DEPARTMENT OF NATURAL RESOURCES

WILDLIFE DAMAGE MANAGEMENT PROGRAM

Fencing Handbook

For

10 ft Woven Wire

Deer Exclusion Fence

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Purpose

This handbook provides guidelines and specifications for the construction of deer-proof fences that will eliminate access by white tailed deer. A number of different types of barrier fences have been described for deer damage control utilizing such materials as energized wire, plastic netting, and woven wire. This handbook will focus on techniques for installing woven wire.

The barrier fence described is approximately ten ft. in height comprised of pressure treated wooden post frame and structure supporting eight foot, high-tensile, woven wire fence fabric, topped with two strands of smooth, high-tensile wire.

Materials

A brief description of the key components follows. Photos and additional details of all tools and components are provided in the glossary at the end of this handbook.

Posts used for such a fence should be pressure treated red pine or other wood of equal life and strength. The posts are treated with either Chromoated Copper Arsenate (CCA), Copper Azole (CA) or Micro Copper Azole (MCA) chemical compounds to a minimum of 0.40 lb/ft^3 pounds per cubic foot (pcf). A treatment of 0.60 pcf is recommended. Cedar posts can be used but may rot off faster than treated posts. The 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 +/- 0.5 in. Post sizes of 6 in. x 16 ft., 5 in. x 16 ft., and 4 in. x 14 ft. are typically used for this type of fence.

Brace Pins are used to assemble the structural elements used to build the corners and support the gates. These pins of various lengths are comprised of 0.35 in. or 3/8 in. diameter galvanized steel.

The **woven wire** fabric used as the actual barrier is Bekaert,Solidlock ®, Bezinol ® coated or equivalent. It is 12.5 gauge, high tensile wire, class 3 galvanized. The woven wire is comprised of 20 horizontal wires, assembled with vertical stay wires 12 in. apart to a height of 96 in. Each roll is 330 ft. long. This wire is referred as 20/96/12 woven wire.

Mechanical strainers are utilized to tighten the smooth wire when building the corner and gate brace assemblies. Donald's or Robertson style strainers are galvanized or zinc coated and feature a 1/2 in. square hub. The square hub allows for rapid winding with the tightening tool, wrench or socket.

Smooth wire should be new, and meet the minimum criteria as stated: the wire should be 12.5 gauge, class 3 galvanized, with a tensile strength of 170,000 pounds per square inch (psi). Avoid wire of higher tensile strength.

Barbed staples that are a minimum 9 gauge, class 3 galvanized, 1- 3/4 in. long, are used to secure the wire to the wooden posts. Longer staples are acceptable but must be barbed as well. Double barbed staples work the best.

Tension springs are used to control the tension of the smooth wire used to finish off the top of the fence. These are galvanized or zinc coated, 9 in. heavy duty springs. They should have compression marks to enable correct tension.

Gates should be purchased prior to fence construction, if possible, so that you can determine the proper spacing for gate posts. Painted lightweight pasture gates made of 1-3/4 in. tube steel work best. These are tubular steel gates with two, ¾ in. x 12 in. hinge bolts on each gate. Hinges are bolted to the gate, not welded. The space between horizontal tubes in the gate should not be more than 9 in. If they are woven wire or hog/cattle panels can be attached to them to stop small deer, fawns, from getting through. Two gates are stacked, bottom to bottom, and connected using a sleeve to create a single gate panel. Gates made of stainless steel or galvanized frames, covered with woven wire, are also available from some fencing supply vendors or fence contractors.

The woven wire fabric is spliced together using **splicing sleeves** such as Nicopress FW 2-3, or equivalent, for 12.5 gauge wire. Two sleeves are used for each splice of high tensile smooth wire and each strand of woven wire. A single long sleeve may be used if they allow sufficient space for two full crimps. Quick connectors such as Gripple ® connectors can be used as well.

Layout, Design & Site Preparation

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. Some general cost effective measures to consider are:

1. Determine the size enclosure you will 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. You will need a minimum width of 10 ft. of clearance on the outside of the fence to install the woven with a skid steer or tractor and future maintenance of the fence. Stake out the corners.

2. Areas that are square in shape are the most efficient in terms of area enclosed per lineal ft. of fence. Keep the perimeter as simple as possible, eliminating as many corners as possible. Remember that it is less costly to enclose a rectangle than an “L” shaped area of the same perimeter length, due to the higher cost of corner assemblies. Keep this in mind when obstacles such as buildings, wetlands, or hills are factors in your design. It may be much more cost effective to enclose a small pond rather than fence around it (**Figure 1)**.

3. A small rectangular area takes the same brace and corner assemblies as a much larger rectangular area. There are cost efficiencies in larger size, as the cost of the corner and gate assemblies are spread out over the length of the wire. In addition, it takes nearly the same preparatory work to stretch a 100 ft. fence line as it does a 650 ft. fence line

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

5. Determine the number of gates necessary for efficient operation. Locate gates next to corner brace assemblies where possible, to save on the cost of additional brace assemblies. Keep in mind however, that the gates are the weak point as far as the security of your enclosure. They can be accidentally left open and if not seen will let deer in.

6. Determine the desired width of gate openings. Make sure they are adequate for the largest piece of equipment you will be using. Plan for the future. If in doubt, larger is better. It is as easy to open and close a 16 ft. lightweight pasture gate as it is a 4 ft. one if hung correctly. Gates can vary in width from 4 ft. to 32 ft. **The same brace assemblies are required regardless of the size of the gate**.

7. To prepare the site, clear a 20 ft. wide path (10 ft. 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. Changes in fence line slope must not exceed 10%.

Figure 1

Construction Methods

Setting Posts

The preferred method for setting posts is by using a mechanical post driver capable of vertically setting 6 in. x 16 ft. round posts to a depth of 6 ft., and 4 in. x 14 ft. posts to a depth of 4 ft.. Some mechanical drivers may only allow 14 ft. tall posts to be driven so an auger must be used to dig a hole for the first two feet. Posts can also be set by auguring a 12 in. diameter hole to the appropriate depth, setting the post, and firmly hand tamping.

Holes are drilled using a skid steer with a 4 ft.x12 in. auger and 24 in. extension. Corner, gate and brace posts are set 6 ft. deep and line posts are set 4 ft. deep. Backfill with a suitable material such as crushed rock or gravel, with a maximum 2 in. crown around each post. All posts should be set vertically, with the larger diameter end set into the ground. Posts should be set plumb to the outside (wire side of the fence) and in straight lines.

Post Spacing

Corner, gate, and brace posts for “H” brace assemblies are set 16 ft. on center, or slightly less, to accommodate the 16 ft. length of the horizontal brace. Line posts are set at a maximum of 20 ft. on center.

Set the corner posts first. Once the corner posts are installed, attach a high-tensile wire, 3 ft. above the ground, to one corner post and string it to the next corner post. This guide wire, tightened with a wire strainer, will form a straight line from which to align the vertical brace and line posts (**Figure 2)**. Measure and mark the location of each post hole so that each lies within 1 in. of the inside edge of the guide wire. Vertical brace posts are positioned 15 ft. 9 in. from the edge of each corner or gate post, to accommodate the 16 ft. horizontal brace post. All line posts are spaced 20 ft. apart (**Figure 3)**. Once the fence line is marked, the guide wire can be dropped to allow for drilling of the holes. After the postholes are drilled, retighten the guide wire and begin installing posts. Install each post so that the outer face is approximately 1/4 in. from the guide wire when plumb. Do not allow the posts to touch the guide wire, as this will cause all other posts to be out of alignment. Once the line posts are installed, the guide wire can be removed and laid to the side – do not discard as this wire will be used as a top wire later in the project. The brace assemblies can now be constructed.

High Tensile wire, strung 3 ft. above ground and stretched from corner to corner, aids in post layout and alignment

Figure 2

Line Post Detail

Pressure treated line posts (4 in. x 14 ft.) are set a minimum of 4 ft. deep, 20 ft. on center, and plumb to the outside (wire side) of the fence.

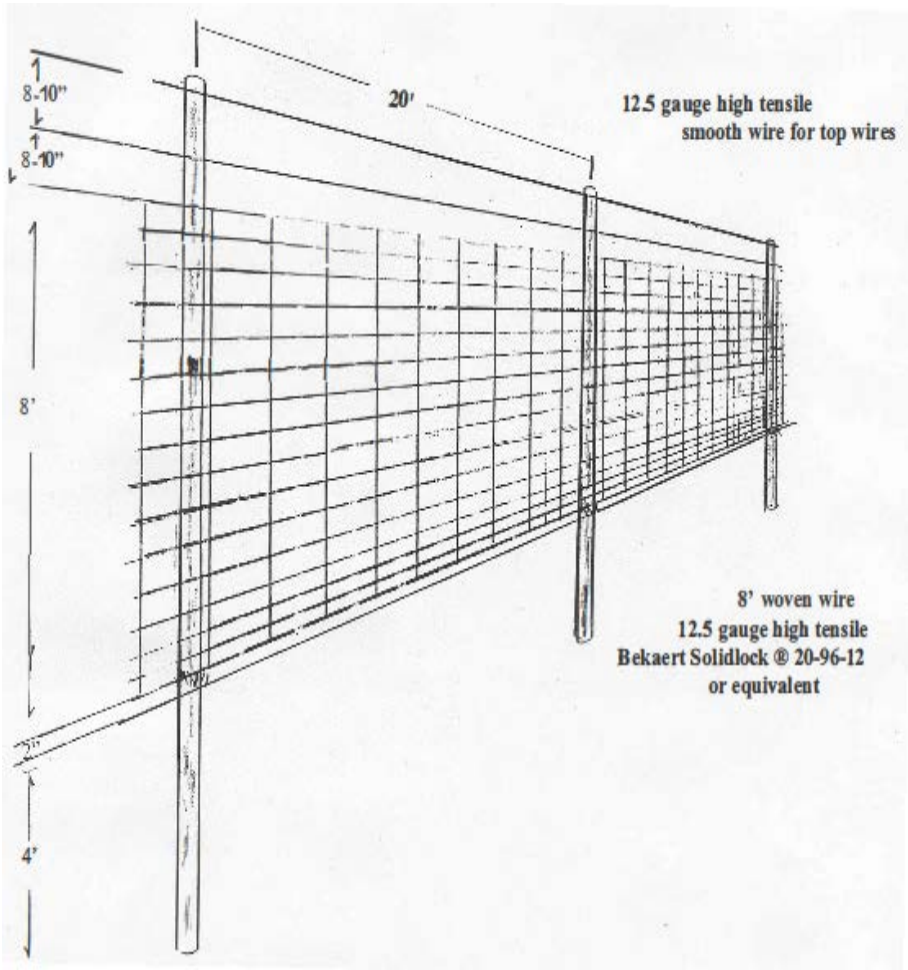

Figure 3

Bracing Materials and Construction

Bracing is required at all corner, end, gate, and pull assemblies in the fence. Brace assemblies use wood posts with a minimum top diameter of 6 in. and a minimum length of 16 ft. that are set 6 ft. into the ground as upright members.

- Corners are required at all points where the fence alignment changes 15 degrees or more. Three, 6 in. x 16 ft. vertical posts and two 5 in. x 16 ft. horizontal braces are required for each corner.
- End bracing is required where the fence ends at a building or on each side of a gate opening. Two, 6 in. x 16 ft. vertical posts and one 5 in. x 16 ft. horizontal brace are required for each end brace.
- Pull assemblies are required in straight sections of fence so that the maximum distance between corners does not exceed 1,320 ft. Two, 6 in. x 16 ft. vertical posts and one 5 in. x 16 ft. brace are required.
- Double braces (**Figure 4**) should be used on each end for straight fence lines exceeding 1,000 ft. Double end braces require three 6 in.x16 ft. posts and two 5 in. x 16 ft. horizontal braces.

All brace assembly posts should be set into the ground to avoid displacement when tension is applied to the wires. Posts should be set in with the small, tapered end up. The bracing (horizontal) member will be a wooden post with a minimum diameter of 5 in. and a 16 ft. length. The horizontal brace post is held in place with a 5 in. long pin on one end and a 10 in. long 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 top diameter of 5 in. should be set at least 72 in. into the ground at all points where excessive upward or downward pull is encountered.

Figure 4

Specifications for Corner and Gate Assemblies

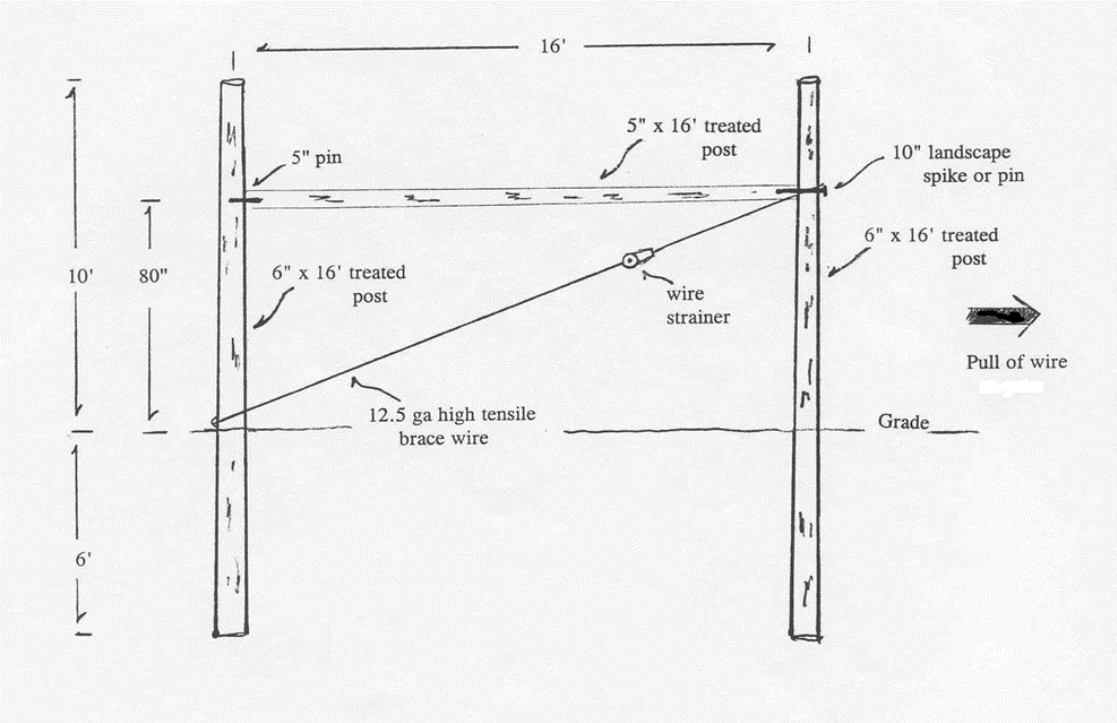

Figure 5

1. When setting posts manually by auguring holes and tamping, allow for movement of the post by setting the post with a 2-3 in. lean away from the pull of the wire. Backfill holes with a course aggregate material (i.e. class 5) and tamp thoroughly. Driven posts can be set plumb to the outside edge. Set the brace posts with the same tilt as the corner posts.

2. Set the two vertical posts first (16 ft. on center) then measure and cut the horizontal brace post to fit between them (**Figure 5)**.

3. For ease of assembly use a 3/8 in. bit to pre-drill holes for the brace pins into the end of the post used for the horizontal brace.

4. The brace wire forms a double loop in a figure eight fashion; 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 be threaded through – **do not set them tight**.

5. Use fence staples placed vertically over the pin at the top, and vertically over the already set staples at the bottom, placing them between the post and wire to keep the wire from cutting into the wood post.

6. Once the wire wrap is complete, the wire strainer should be positioned on the side of the loop away from the woven wire (inside of the fence), to avoid interference when stretching the woven wire.

7. Double brace assemblies (a third 6 in. x 16 ft. post in line with a second 5 in. x 16 ft. horizontal brace post) are required in soft or sandy soils, and for long pulls.

8. Install “in-line” brace assemblies when fence line exceeds 1320 ft., or if changes in topography require additional bracing.

Woven Wire Installation

Once all posts, supports and bracing are installed the fence is now ready for wire installation (**Figure 6**). Woven wire should be installed and stretched according to the manufacturers recommendations. The woven wire should be held approximately 2 in. above ground.

Figure 6

With the use of a tractor and front end loader, the wire is unrolled along the length of the fence-line (**Figure 7**). It is temporarily tacked into place as it is unrolled. Each horizontal wire is then wrapped around the end post and back around itself with a minimum of three twists to securely fasten it. Once the wire is permanently tied off at the end of a “pull” (corner or gate assembly), it can be stretched, spliced, and permanently stapled to the line posts. Remember to set the staples loose enough to allow the woven wire to slide, as it will expand and contract throughout the seasons.

Figure 7

Stretching Wire

The woven wire is mechanically stretched using bars and pullers designed for this purpose (**Figure 8)**. Each side of the wire is fastened to a set of bars with pin wedges. The bars are connected with the pullers and then drawn to the desired tension. Once tensioned, the two ends of each horizontal wire are spliced together to form a continuous fabric and the stretched fabric is permanently stapled to the line posts.

Figure 8

The wire is pinned, using the silver wedges, to the blue stretching bars and is drawn tight with red mechanical chain pullers (**Figure 8**).

Staples should be set to allow movement of the horizontal wires. The two top and two bottom horizontal wires should be stapled on each line post with an additional 6 staples used on the remaining wires in random alternating pattern, with a minimum of 10 staples on each line post.

Woven Wire Splice

Splices may be accomplished by either lap splice or compression splice. If lap splices are used, the line wire ends are each twisted a minimum of four wraps around the corresponding wire and trimmed. If compression sleeves are used, a minimum of two sleeves (Nicopress FW 2-3 or equivalent) per wire must be used. A single, long crimping sleeve that allows two mechanical crimps may be used. The end of each wire should be bent perpendicular to the horizontal wire and trimmed.

Once the splice is complete and all posts stapled, the pullers can be removed followed by removal of the stretching bars.

Installing Top Wires

Once the woven wire has been stretched and fastened, the top wires are ready to be attached to the fence. These are spaced 8-10 in. apart, and 8-10 in. from the top of the woven wire (**Figure 3**). When stapling these wires to the line posts, be sure to staple them loose enough so that the wire can slide freely. These top wires are anchored at each gate post using a crimping sleeve or a New Zealand slip knot as described in **Appendix E**. Tighteners (strainers) are installed on each section (pull) of these wires, to keep them from sagging.

Figure *9*

Indicator springs are installed in conjunction with the strainers, to measure the tension on the wire. Wires strung too tightly can cause maintenance issues by pulling corner posts inward. Therefore, these wires should be loosened in the fall when cold temperatures cause the wires to contract, and re-tightened again in the spring. A completed fence line will have posts spaced at 20 ft., and two horizontal strands of smooth wire strung above the woven wire (**Figure 9**).

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 (**Figure 10** diagrams a–f). Reassemble the spring with the strainer attached (**Figure 10** diagrams f-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, and bend a tight "C" in the end of the wire to secure it to the spool. 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.

Diagram a

Diagram b

Diagram c

Diagram d

Diagram e

Diagram f

Diagram g

Figure 10

Gates

Figure 11

Gates are the final detail of an exclusion fence for deer. Cost effective gates can be made easily by using standard livestock gates available at most farm supply stores. Two of these gates can be set bottom to bottom and bolted together using a piece of EMT conduit as a sleeve (**Figure 12)**. Four 10 ft. gate panels are used for a 20 ft. opening; two for each panel (**Figure 11**). For most applications, gates made of 1-3/4 in. tubing are sufficient. For applications requiring a heavier, stronger gate, 2 in. tube gates are available. **Make sure the gates you buy have bolt through hinges**. Some manufacturers use lag screws for lighter gates. These are less desirable since the lag screws are not as strong and adjustment becomes very difficult once the gates are installed. The bolt through hinge design allows for easier adjustment.

During the layout and design of your fence you will determine the gate opening width. Gate openings can be in 2 ft. increments from 4 ft. – 32 ft. You will also have to determine whether the opening will be covered by a single gate panel, for openings from 4 ft. to 16 ft. or two gate panels, for openings of 8 to 32 ft. Most gate manufacturers allow for hinge dimensions and post clearance during the manufacturing of the gates. A 16 ft. livestock gate is actually about 4 in. shorter (15 ft.- 8 in.). This will vary by manufacturer. It is important that the distance between the **inside edge** of your gate-posts are set as near as possible to the stated gate dimension. If a double gate is planned for a 16 ft. opening, the gate posts should be installed 2 in. closer; for example 15 ft. 10 in. for two 8 ft. gate panels

Avoid gates with lag style hinge screw. These reduce the ability to make minor adjustments without first removing the gate.

Figure 12

Materials required:

2 - 1 3/4 in. livestock gates of desired length

2 - 12 in. pieces of 1 1/4 in. EMT electrical conduit or pre-formed connectors (see glossary – item #2).

8 - 5/16 in. x 2 ½ in. hex head bolts, split washers and nuts (for EMT conduit connectors)

16 - flat washers (for EMT conduit connectors)

16 - #10 x 5/8 in. hex head self-tapping screws (for pre-formed connectors).

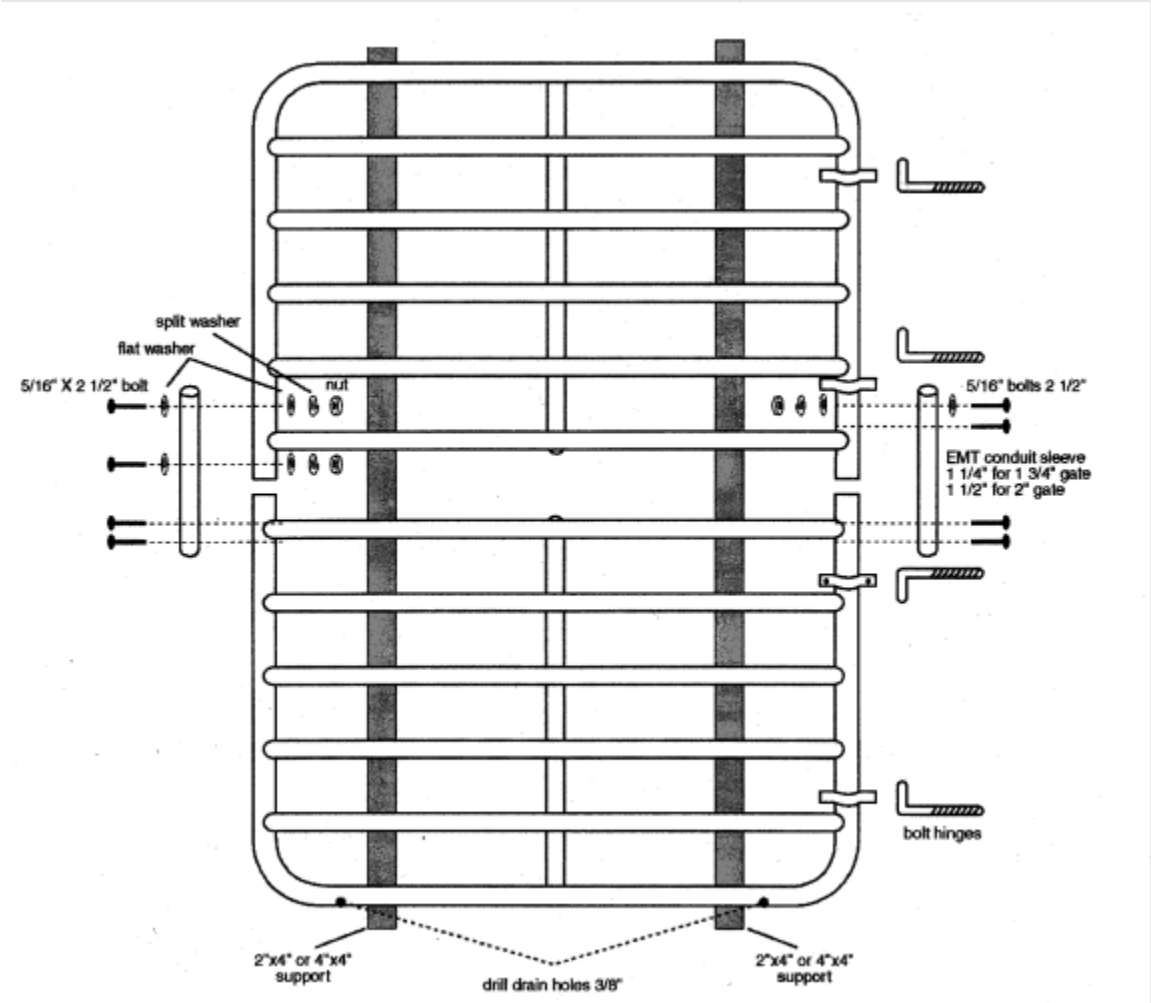

Figure 13

Procedure

1. Lay the gate panels bottom to bottom on the 4 in. x 4 in. posts. The 4 in. x 4 in. posts are for support only and are not fastened to the finished gate (**Figure 13)**.
2. Slip the 12 in. EMT conduit pieces 6 in. into the bottom of each end on one gate panel (**Figure 11).** If using preformed connectors attach at this point and secure by drilling self-tapping screw 1.5 inches up from the bottom across from each other, slip second gate panel over sleeves and secure the same way then skip to step 6.
3. Mark the bolt locations with a punch approximately 2 in. & 4 in. from the bottom.
4. Drill holes for bolts using a 3/8 in. bit and bolt the conduit into the first gate with the 5/16 in. bolts.
5. Slip the second gate over the conduit and repeat steps 3 & 4.
6. Drill several holes 1/4 in. or 3/8 in. diameter in the bottom of the two-gate panel assembly about every 24-36 in. depending on gate l to allow water drainage.

You will have a finished gate panel 96-100 in. tall to install in your 10 ft. fence. Mount the gate 6-8 in. off the ground. For added security, one of the bolt hinges should be mounted from the top of the hinge. This prevents the gate from being lifted off of the hinges (**Figure 13)**. If necessary, bolt type hinges can be purchased separately at most farm supply retailers. Exercise caution when purchasing hinges separately since they are designed to fit specific gate sizes (i.e. 1 3/4 in. or 2 in.).

Figure 14

Custom gates are available through fence supply vendors (**Figure 14**). The gate to the left is built with a stainless steel frame covered in the same fabric as the fence. The gate to the right is built with a galvanized frame and galvanized welded wire.

Fence Maintenance

Fences should be thoroughly inspected at a minimum of twice annually, spring and fall. Examine the fence line for the purpose of identifying loose staples, heaving posts, and broken or damaged posts or wire, and make repairs as necessary. The fence should be inspected after any major storm event as well. Ice and snow build up or objects falling on a fence can break the wires or posts.

Tension on the top smooth wires should be adjusted each spring and fall. Tension should be lessened in the fall to prevent over-tightening, as cold winter temperatures cause the wire to contract. These smooth wires should be re-tightened in the spring to correct sagging caused by heat expansion.

Gate openings should be inspected frequently to ensure that gates are not sagging, and that the gate posts are not leaning. This can create gaps under the gate opening large enough for a deer to squeeze through. Try to keep gaps under the gate opening to 6 in.

It is recommended that vegetation along the fence line be mowed to eliminate cover that would allow deer to approach the fence without being seen. Deer will also travel along fence line clearings and will take advantage of unsecured voids or access points. Vegetation also cause drifting of snow to occur and put stress on the fence.

Maintenance Tools

Once the woven wire fence installation has been completed, only a few tools are required for routine maintenance. Either a Knipex brand 8 in. wire cutter or equivalent, with recessed cutter, or a heavy duty 8 in. fencing plyers with side wire cutter like a Gallagher G522 or equivalent is necessary. Both are extremely durable and useful tools. An E-Z Pull crimping tool is a high quality, multi-purpose tool required for crimping splicing sleeves; its hooked end facilitates removal of staples. A strainer-tightening handle, matching the style of strainer used on the fence, is necessary for adjusting the strainers. A crescent wrench can be used to adjust gates if bolt type hinges are used and strainers if ones featuring a 1/2 in. square hub are used.

Appendix A. Minnesota Vendors for Fencing Supplies

This list is comprised of Minnesota fencing companies that we know provide fencing supplies to this manual specifications and provide delivery services in Minnesota. This list is not a complete list of places selling fencing supplies. 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.

K Fence
62411 386th Ave.
Zumbro Falls, MN 55991
Phone (507) 753-2943
Fax (507) 753-2706
https://www.kfence.com/

Midwest Fence
220 Co Rd 1
Dundas, MN 55019
Phone: (507) 334-4030
https://midwestfencemn.com/

Olson Fencing
20766 County Rd. 25
Winona, MN 55987
(507) 421-6934
mike@olsonfencingllc.com
www.olsonfencingllc.com/

Appendix B. Treated or Cedar Wood Post Vendors

This list is comprised of contractors that we know who provide white cedar posts or post treatment to this manual specifications and provide delivery services in Minnesota. This list is not a complete list of places selling treated or white cedar posts. 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.

Treated Posts

Pliny Post and Pole
20110 210th Street
McGrath, MN 56350
Phone: 320-592-3700
Fax: 320-592-3032

Land O' Lakes Wood Preserving
171 3rd Ave N Suite A
Tenstrike, MN 56683
Phone: 218-586-2203
https://landolakeswood.com/

Cedar Posts

The Cedar Mill LLC
7350 County Road 141
Big Falls, MN 56627
Phone: 218-244-7107
Email: thecedarmill@outlook.com

Appendix C. Manufactured Cattle Guard Sources

This list is comprised of contractors that we know provide cattle guard services in Minnesota. This list is not a complete list of cattle guard sources. 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.

Al's Concrete Products, Inc.
800 Townhall Road
La Crescent, MN 55947
Phone: 800-982-9263
507-895-6905
https://alsconcreteproducts.com/
Manufactures and distributes precast concrete cattle guards. 16 ft. width

True North Steel
702 13th Ave E
West Fargo, ND 58078
Phone: 866-982-9511
Email: INFO@TRUENORTHSTEEL.COM
Manufacture and distribute various types and sizes of metal cattle guards

True North Steel
3575 85th Ave NE
Blane, MN Office
Phone: 763-780-1760
Email: INFO@TRUENORTHSTEEL.COM
Manufacture and distribute various types and sizes of metal 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 ft. and 12 ft. widths.

Appendix D. Wire “tying” Techniques

There are several wire ‘knots’ used in the construction of woven-wire fences using high tensile smooth wire. Three 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 PSI is recommended. All of the following techniques are described for right handed people. 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 springs to HT top wires of the woven wire fence. This technique can also be used to fasten wire at end posts, such as gates. In this situation, a wire bender tool will ensure a tighter wrap (see glossary – item 9 under Tools). In this example 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 in. from the end.
2. Thread the wire through the hole in the end of the strainer to the bend in the wire.
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 in. tail of wire with your right hand, about 6 in. 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 time twist your wrist to create a 90 degree bend in the wire tail.

Diagram 1

Diagram 2

Diagram 3-5

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.
7. On the last wrap, twist your wrist to the right so that the handle is perpendicular to the pull of the length of wire.
8. Crank the wire by pulling up in a circular fashion in one direction. It should snap off easily. Don’t twist the wire back and forth.
9. Steps 5-8 are the same technique used to finish off the tying of springs.

Diagram 6

Diagram 7

Diagram 8

New Zealand slip knot

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

1. Start by putting a sharp bend 12-14 in. from the end of a piece of smooth wire.
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.
3. Bring the tail end of the wire up along the post and pull out of the top of the loop.
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.
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.
6. Reach under with your right hand and grasp the wire tail and with a left twist of the wrist create a 90 degree bend to make a handle.
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.
8. Repeat steps 5-8 of the simple wrap to finish.

Diagram 1

Diagram 2-3

Diagram 4

Diagram 5

Diagram 6

Diagram 7

Diagram 8

When done correctly, the wire will slide under tension and cinch up around the post.

Spring square knot

1. Hold the tension spring in your left hand, palm up.
2. From the bottom thread about 24 in. of the wire through the loop in the end of the spring drawbar and come up through the top and around your wrist to the left side.
3. Continue to bring the wire back under the spring from the left side and bring it up and down through the drawbar loop where you started.
4. You will have the spring in your left hand, with the wire looped around your left wrist, and about 18 in. of free wire sticking out through the drawbar loop.
5. Bend the loop of wire away from the spring as you pull hard to seat the wire in the drawbar loop.
6. Complete the procedure by repeating steps 4-8 of the simple wrap.

Diagram 1

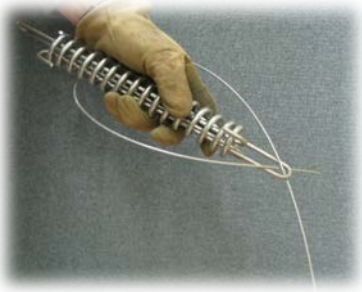

Diagram 2A

Diagram 2B

Diagram 3-4

Diagram 5

Diagram 6

Appendix E – Fence Contractors

This list is comprised of contractors that we know provide fence building services in Minnesota to this manuals specifications. This list is not a complete list of fence contractors in Minnesota. 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.

Wavrin Services
6149 NE 14th Ave
Medford, MN 55049
Phone (507) 475-0673
https://wavrinservicesfencing.com/

K Fence
62411 386th Ave.
Zumbro Falls, MN 55991
Phone (507) 753-2943
Fax (507) 753-2706
https://www.kfence.com/

Minnesota Pro Fence
34597 275th Ave.
Browerville, MN 56438
Phone: (320) 360-6308

Olson Fencing
20766 County Rd. 25
Winona, MN 55987
Phone: (507) 421-6934
mike@olsonfencingllc.com
www.olsonfencingllc.com

Deutschlander Fencing
1015 Hillside Ave. SW
Pine City, MN 55063
Phone: (320) 629-1288
www.brianfence37@rocketmail.com

Sogn Valley Fence
40764 County 14 Blvd
Kenyon, MN 55964
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Fax: (507) 789-5591

Grassland Solutions
205 Broadway Ave N
Cokato, MN 55321
Phone: (320) 286-2196
http://www.grasslandsolutions.com/

Outback Fence & Fabrication
928 Chestnut St NE
Mazeppa, MN 55956
Phone: (507) 951-7632
http://www.outbackmn.com/index.html/

Rolling Green Fencing
2408 4th St NW
Austin, MN 55912
Phone: (507) 433-4845

Glossary of Woven-Wire Fence Hardware Components & Tools

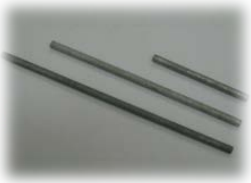
These products are available through local and online fence vendors and contractors.

Components

Gates. Versatile, cost effective, gate panels can be assembled for woven wire fences by fastening two light pasture gates (1-3/4 in. tubular steel) bottom to bottom with a conduit or preformed sleeve. This allows for gate openings from 4 ft. to 32 ft. A 1-1/8 in. box end wrench is useful for adjusting the ¾ in. nut on the gate hinges.

Gate hardware, conduit sleeves & bolts. Two gate panels can be joined bottom to bottom using a 12 ft. piece of 1-1/4 in. and 2-1/2 in. x 5/16 in. bolts or by using pre-formed sleeve connectors and self-tapping screws.

Pins, brace 5 in., 10 in., and 12 in. These pins are used to assemble H braces for corners and gates, 0.35 in. diameter, galvanized pins in 5 in. & 10 in. lengths (one each) are used to construct a single brace assembly; 12 in. brace pins can be used in the center post of a double brace assembly.



Posts, treated wooden – All 6 in., 5 in. and 4 in. wooden posts shall be pressure treated (CCA or ACZA) with a minimum retention of 0.40 pcf; however, 0.60 pcf is recommended. Species should be red pine or other wood of equal life and strength and must be straight, free of bark, sound, new, and free from decay with all limbs trimmed substantially flush with body.

Splicing sleeves. These sleeves are used to splice smooth wire or to splice two sections of woven wire. Open line taps (pictured at far right) are for electrical connections only and should not be used on woven wire fences. Quick connectors such as Gripple ® connectors can be used as well.

Spring, heavy duty, tension. These 12 in. springs are used with in-line strainers to maintain tension on the top wires of woven wire fences. Zinc alloy coated with holding strength of more than 2,200 pounds.

Staples, 1-3/4 in. class 3 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. The staple length can exceed 1-3/4 in., but be sure they are barbed. (approx. 50 staples/lb).

Strainer handle. This tool is used to adjust in-line strainers to maintain wire tension. Purchase from the same supplier as the strainers to ensure a proper fitting handle.

Strainer, in-line. A key component of 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 the top wires. The All flex, Donalds, or Robertson tighteners have the advantage of a square hub to allow the use of crescent or socket wrenches to tighten. Other brands, such as the Hayes type, do not have this feature, and don't hold as much wire.

Screws, self-tapping, #10x5/8 in. hex head. These screws will drill through the tube gate and pre-formed gate sleeve without pre-drilling a pilot hole. Do not use if joining gates with EMT conduit.

Wire, smooth – 12.5 gauge, high tensile (170,000 psi), should have a zinc coating of 0.80 (oz./sq.ft) with a minimum Federal Spec. RR-F-221 rating of Class 3. Note: wire with 200,000 psi tensile strength wire, found at some farm supply stores, is too stiff to work with comfortably.

Woven wire – 12.5 gauge, high-tensile, class 3 galvanized, fixed knot, 20/96/12 (20 horizontal wires, 96 in. tall with vertical stays spaced at 12 in.).

Tools

Bobcat or ASV with 12 in. x 4 ft. auger & 24 in. extension.

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

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.

Fencing pliers. The wide jaws of these pliers make it useful for wire bending, like the tight bend for strainer hubs. The compound lever action makes for an efficient wire cutter.

Knipex wire cutter. A high quality, small hand tool used to cut high tensile wire. A must tool for frequent handling of HT wire. The easy to use 8 in. Knipex wire cutters are extremely durable when properly used. **To avoid jaw damage, do not cut wire at an angle and do not pry wire with the jaws of the cutter.**

Marking crayon. A marker is useful to mark the depth each post is to be set to insure proper finished height and orientation (i.e., small end up).

Spinning jenny. A simple device to hold coils of wire for control while unwinding. Also called a payout spinner. This is an absolute must when working with coils of high tensile wire.

Stretching bars with pins. These steel pins serve to pinch the wire against the stretching bars prior to stretching the fence fabric. The photo shows the stretcher bars (blue) in place. The wire is ready to be stretched.

Wire bending tool. These small hand tools are useful for wrapping the ends of wires for splices or for finishing the wire at terminal points, such as gates or corners. They provide added leverage for your fingers, an advantage with the stiff, high tensile wire used for woven wire fences.

Wire spooler. This piece of equipment attaches to a loader bucket and is used to handle rolls of woven wire. The wire is unrolled and temporarily tacked to the fence posts as the tractor backs along the fence line.

Wire twister. A mechanical accessory to be used with a cordless drill. This device neatly wraps the wire around itself. It is used for finishing off the wire at end posts, such as gates.