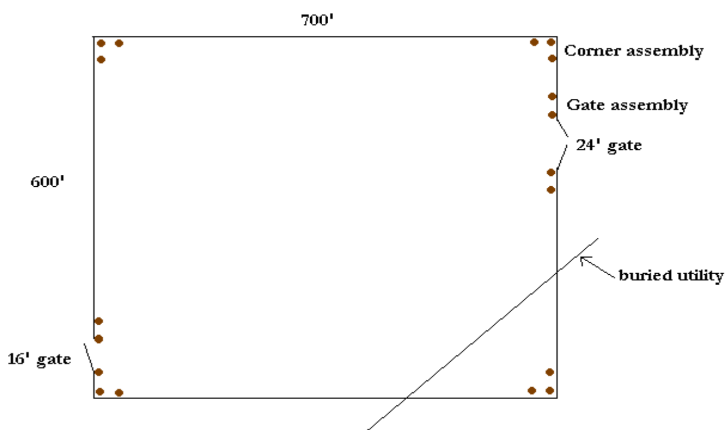


Figure 3. A simple sketch of the fence layout.

9. Plan to build your new fence at least 5' from old fence rows, brush lines or woods. Old fence rows are often full of old wire and other metallic debris that can create future problems.

10. The fence charger should be on hand before construction begins so that each section of fence can be energized as soon as it has been completed.

Site Preparation

Clear a swath of 20’ (10’ on each side of the fence line) to provide room to maneuver construction equipment. Remove stumps, large rock, and mow ground cover close to the ground. Mowing close to the ground will reveal hidden obstacles and holes that could pose trip hazards to the workers. It will also make marking locations for post holes much easier and will ease the task of backfilling the soil into the hole. It is worth the effort required!

Energized fence basics

An energized fence is an electrical system, comprised of a grounding system that includes lightening protection, and the energized fence wires designed to deliver the shock. The energizer provides a brief, .003 second, pulse of energy. A shock is delivered when contact is made between the wire that carries the pulse and the grounding system. The animal (or careless human) provides the contact between the wire and ground system and receives the shock.

Electrical Systems

Wire Spacing

Proper wire spacing is crucial to deliver voltage to the animal’s face (in front of the ears). If the animal’s head is through the plane of the fence before it receives voltage, it will bolt forward and breech the fence.

- The bottom energized wire must be within 12” of the ground to control deer (6” for raccoons). Deer naturally search for a place to go under or through a fence. As a last resort they will jump over the fence. By delivering voltage to the animal while it is searching for a place to go through, the learning process is enhanced. The deer will then avoid the fence rather than jump it.
- Once a deer has learned to jump an energized fence, it will continue to jump it. An animal that is jumping an energized fence must be eliminated.
- Spacer battens should be installed at least every 15 feet. This is the part of the fence that landowners most commonly underestimate. Battens are the most inexpensive portion of the fence and yet can make or break the effectiveness of the fence. The battens maintain proper wire spacing, thus reducing the chances of deer slipping through improperly spaced wires.
- When measured from the ground the wires should be spaced as follows:

- 0-2” ground wire
- 6” first hot wire if raccoon control is desired (a total of eight hot wires)
- 12” first hot wire without raccoon control (a total of seven hot wires)
- Other wires spaced as follows: 20”, 28”, 36”, 44”, 56”, 68”. (See figure 4.)

It is critical when building an energized fence that the ground and power source be installed first. All sections of fence (even if only a short section) must be energized immediately following construction. If deer are given the opportunity to learn that they can breech a fence, they will continue to do so, even when the fence is completed and the power is on. These deer must then be eliminated to ensure that others do not follow suit. The same thought applies throughout the year. Any time an energized fence is in place it should be energized, even during winter months when there is no vegetable or other crop to protect.

Insulators

There are a wide variety of insulators available for use with wooden posts, consisting of porcelain or plastic material. Porcelain insulators last longer, and are fire resistant. Do not use ceramic insulators which are porous and will retain moisture. Landowners choosing to use plastic insulators should take the following precautions to extend the life of the insulators and to prevent electrical shorts resulting in lower voltage:

- There must be at least 1 cm. of material between the area where the live wire is located and where it is attached to the post.
- Use steel reinforced insulators when there is high tension on the insulator.
- Use galvanized nails and staples to fasten the insulators.
- Do not distort the insulators with nails or staples.

Selecting an Energizer

Use a good quality energizer. This is the heart of the system and is no place to try to save a few dollars.

The most common energizers are 110v AC powered. They are the preferred option for several reasons: power is guaranteed unless there is a power outage; there is no monitoring or charging of a battery; and AC chargers are the least expensive to operate.

Battery powered energizers are just as effective as AC powered units of equivalent joule rating as long as the battery is properly charged and operational. Compare energizers by power rating (joules) per unit of cost. Any energizer used to control deer should maintain fences above 6,000 volts. Joules are a unit of energy that represents the “push” of the electrical charge on the fence wire.

When using battery powered energizers, always have two quality batteries available. This allows you to charge one battery while the other is running the fence.

Solar energizers

The solar panel of a solar energizer system provides an energy source to maintain a trickle charge to the battery within the system. Solar panels are not intended to provide the power to operate the energizer itself. The battery is the power source. Solar panels will usually greatly extend the cycle of time required between recharging the battery and may eliminate the need to recharge the battery entirely.

> It should be noted, that solar panels can confuse "trouble shooting" a battery powered fence system. Snow, dirt or debris can accumulate on the solar panel and reduce or even eliminate its ability to produce electrical power. Further, a solar panel will produce sufficient electricity, in some systems, to operate the energizer during daylight hours even with a discharged battery. When testing the voltage of a system equipped with a solar panel it is a good practice to check the voltage, then cover the panel with any material to block the sun (cardboard, shirt, jacket, towel) and recheck the voltage 30 minutes, or more, later. A drop in the voltage readings indicates that the battery may need attention.

Voltage

The electrical shock delivered by the fence to the animal is the deterrent. Remember these fences are not physical barriers. Most animals are fully capable of going over, under, or through them. Energized fences are effective only when the animal has experienced negative reinforcement and has learned to avoid the discomfort of the energized shock.

- The fence must maintain adequate voltage (≥6000 volts) to deter deer.
- The fence must remain clean. A "dirty" fence (vegetation growing on fence; poor maintenance) will lose voltage and be ineffective.

The Grounding System

Key elements of a good grounding system:

- The ground should be as good as or better than the utility ground (≤ 10 Ohms). A good ground translates to voltage being delivered to the animal. Fences not adequately grounded will not have sufficient voltage to deter penetration by deer. Use 4, 6' galvanized ground rods per every 2,000 feet of fence line.

- Ground rods should be driven 6' deep and placed 10' apart. Connect ground rods to the bottom wire of the fence.

- One set of rods should be provided as ground for the energizer.

- Ground rods should be placed at least 30' from:

  - another ground rod connected to a different electrical system
  - a telephone ground rod
  - underground metal piping used for water
  - any metal support or structure underground

Check for efficient grounding by putting one lead of a voltmeter on the ground rod and the second lead on the shaft of a screwdriver that has been pushed into the ground. If grounding is sufficient, the voltmeter reading should be .00. If the meter has a reading, make sure that the ground rods are galvanized and are long enough (at least 6'). Add additional ground rods as necessary.

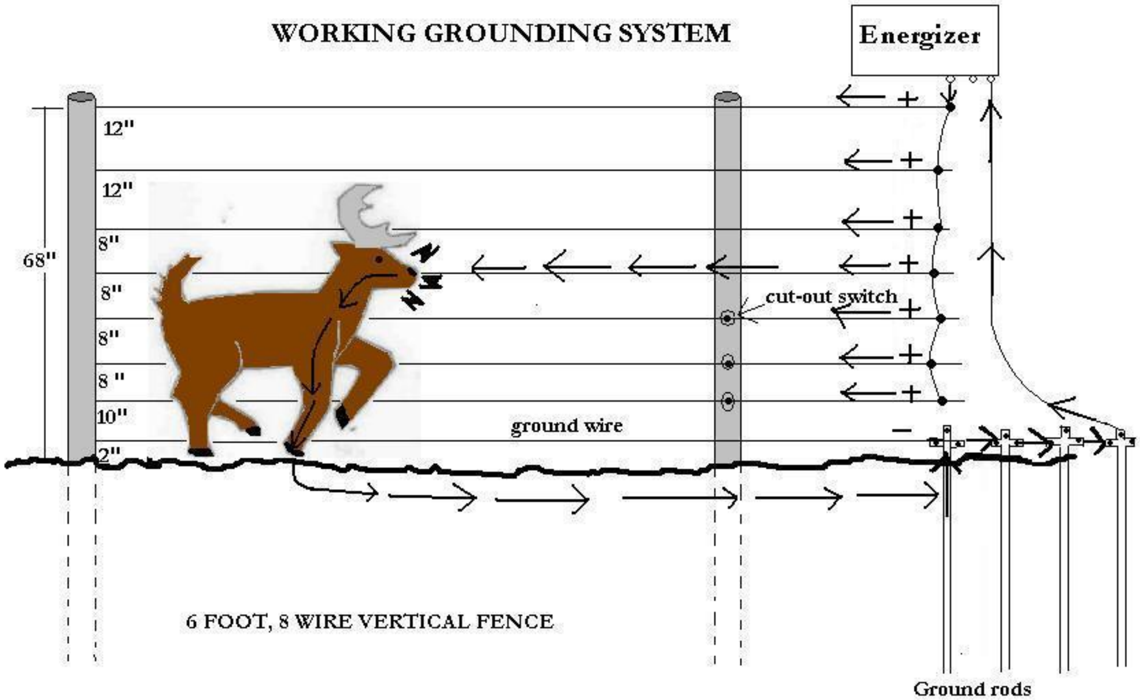


Figure 4. Grounding system

Lightening Protection System

A lightening protection system provides a way for excessive electrical energy that may be present during an electrical storm to be diverted to the grounding system. This is to help avoid damage to the energizer.

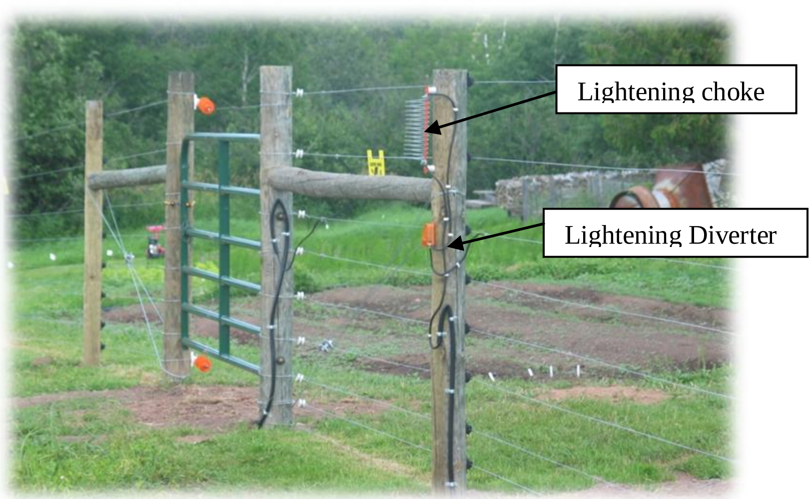


Figure 5. The installation of a lightening choke, and lightening diverter are visible mounted on a brace post.

Construction Specifications

Post spacing

Corner, gate and brace posts for "H" brace assemblies are set 10' on center to accommodate the 10' length of the horizontal brace. Wooden line posts should be spaced no more than 60' apart, with spacer battens placed in between the line posts at 15' intervals. Line posts should be added, as necessary, to accommodate changes in grade.

Bracing Materials

Bracing is required at all corner, end, gate, and pull assemblies in the fence. Brace assemblies will use wooden corner, end and gate posts with a minimum top diameter of 6 inches, a minimum length of 12 feet, and set 72 inches into the ground as upright members; wooden vertical brace posts with a minimum top diameter of 5 inches, a minimum length of 10 feet and set 48 inches into the ground as upright members; and wooden horizontal brace posts with a minimum top diameter of 4 inches, and a minimum length of 10 feet. See **figure 6**.

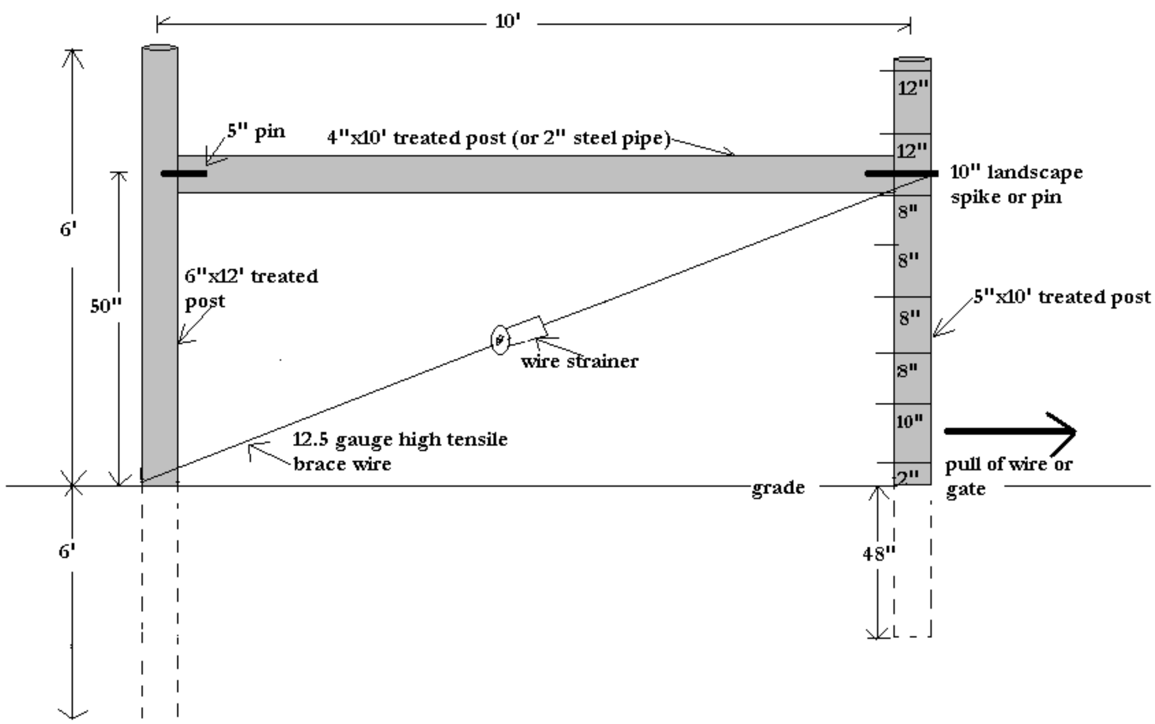


Figure 6. Typical "H" brace assembly used for corner, end, and gate brace assemblies.

- Additional bracing is required at all points where the fence alignment changes 15 degrees or more. This can either be a corner brace assembly or a diagonal brace assembly as described later. See **Figures 14 & 15**.
- End/gate bracing is required where the fence ends and on each side of the gate openings.

- In-line brace assemblies are required in straight sections of fence so that the maximum distance between the corner brace assemblies, or the corner and an in-line brace, does not exceed 1,000 feet.
- Double braces should be used on each end and/or corner for straight fence lines exceeding 1,000 feet.
    - Double end braces require one 6"x12' post, two 5"x10' vertical braces, and two 4"x10' horizontal braces.
    - Double corner assemblies require one 6"x12' post, four 5"x10' vertical braces, and four 4"x10' horizontal braces.
- All brace assembly posts will be driven into the ground, or placed in an augured hole and firmly tamped, to avoid displacement when tension is applied to the wires. Posts will be set with the smaller tapered end up.
- The horizontal brace post is held in place with a 5" pin on one end and a 10" pin on the other end.
- The brace assembly is held together with a double loop of 12 ½ gauge high tensile wire and strainer.
- Over uneven terrain, additional bracing may be required between corner, end, and brace assemblies. Wood posts with a minimum diameter of 5 inches should be set at least 48 inches into the ground at all points where excessive upward or downward pull is encountered.

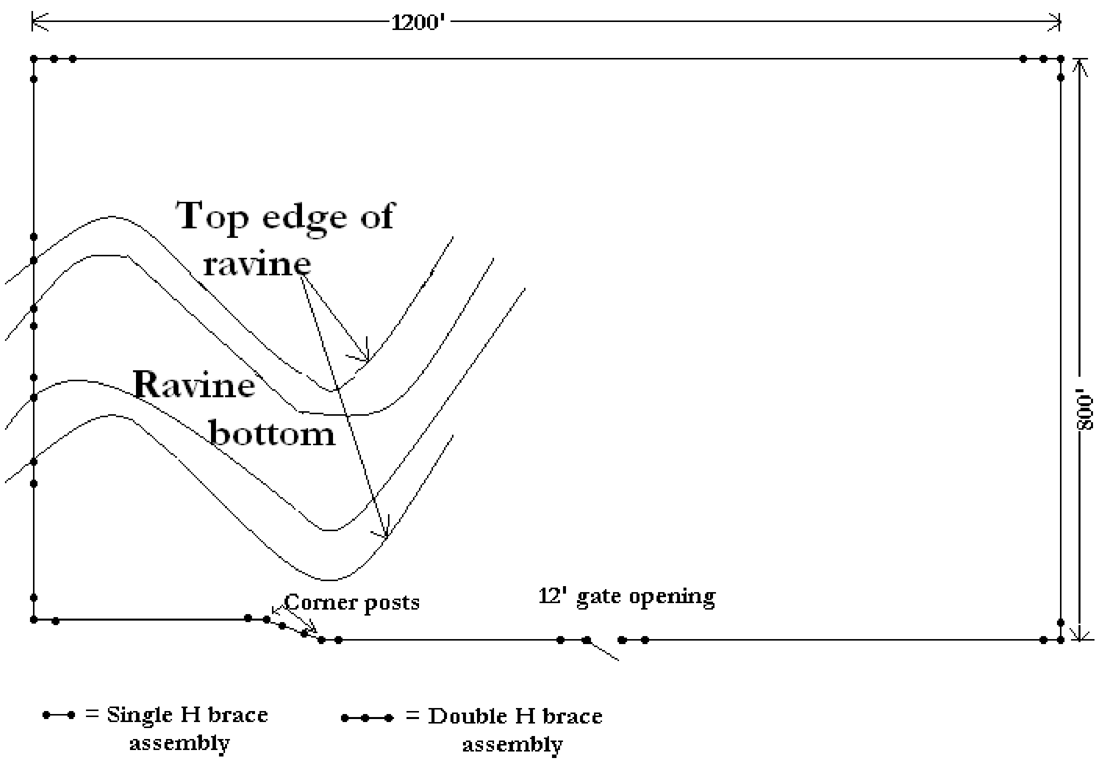


Figure 7. Bracing requirement scenarios.

Getting Started

The sequence for installing the fence is fairly straightforward.

1. Install each corner post.
2. Pull a wire or a cord from corner to corner as a straight line to locate the other posts.
3. Mark posts locations.
4. Auger holes and set all posts.
5. Build brace assemblies.
6. Install all insulators.
7. Complete the grounding system.
8. Acquire and install energizer.
9. Install fence wire.
10. Install spacer battens.
11. Energize system.

"H" Brace Assembly

Setting posts

The preferred method for setting posts is by using a "King Hitter" mechanical post driver, or comparable equipment, capable of vertically setting 6" x 12' round corner posts to a depth of 6 feet, 5" x 10' vertical brace posts to a depth of 4', and 4" x 8' line posts to a depth of 2'. Driven posts can be set plumb to the outside edge.

Figure 8. King Hitter mechanical post driver.

Posts may also be set manually by auguring a 12" diameter hole to the appropriate depth and setting the post. When setting posts manually, allow for movement of the post by setting it with a 2-3" lean away from the pull of the wire. Backfill with a suitable material such as crushed rock or gravel, and tamp the fill material firmly. Leave a maximum 2" crown of fill around each post. Set brace posts with the same tilt as the corner posts.

Figure 9. Holes are drilled using an ASV or skidsteer with a 12" auger and 24" extension. Corner and gate posts are set 6' deep, brace posts are set 4" deep, and line posts are set 2' deep.

Assembly of the "H" Brace

1. Set the two vertical posts first (10' on center) then measure and cut the wooden horizontal brace to fit.

2. Drill 3/8" holes for the brace pins at 50" above ground level and place the short pin into the corner post.

    a. Drill 2" deep in the corner post for the short pin.
    b. Drill through the brace post for the long pin.

It is not recommended to use concrete around the posts of brace assemblies. The cement will hold moisture against the wooden posts and hasten post deterioration. Concrete also complicates later replacement of a damaged post.

3. For ease of assembly, pre-drill holes for the brace pins, 2"deep, into the ends of the 4" x 10' horizontal brace with a 3/8" bit.

4. Set the wooden horizontal brace over the short pin in the corner post and hold it in place while tapping the long pin in place. Leave about 1" of the pin extended out of the post.

5. The brace wire forms a double loop. It is positioned over the brace pin at the top, and is held in place by fence staples at the bottom. The staples should be set with sufficient space to allow the wire to move – do not set them tight.

6. The wire strainer should be positioned on the side of the loop away from the fence wire, to avoid interference and reducing the chance for an electrical short.

7. Use fence staples over the pin at the top, and between the post and wire at the

bottom. These keep the wire from cutting into the wood post. See **Figure 10**.

8. Double brace assemblies (a second 5”x10’ vertical brace post in line with a second 4”x10’ horizontal brace post) are required in soft or sandy soils, and for long pulls $\geq$ 1,000’.

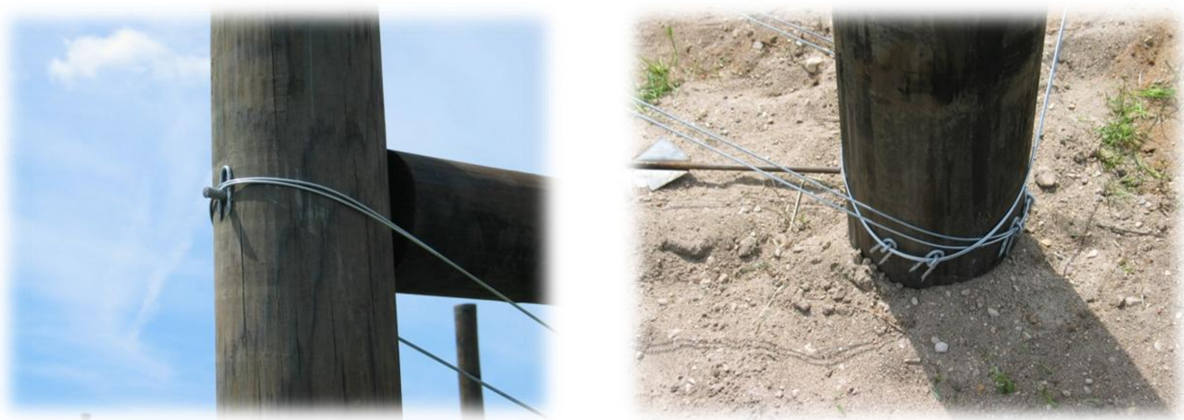
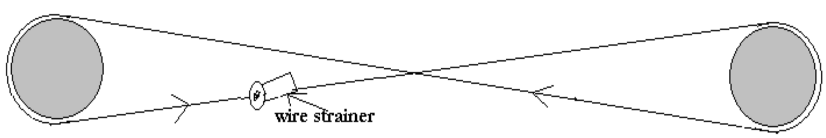


Figure 10. Notice how a staple is placed over the brace pin in the photo to the left and how the staple is place over another staple holding the brace wire in place in the photo to the right.



Tip: By looping the wire in a figure 8 pattern, there is less interference with the fence wires.

Figure 11. A figure “8” wire wrap. The horizontal brace is not shown for clarity.

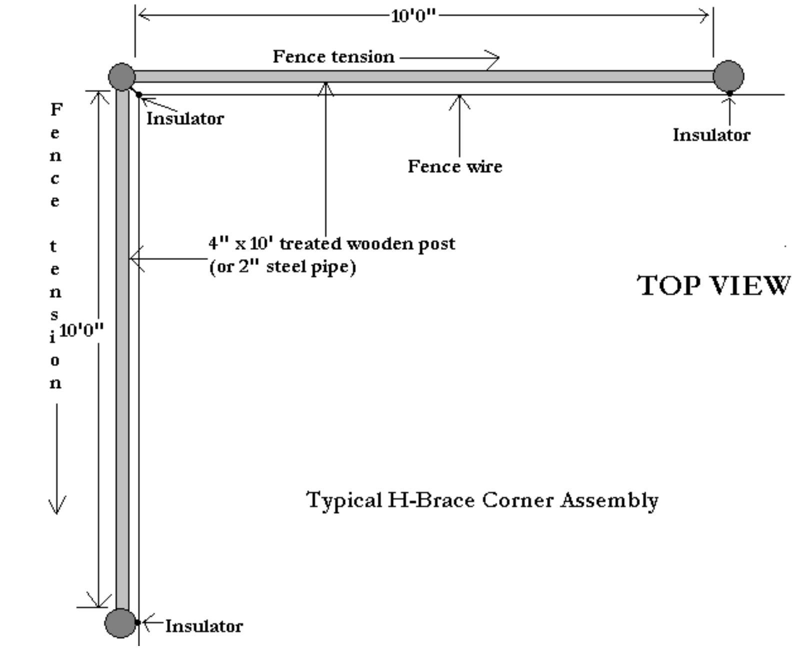


Figure 12. Typical H-brace corner assembly – top view. Note that in this detail the energized wires are on the inside of the brace assembly. If the fence wires will terminate a run in the corner, the wires can be placed on the outside (**Figure 13)**.

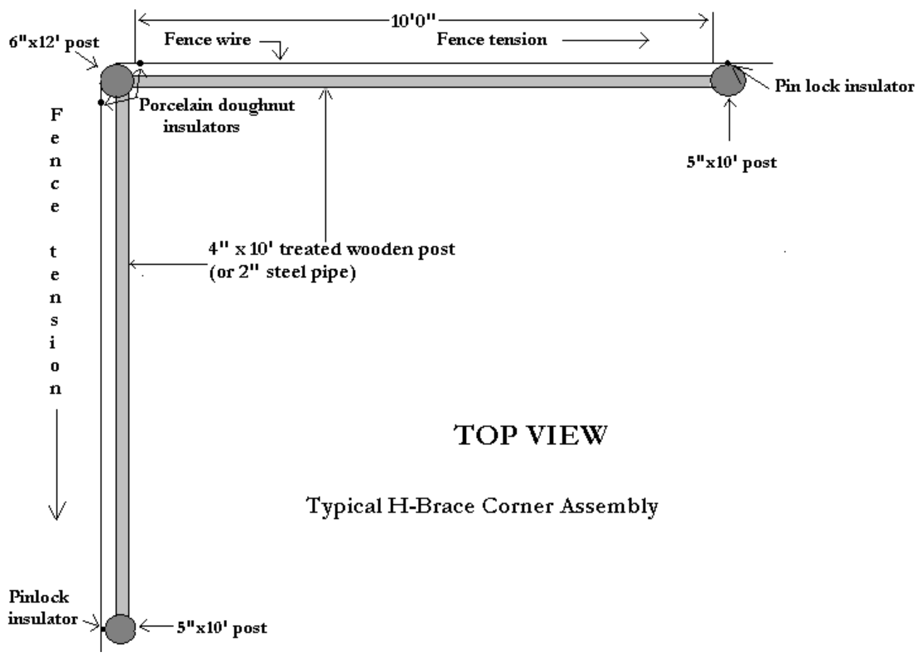


Figure 13. Corner end assembly. In this figure the wires terminate at the corner and are maintained to the outside of the corner.

Diagonal Braces

Diagonal braces can be utilized where ever an "H" brace assembly is used. They provide just as much support and strength for the corner posts but they are a bit more difficult to build. This form of bracing is particularly useful when changes in fence direction are needed that are greater than 120 degrees. They are also useful to reduce the number of holes to auger if the fence is installed in difficult or rocky conditions.

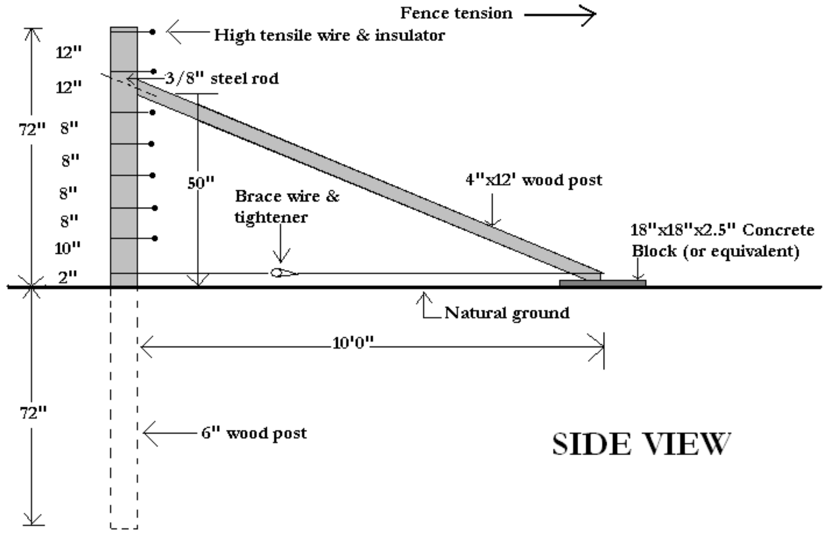


Figure 14. Diagonal brace corner assembly – side view. These diagonal assemblies can be used rather than "H" assemblies. They are often used for minor changes in the direction of the fence.

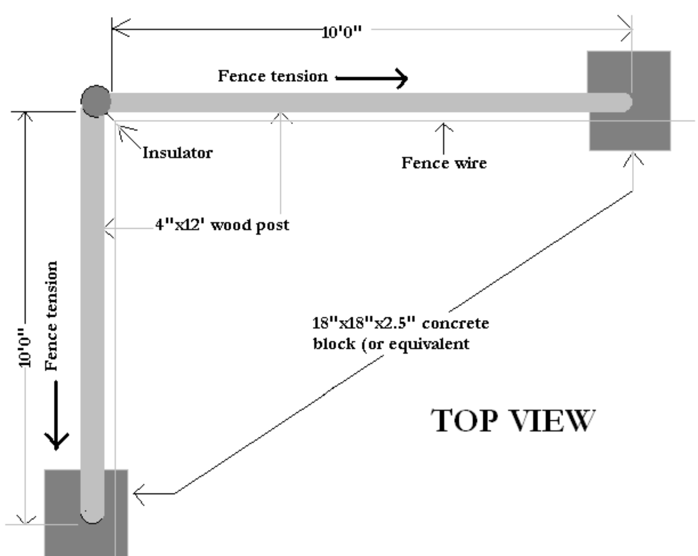


Figure 15. Diagonal brace corner assembly – top view

Line Post Specifications

1. Pressure treated wooden line posts (4"x8') are set 2 feet deep, 60 feet on center, and plumb to the outside (wire side) of the fence. Spacer battens (6' length of ½" PVC) used in conjunction with the wooden line posts should be predrilled, with holes lining up with the appropriate wire spacing (see **Figure 16**). Spacer battens should be placed at 15' intervals between each set of line posts.

2. Attach the pin-lock insulators to the line posts at the appropriate wire heights using galvanized nails. High-tensile wire will be attached to the wooden line posts with plastic pin lock insulators.

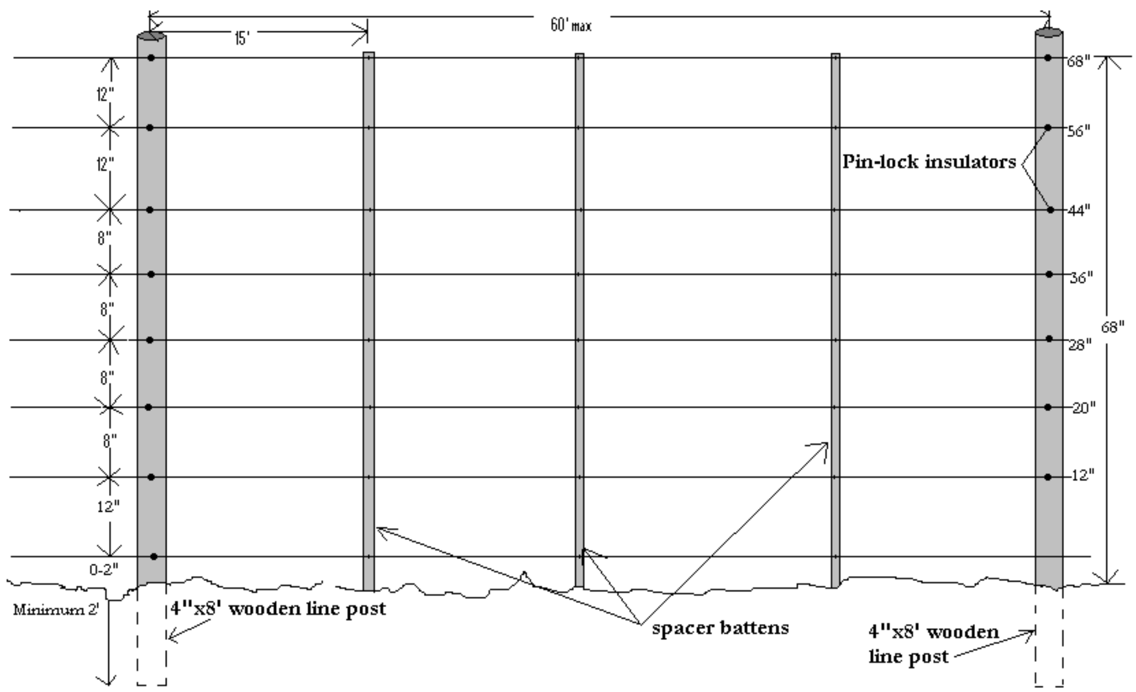


Figure 16. 6 foot, 8-wire vertical fence line post detail. Note an additional wire may be added at 6" above the ground if raccoon control is necessary.

Wire installation

Each wire is fastened to the end posts using porcelain donut insulators. Each wire is fastened to the line posts by using pin-lock insulators that have been nailed to the line posts. Attach the insulators to the end posts by tying a length of smooth wire around the end

post, then wrapping the loose end around the outside of the donut insulator. Staple the wire with insulator to the end post to maintain appropriate wire height. Using a spinning jenny, lay out the wire along the length of the fence line to the next end post, leaving a generous length (24”) to thread through the donut insulator and tie off with crimping sleeves. As each spool of wire is depleted, splice the end to a new spool using 3 crimping sleeves. Repeat this process with each wire, making sure to maintain the appropriate wire height of each. As each wire is fastened to the end posts, it can then be fastened to the line posts with the pin-lock insulators at the appropriate height. It works best to fasten each wire to the insulator as it is laid out, to minimize wire tangles as they are tensioned. Wire is fastened to the pre-drilled spacer batons with 17 gauge wire as depicted in the photo below.

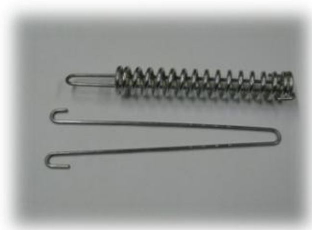
All fence wires should be stretched using in-line strainers, with associated tension springs, to the appropriate tension. Strainers with tension springs should be placed near the middle of each pull.

Attach the mechanical strainers to the tension springs by disassembling the spring and threading one end of the compression wire through the hole in the strap of the strainer (See **Figure 17 a– d**). Reassemble the spring with the strainer attached (See **Figure 17 e - g**). Thread one end of the wire through the loop on the end of the spring and fasten with 2 crimping sleeves, or hand tie. Thread the other end of the wire through the hole in the spool of the strainer, bend a tight ”C” in the end of the wire to secure. Then tighten the wire by using the strainer handle. Ratchet the wire around the strainer sprocket until the appropriate tension is shown on the indicator spring.

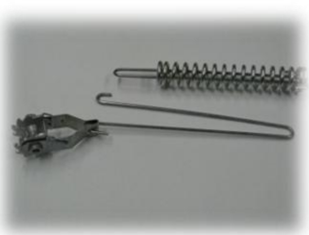
a.

b.

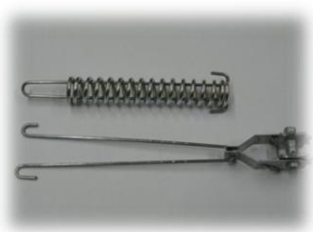
c.



d.



e.



f.

g.

Figure 17. Sequence for attaching strainers to heavy duty springs.

Gate Openings

Gate openings should be large enough to accommodate your largest piece of equipment. Locate gates for maximum convenience and efficiency. Gates should be positioned on flat areas and away from steep banks where erosion could occur. The gates should be installed so that they are level, and ground clearance under them should not exceed 10”.

Tube gates are preferred over panel gates, as panel gates will catch the wind and become damaged more easily than the tube gates. At each gate, double insulated energized wire is buried 24” deep inside ½” vinyl water pipe. This wire is connected to one of the middle wires on each side of the gate, to form a continuous flow of current around the perimeter.

In high-use areas, cattle guards may be considered. More on cattle guards can be found on page 21 of this manual.

Figure 18. Typical gate detail. Note orange handles above and below gate. Insulated wire, used for electrical connections, is installed around horizontal brace to prevent shorting.

Cattle Guards

Cattle guards can provide a convenient and effective vehicle entrance to your fenced area. They have some drawbacks to consider in your planning.

- They are rather costly. Expect to pay $1,000 or more per opening.
- They are not effective during periods of heavy snow accumulation. Compacted snow will build up between the bars, this will vary with design.
    - A set of gates is strongly advised to secure the area during times of infrequent use or periods with heavy snow.
- They must be designed to handle the heaviest vehicle ever expected to use the opening.

Figure 19. Cattle guards like this pre-cast concrete installation may be a solution to a heavily used gate area. Cattle guard must be 20”- 24” deep and measure 15 ft. from front to back to be effective. Short, “wing” fences on the sides of the approach will also enhance effectiveness.

GLOSSARY OF ENERGIZED FENCE HARDWARE COMPONENTS & FENCING TOOLS

Fence Components

1. **Anchor, Tie down.** This simple device is used to hold down the energized fence wires over dips and low areas where the wire tension is creating a gap. A length of high tensile wire is threaded through the hole in the in end of the anchor and the two ends are threaded through the hollow handle of the installation tool. The anchor is twisted into the ground and the loose ends are then fastened to the ground wire near a spacer batten.

2. **Energizer.** Good brand names include Gallagher, Speedrite, Hallman, Pel and Premier. AC energizers are recommended, with the understanding that some landowners may have to rely on battery powered or solar energizers when a power source is unavailable. The energizer should maintain fences above 6,000 volts to be effective for deer exclusion.

3. **Solar Panel.** An accessory to a battery operated energized fence system. The solar panel provides a trickle charge to the battery driving the system. Avoids or reduces the need for recharging the battery.

4. **Ground rod with clamp.** Ground rods should be 6’ in length and galvanized. Clamps should also be galvanized and heavy duty. A minimum of three ground rods, placed 10’ apart, should be used for every 2000’ of fence line. Galvanized is specified to match the other fence components. Electrolysis will occur with dis-similar metals such as copper and galvanized steel causing corrosion at points of contact.

5. **Gate.** Light weight farm pasture gates are readily available at any farm supply store. Look for gates that have a bolt for the hinge not a lag screw. Gates are available from 4’ – 16’ and will allow for openings up to 32 ft. Install gates ample for your needs but no larger than necessary.

6. **Gate Anchor, Insulated.** These are useful to create energized wire barriers across gate openings or above and below gates to minimize vulnerable gaps. These insulated anchors provide a means to connect gate handles attached to energized wires to wooden gate posts.

7. **High Tensile Smooth Wire.** The wire must have a minimum tensile strength of 170,000 psi. and a gauge of 12.5. It will have a zinc coating (oz/sq.ft) of 0.80 with a minimum Federal Spec. RR-F-221 rating of Class 3. Higher tensile strength is acceptable but is much harder to work with especially if you are hand tying. Caution! A 4,000 ft coil of wire weighs approximately 100 lbs.

8. **Lightening Choke.** A simple device designed to slow the flow of a high voltage charge. It will encourage the charge to flow to the grounding system when coupled with a lightening diverter.

9. **Lightening Diverter.** A simple adjustable spark gap that will allow a high voltage surge of energy to jump to the grounding system. The lightening diverter protects the energizer from lightening by diverting the lightening from the fence to the earth ground.

10. **Cut-off switch.** Cut-off switches are used to disconnect the "hot" wires from the energizer and can be used in situations where snow will cover the wires, causing electrical shorting and a substantial drop in voltage.

11. **Livelite - Neon warning light:** When connected to an electric fence, this device is a visual indicator that your electric fence is operating. It will emit a flash with every pulse of electricity above 3,000 volts. If the fence voltage drops below 3,000 volts, the device will flash intermittently, or not at all. It is especially useful, as a visual indicator, to determine if your fence is working at night, when crops are most susceptible to deer damage.

12. **Pipe, ½" black vinyl water pipe.** Pipe is used as added protection for underground insulated wires that carry the electrical charge under gate openings.

13. **Posts, corner, gate and brace** The gate and corner assembly posts are pressure treated pine or other wood of equal life and strength. All wood posts are treated with CCA or ACZA to a minimum of 0.40 lb/cu.ft. (pcf). Wood posts should be new, sound, free of bark, and free from decay with all limbs trimmed substantially flush with the body. They should be substantially straight throughout their length. All post dimensions are based on the minimum diameter +/- .5 inches. Post sizes of 6" x 12' (corner posts), 5" x 10' (vertical brace posts), and 4" x 10' (horizontal braces) will be required.

14. **Posts, line** shall be 4"x8' wooden posts of the same specifications as above. Line posts should be spaced a maximum of 60' apart, with spacer battens placed between them at minimum intervals of 15'.

15. **Pins, brace 5", 10", 12".** These pins are used to assemble H braces for corners and gates. Galvanized steel, .35" diameter.

16. **Spacer Batten.** Spacer battens consist of ½" PVC conduit (UV resistant) cut to 72" lengths, with holes drilled at appropriate spacing to accommodate the 8 wires (1" for the ground wire, 12", 20", 28", 36", 44", 56", 68"for the energized wires). Note how the energized wire is attached to the pvc batten

17. **Splicing sleeves**. These sleeves are used to splice smooth wire or to splice two pieces of woven wire. Open line taps (far right in photo) are for electrical connections only and should not be used where wire is tensioned. Nicopress FW 2-3, or equivalent, for 12.5 ga. Wire. Three sleeves should be used for each splice of wire. One sleeve is sufficient for connecting fence wire to strainers and porcelain insulators.

18. **Spring, heavy duty, tension.** These 9" springs are used with in-line strainers to maintain tension on the top wires of woven wire fences or all wires of an energized fence. Galvanized, or zinc coated, heavy-duty spring. They must have compression marks to facilitate correct tension.

19. **Split Bolt Wire Connector.** This type of wire connector is useful for connecting multiple strands of High tensile wire.

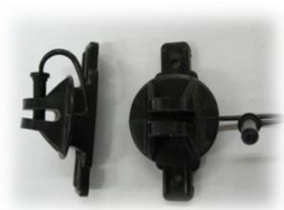
20. **Staples, 1-3/4" galvanized, barbed**. Staples are available in different lengths with, or without barbs. The barbs increase holding power and reduce staple failure. Staples are used to build "H" brace assemblies, fasten the woven wire to posts, and secure the top wires. Longer staples are acceptable but must be barbed. Double barbed is preferred.

21. **Strainer handle.** This tool is used to adjust in-line strainers to maintain wire tension. **Strainer handle:** The strainer handle shall be purchased from the same supplier as the mechanical strainers to ensure a proper fitting handle.

22. **Strainer, in-line.** Smooth wire tighteners, Donald's style or Robertson clip style, galvanized or zinc coated, ½" square hub. A key component of energized and woven wire fences these strainers are used to maintain the tension of the brace wires used to build "H" braces. They are also used with a HD tension spring to maintain the tension of fence line wires.

23. **Surge Protector.** Used with AC systems. Protects the energizer from spikes in line voltage from the power source.

24. **Insulators, Pin Lock.** Vertical brace post and wooden line post insulators shall be plastic, pin-lock style, and will be fastened to the posts with galvanized nails. All plastic insulators should be UV resistant.



25. **Insulators, Porcelain Doughnut.** These are used throughout an energized fence where an energized line changes direction or is terminated. Do not confuse porcelain insulators with ceramic. Porcelain will not hold moisture like ceramic insulators. Corner post insulators shall consist of 1½" porcelain donut insulators.

26. **Insulators, Porcelain Bullnose.** May be used to terminate a line. They are stronger and are better suited for long pulls.

27. **Joint Clamp.** A flanged bolt used to connect multiple wires.

28. **Joint Clamp L shape.** Used to connect multiple wires.

29. **Warning sign.** Signs are hung on the wires of the fence to warn of the electrical shock hazard. Fence signs not only provide an obvious warning for people but they also make the presence of a fence more visible to deer.

Tools

1. **Anchor tie-down installation tool.** This simple tool is required if you plan to use the anchor tie downs. The wire used to fasten the tie down is threaded through the hollow tubular handle.

2. **Bobcat or ASV** with 12”x 4’ auger & 24”extension.

3. **Drill bits.** A 12’ x 3/8” bit is used to drill the pilot holes for the brace pins on H assemblies. A ¼” bit is used to drill drain holes in the bottom gate panel. A 5/16” bit is used for gate assembly if conduit sleeves are used. The 13/16” ships auger is used to drill the holes for gate hinge bolts.

4. **E-Z pull crimping tool & wire cutter.** A versatile, light-weight, tool used primarily to crimp splicing sleeves. It will also cut wire and its unique design facilitates removal of difficult staples.

5. **Fencing pliers**. The wide jaws of this pliers make it useful for wire bending like the tight bend for strainer hubs. The compound lever action makes for an efficient wire cutter. A very durable tool.

6. **Knipex wire cutter.** A high quality small hand tool used to cut high tensile wire. A must tool for frequent handling of HT wire. Knipex brand 8” with recessed cutting edge have proven to be the easiest to use and are extremely durable when used properly. However, careless use can result in chipping of the high carbon cutting edge rendering the tool useless. Heed manufacturer’s advisory warning!

7. **Marking crayon.** A marker is useful to mark the depth each post is to be set, and will help avoid posts set too deep or too shallow. Marking the posts also helps to insure that the posts are set with the proper orientation i.e., small end up.

8. **Volt Meter, Digital.** Used to monitor fence voltage and determine the location of fence line shorts. It is an essential tool for proper fence maintenance.

9. **Wire bending tool.** The flat style wire bender is used for bending high tensile wire. It’s short size allows use in areas with little clearance. The round wire bender is usefull for bending wire for spacer battens and it is also useful for bending high tensile wire.

10. **Wire payout spinner (spinning jenny).** This is an essential piece of equipment when handling large spools of high tensile wire. The coil of wire is secured on the jenny before the retaining bands on the wire coils are removed. Loose ends are wrapped to the jenny, **never** pushed back into the coil.

Hand and power tools useful for fence construction.

1. **Hammer** - framing hammers have a knurled face that makes driving staples easier.
2. **Hand maul** – useful for driving the gate hinges through the posts
3. **Shovels** – spade and flat
4. **Post hole digger** (manual), auger type useful for cleaning out some holes
5. **Chain saw** – for trimming horizontal brace post to fit when constructing “H” braces.
6. **Tape measure** (30’ & 300’)
7. **Crescent wrench**, small for adjusting brackets on spinning jenny. Large for adjusting gate hinges.
8. **Cordless drill** for drilling holes for brace pins and gate hinges.
9. **Levels** (2’ & string level)
10. **Ratchet wrench** ½” drive and 3/8” drive
11. **Sockets** 3/8” drive 1/2”, 9/16”; ½” drive 1-1/8” for gate hinges.
12. **Measuring wheel** or 300’ tape measure for layout.
13. **Marking paint** for layout marking post locations
14. **3/8” fiberglass posts** for layout marking post locations.
15. **Tin snips** or aviation cutter for cutting bands on posts and coils of wire.
16. **Step ladder** – 6ft. for drilling brace pins, hanging gate, and installing top wire.
17. **Leather gloves**
18. **Protective eyewear –** protect eyes when working with wire.
19. **Tamper** for packing soil around posts.

Appendix A

Fence Supplies Vendor List

The listing of company and product names is for the reader's convenience and is not considered comprehensive. The State of Minnesota neither recommends nor endorses specific products or companies.

DARE Products, Inc.
860 Betterly Road
Battle Creek, MI 49037-8340
(269) 965-2307
(800) 922-3273
Fax (269) 965-3261
www.dareproducts.com
Carries components for both polypropylene and high tensile energized fences.

Gallagher
130 West 23rd Ave
PO Box 7506
North Kansas City, MO 64116
(800) 531-5908
www.gallagherusa.com

Carries components for both polypropylene and high tensile energized fences.

Geotek, Inc.
Common Sense Fence
1421 2nd Ave NW
Stewartville, MN 55976
(800) 533-1680
(507) 533-6076
fax (507) 533-4784

Manufacturer of fiberglass composite fence posts and the Mule(tm) fence system. Carries a selected line of energized fence components.

K Fence
RR 1, Box 195
Zumbro Falls, MN 55991
(507) 753-2943
fax (507) 753-2706
Hugh Kraemer

Carries a complete line of fence supplies for woven wire and energized fences.

Kencove
Farm Fence Supplies
344 Kendall Road
Blairsville, PA 15717
(724) 459-8991
fax (724) 459 9148
www.kencove.com

Carries a complete line of fence supplies for woven wire, energized and polypropylene fences.

Midwest Fence
5201 St. Paul Road
Medford, MN 55049
(507) 451-8657
fax (507) 451-1074
Tom Wavrin

Carries all materials for woven wire fences and some components for energized fences. Handles extra long "t" posts in 10',11& 12' lengths.

Premier 1
2031 300th St.
Washington, IA 52353
(800) 282 6631
(319) 653-7622
fax(319) 653-6304
fax (800) 346-7992
www.premier1supplies.com
Carries a complete line of fence supplies for woven wire, energized and polypropylene fences. Source for "P" springs and Maxi-shock wire used for apiary fences.

Appendix B

Treated Wood Post Vendors

K-Fence
RR1, Box 195
Zumbro Falls, MN 55991
507-753-2943
507-753-2706 FAX

Chippewa Forest Wood Products
Rt 6, Box 323
Bemidji, MN 56601
218-585-2776

Turtle River Wood Treating
1024 Wintergreen Lane NE
Bemidji, MN 56601
218-586-2271
218-586-2029 FAX

Pliny Post and Pole
Rt. 2
McGrath, MN 56350
320-592-3700
320-592-3032 FAX

Land O' Lakes Wood Preserving
PO Box 87
Tenstrike, MN 56683
218-586-2203
218-586-2005 FAX

Page and Hill Forest Products
PO Box 450
Big Falls, MN 56627
800-526-5110
218-276-2352 FAX

Midwest Fence
5201 St. Paul Road
Medford, MN 55049
507-451-8657
507-451-1074 FAX

Appendix C

Manufactured Cattle Guard Sources

072904

Al's Concrete Products, Inc.
800 Townhall Road
La Crescent, MN 55947
800-982-9263
507-895-4509

Manufactures and distributes precast concrete cattle guards. 16' width

Benner's Gardens
6974 Upper York Road
New Hope, PA 18938
800-753-4660
FAX 215-477-9429

Manufactures and distributes ADeerGuard@ gateless deer protection for driveways.

Farnam Equipment Company
6847 N. 16th St.
P.O. Box 12068
Omaha, NE 68112
800-528-1378

Distributes manufactured steel pipe cattle guard and wing systems.

Powder River, Inc
Livestock Handling Equipment
P.O. Box 50758
Provo, UT 84605
800-453-5318
fax 1-801-377-6927
www.powderriver.com

Manufactures and distributes steel cattle guards and wing systems.

Sollenberger Silos Corp.
Box N
Chambersburg,PA 17201
717-264-9588

Manufactures and distributes precast concrete cattle guards.

South Dakota Concrete Products Div.
The Cretex Companies, Inc.
209-TW. Dakota Ave., Suite 102
P.O. Box 1079
Pierre, SD 57501
605-224-8641
fax 605-224-6928

Manufactures and distributes precast concrete cattle guards.

Wieser Concrete
W3716 US HWY 10
Maiden Rock, WI 54750
800-325-8456
715-647-2311
fax 715-647-5181
email wiesercp@win.bright.net
www.wieserconcrete.com

Manufactures and distributes precast concrete cattle guards. 16' and 12' widths

Dimensions and details for construction of cattle guards are available through the Wildlife Damage Management offices in Brainerd (218) 833-8630.

Appendix D

Bobcat Operators

092005

Chuck Connell
h 763 389 1696
c 763 360 4279
f 763 634 9192
connell@sherbtel.net
Work Area: Princeton area

Kevin's Bobcat Service
Kevin Bolf
(218) 721 3208
(218) 391 9038
Work Area: Duluth, Cloquet

John's Bobcat Service
Becker, MN
(763) 263-2764
Work Area: Monticello/St. Cloud area

Whitey's Bobcat Service
Bemidji, MN
(218) 751-2248
Work Area: Bemidji area

Art Schlinger
(218) 534-5348
Work Area: Aitkin/Brainerd area

Lawrence Lake Welding
Casey Venema
Bus.(218) 245-2749
Cell (218) 259-2749
www.lawrencelakewelding.com
Work area: north Grand Rapids, Bovey

Blaise's Skidsteer Service
Blaise Weidenborner
4510 Washington Ave. SE
Bemidji, MN 56601
(218) 368-3026

Phils Bobcat Services
(507) 334-5060 (H)
(507) 334-9009 (W)
(507) 279-9141 (C)

Appendix E

Wildlife
Damage
Management
Program

Fence Building Contractors

051608

This list is comprised of contractors that we know provide fence building services in Minnesota, and undoubtedly, the list is incomplete. It should not be implied that the companies listed are endorsed or recommended by the Minnesota Department of Natural Resources. No discrimination is intended against those companies not listed.

Brian Deutschlander
Deutschlander Fencing
1015 Hillside Ave. SW
Pine City, MN 55063
Phone (320) 629-1288
www.brianfence@myway.com

Fence Types: Energized and Woven Wire

Hugh Kraemer
K Fence Systems
62411 386th Ave.
Zumbro Falls, MN 55991
Phone (507) 753-2943
Fax (507) 753-2706
Fence Types: Energized and Woven Wire

Tom Wavrin
Midwest Fence
RR 1 Box 114
Medford, MN 55049
Phone (507) 451-8657
Fax (507) 451-1074
Fence Types: Woven Wire

David Baird
Pasture Management Services
12151 Norell Ave. N.
Stillwater, MN 55082
Phone (651) 439-8478
Fence Types: Energized

Marshall Flom
Sogn Valley Fence
40764 Cty 14 Blvd
Kenyon, MN 55964
Phone (507) 789 5338
Fax (507) 789-5591

Phil (507) 789-6704
Nate (507) 789-5776

Mark Moore
Home (605)757-7474
Cell (605)941-2992

Precision Fence
Cordell Huebsch
38132 470th Ave.
New York Mills, MN 56567
(218) 841-2364
precisionfence@arvig.net
Fence Types: Energized and Woven Wire

Best Built Fence Co.
Tom & Sue Sherry
River Falls, WI
(715) 426-0457
(715) 307-2075

Fence types: Energized and Woven Wire

Appendix F

Wire "tying" Techniques

There are several 'knots' used in the construction of fences using high tensile smooth wire whether the fence is woven wire or multi-strand energized. All four of the basic forms are discussed here. Remember that the stiffness of the wire will greatly influence the ease, or difficulty, of these knots. Wire with a tensile strength of 170,000 lbs./square inch is recommended. All of the following techniques are describe for right handed persons those that are left handed would mirror the technique. A good pair of snug fitting leather gloves is recommended when working with this wire.

Simple Wrap

The simple wrap is probably the most frequently used technique. It is used to fasten strainers to the wire and it is the finish wrap for securing insulators and springs to HT wire. In this discussion we will fasten a strainer to a length of smooth wire.

1. Start by taking the end of the wire in your left hand and with your right hand bend a sharp hook in the wire about 12 inches from the end (**a**.).
2. Thread the wire through the hole in the end of the strainer to the bend you just created in the wire (**b**.).
3. Grasp the strainer in the palm of your left hand and hold slight tension in the wire (this may require stepping on the wire if the other end is not secured).
4. Grasp the 12" tail of wire with your right hand about 6" away from the strainer.
5. Push the tail of wire past your left hand bending the wire around the base of the strainer – at the same twist your wrist to create a 90 degree bend in the wire tail (**c**.).

a.

b.

c.

d.

6. Reach over the strainer and grasp the handle created by the 90 degree bend and wrap the wire tightly around itself 3-4 times (**d**.).

On the last wrap twist your wrist to the right so the “handle is perpendicular to the pull of the length of wire (**e**.).

7. Crank the wire by pulling up in a circular fashion in one direction (**f**.). It should snap off easily. Don’t twist the wire back and forth.

Steps 5-7 are the same technique used to finish off the tying of insulators and springs.

e.

f.

New Zealand slip knot

Remember over-under- over- under when doing this knot.

1. Start by putting a sharp bend 12-14” from the end of a piece of smooth wire (**a.**).
2. Wrap the wire around the post you are fastening it to and hook the bend in the wire over top of the length of wire (**b.**).
3. Bring the tail end of the wire up along the post and pull out of the top of the loop(**c**.).
4. Cinch the wire snug to the post and hold in place with your left thumb and forefinger. You’ve completed the first over-under (**c.**).
5. Take the loose tail of wire that is sticking up along the post and bend this wire sharply down over the wire at the point just before where the first bend was created (**d.**).
6. Reach under with your right hand and grasp the wire tail. With a left twist of the wrist create a 90 bend to create a handle (**e.**).
7. Pull this handle up from the bottom and over the length of wire to create a tight wrap. You have completed the second over-under(**f.**).

a.

b.

c.

d.

e.

f.

g.

8. Repeat steps5-7 of the **simple wrap** to finish (**g**.).

When done correctly the wire will slide under tension and cinch up around the post. This is the first procedure in the two step insulator wrap.

Insulator wrap

1. As described above complete a slip knot around the post using a 5-6' length of wire, leaving an end of wire free that is 24 – 30" long.
2. Measure a 3-4" distance away from the post and put a soft bend in the wire (**a.**).
3. Place a doughnut insulator in the bend of the wire and hold in place with a firm grip of your left hand.
4. Grasp the free end of the wire with your right hand and wrap this around the outside of the insulator two times (**b.**).
5. After the second wrap bend the wire around itself between the insulator and the post (**c.**).
6. Complete with steps 4-7 of the simple wrap (**d.**).

a.

b.

c.

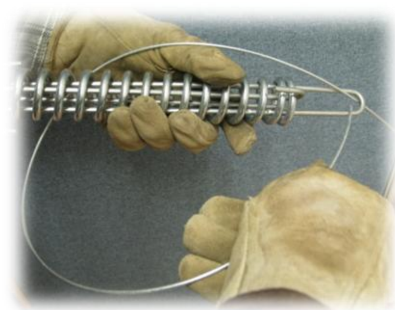
d.

Tension Spring square knot

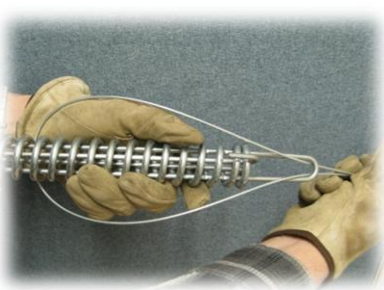
1. Hold the tension spring in your left hand palm up (**a.**).
2. Thread about 24” of the HT wire through the loop in the end of the spring drawbar from the bottom and come up through the top and over your wrist to the left side (**b.**).
3. Continue to bring the wire back under the spring from the left side and bring it up over the top and down through the drawbar loop (**c.**).
4. You will have the spring in your left hand with the wire looped around your left wrist and about 18 inches of free wire sticking out through the drawbar loop(**d**.).
5. Bend the loop of wire away from the spring as you pull hard to seat the wire in the drawbar loop(**e.**).
6. Complete the procedure by repeating steps 4-8 of the simple wrap (**f.**).

a.

b.



c.



d.

e.

f.