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Chapter 4

Metal Fence Systems

Topics

- 1.0.0 Layout
- 2.0.0 Terminal Posts
- 3.0.0 Line Posts
- 4.0.0 Terminal Post Fittings
- 5.0.0 Top Rails
- 6.0.0 Tension Wires
- 7.0.0 Hanging Fence Fabric
- 8.0.0 Stretching Fence Fabric
- 9.0.0 Fabric Ties
- 10.0.0 Gates

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Overview

As a steelworker you will be involved in setting up different types of fencing from reinforced seven-foot, barbed-wire topped security fencing around an armory to a light residential baseball field fence. Because of the differences in the specifications for setting up these varied fences, we will only discuss the basic installation for a chain link fence, but once you know the basics, you will become a valuable asset to any fence project with another skill in your personal tool kit.

This chapter will discuss the layout procedures for terminal and line posts, as well as the assembly and hanging of the fence fabric. It will also discuss terminal post fittings, top rails, tension wires, and how to stretch fence fabric. The chapter concludes with fabric ties and installing single and double gates.

Objectives

When you have completed this chapter, you will be able to do the following:

1. Identify the properties of metal and metal alloys.
2. Describe the layout of metal fencing systems.
3. Describe the installation of terminal posts.
4. Describe the installation of line posts.
5. Describe the installation of terminal post fittings.
6. Describe the installation of top rails.
7. Describe the installation of tension wires.
8. Describe the procedure of hanging fence fabric.
9. Describe the procedure of stretching fence fabric.
10. Describe the installation of fabric ties.
11. Describe the installation of gates.

Prerequisites

None

1.0.0 LAYOUT

The first step to any fence project is the layout. This will give you all the information you need to order the material to complete the job.

You may or may not be given a set of plans to erect the fencing; however, you will need to determine the perimeter of the project, and locate any underground lines or pipes to prevent digging or drilling mishaps.

Installation for the fence line, terminal posts, and gates will vary depending on the security level required, site conditions, geographical location, soil conditions, and weather conditions. The best documents to assist you in this process are ASTM-F567, "Standard Practice for Installation of Chain Link Fence", and the MIL-HNBK-1013/10 "Design Guidelines for Security Fencing, Gates, Barriers, and Guard Facilities".

Once you determine the perimeter, drive stakes a foot or two away from where you will locate the corner posts; this will allow you to drill or dig holes without obstructions (Figure 4-1). It will also allow you to 'drop' the string while excavating for holes. Be careful not to bump or move stakes. If you remove the string to excavate holes, take care to restring the line back the way it was prior to removal.

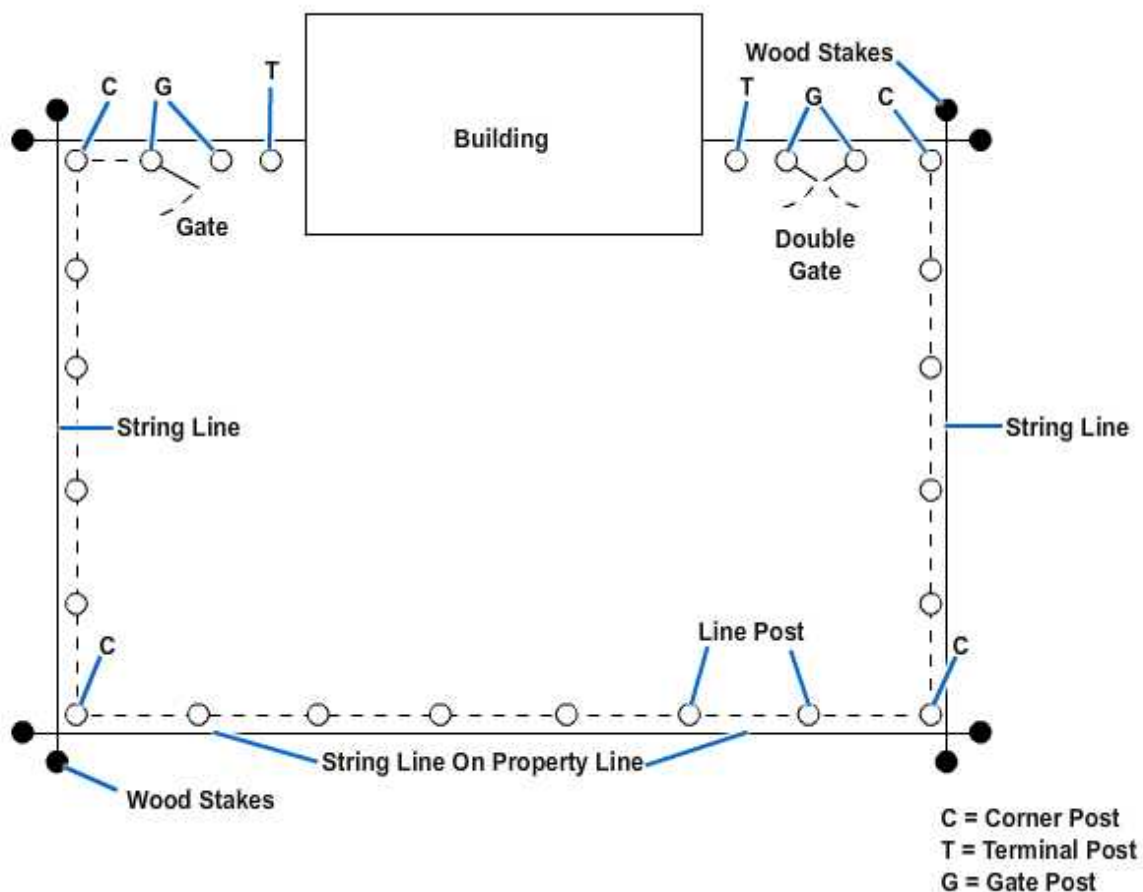
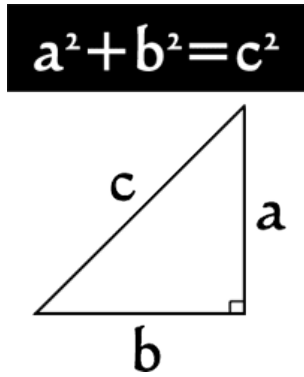


Figure 4-1 — Layout of fence perimeter.

You may want to create a right angle somewhere in your fence line. You can calculate this right angle by using the Pythagorean Theory (for mathematicians),



or by what is also called the 3-4-5 method (for construction application) (*Figure 4-2*):

1. Stake the spot where your fence will start.
2. Tie a string to the stake and stretch it out roughly parallel to the stake.
3. Measure 4 feet out on the string and mark it.
4. Tie another string to your second stake and stretch it out roughly perpendicular to the first string.
5. Mark a point 3 feet away from the stake.
6. Hold a tape measure diagonally between the three foot mark and the four-foot mark on the string, and move one of the strings until the distance between the marks is exactly 5 feet.
7. Adjust either one of the string lines as necessary to place the fence in the desired direction, and tie it down to this spot. The string lines are now exactly perpendicular. This works because $3^2 + 4^2 = 5^2$ or $9 + 16 = 25$.

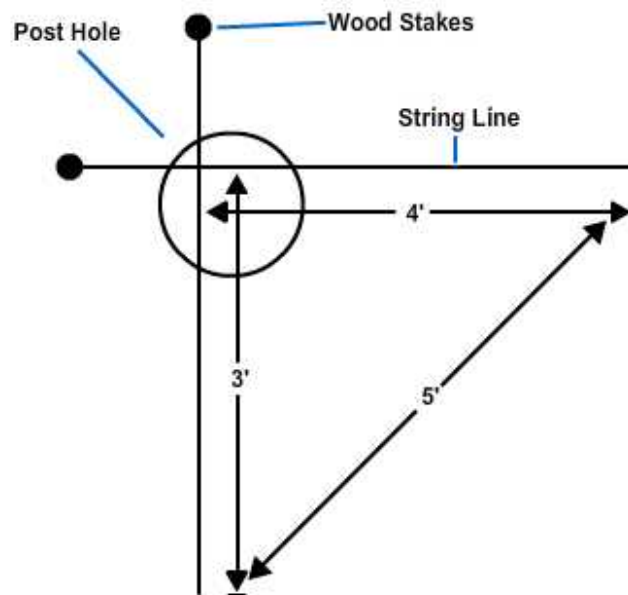


Figure 4-2 — 3-4-5 method.

You can use this method for greater accuracy over longer distances as well, just double or treble up the numbers, for example 6-8-10 ($36 + 64 = 100$), or 9-12-15 ($81 + 144 = 225$).

Tie the string tight between the stakes. This string will represent the location of the fence and serve as a guide string as you set posts. Posts will be set in concrete or driven a measured distance from the string line so the work does not interfere with the straight edge line the string provides.

Long stretches of fence require intermediate stakes to eliminate sagging, and windblown curves. Be sure to pull the string taut, since a string that sags or moves with the wind will cause posts to be set incorrectly. Keep in mind, the fence can only be as straight as the guide string.

2.0.0 TERMINAL POSTS

While exact post depth will be determined by local weather and soil conditions, holes for terminal posts (end, corner, and gate) are generally dug three times (usually 8"-10" wide) the post diameter (terminal posts are typically larger diameter than line posts), and 30" deep with vertical sides (the hole should not slope, but be slightly wider at the bottom). If available, use a power auger to dig all postholes (*Figure 4-3*).



Figure 4-3 — Power auger.

Next, with crayon or chalk, mark the ground line on the posts so once in place, the terminal posts will be the height of the fence fabric plus 2". Terminal posts should be set 2" higher than the height of the fence fabric and line posts 2" lower than the height of the fence fabric (terminal posts should be 4" higher than the line posts).

Set posts in concrete with the following mix: 1 part cement, 2 parts sand and 4 parts gravel. Mix a thick solution because too much water weakens concrete and may cause cracking. Posts should be centered in the hole (*Figure 4-4*). Be sure the crayon or chalk mark remains at ground level. Check the plumb with a carpenter's level. When plumb, crown all concrete post footings for water drainage by sloping concrete away from post.

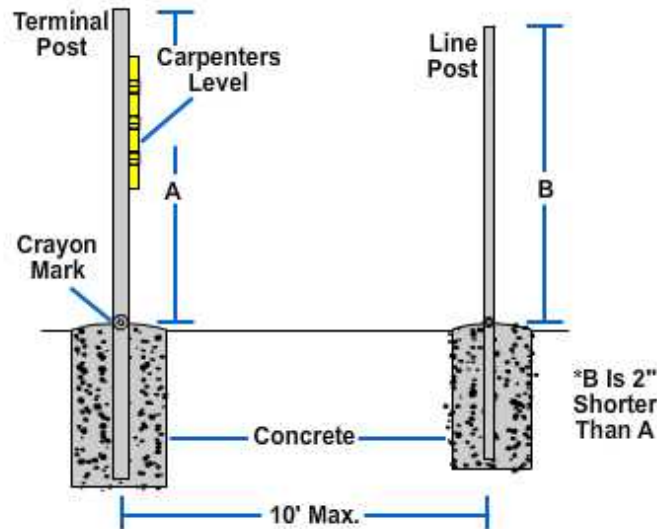


Figure 4-4 — Terminal Post.

3.0.0 LINE POSTS

After concrete footings have hardened enough for terminal posts to remain plumb (usually about 24 hours), stretch a piece of nylon string from the base of one terminal post to the base of the other. You want the string to be on the side you are going to have the chain link fabric on, usually the outside of the yard.

You will need to determine the actual distance of the section to be marked (for example, use 52' as the distance between terminal posts). Divide the distance by 10 and round your answer down to the next whole number. This is the required number of line posts. Example: $52' \div 10 = 5.2$. Round down to 5. You will need 5 line posts for this section. If you place 5 line posts in between these 2 terminal posts, it will yield 6 sections of fence. Maximum recommended distance between line posts is ten feet.

To determine the proper, equidistant spacing of line posts, divide the number of sections into the total distance. Example: $52' \div 6 = 8.66$ feet, or 8' 8".



When you arrive at a decimal answer like .66 feet, remember that you are working in 12 inch increments, so .66 feet is *NOT* rounded up to 7 inches, you must multiply .66 x 12 inches. Another way to remember is that .66 is equivalent to 2/3rds, and 2/3rds of a foot (12 inches) is 8 inches. See *Table 4-1* for line post distances.

Table 4-1 — Line post spacing chart.

Space Between Terminal Posts	Set Line Posts Apart	Space Between Terminal Posts	Set Line Posts Apart
30 ft	10 ft	76 ft	9 ft 6 in
31 ft	7 ft 9 in	77 ft	9 ft 7 in
32 ft	8 ft	78 ft	9 ft 9 in
33 ft	8 ft 3 in	79 ft	9 ft 10 in
34 ft	8 ft 6 in	80 ft	10 ft
35 ft	8 ft 9 in	81 ft	9 ft
36 ft	9 ft	82 ft	9 ft 1 in
37 ft	9 ft 3 in	83 ft	9 ft 3 in
38 ft	9 ft 6 in	84 ft	9 ft 4 in
39 ft	9 ft 9 in	85 ft	9 ft 6 in
40 ft	10 ft	86 ft	9 ft 7 in
41 ft	8 ft 2 in	87 ft	9 ft 8 in
42 ft	8 ft 5 in	88 ft	9 ft 9 in
43 ft	8 ft 6 in	89 ft	9 ft 10 in
44 ft	8 ft 9 in	90 ft	9 ft
45 ft	9 ft	91 ft	9 ft 2 in
46 ft	9 ft 2 in	92 ft	9 ft 2 in
47 ft	9 ft 5 in	93 ft	9 ft 3 in
48 ft	9 ft 7 in	94 ft	9 ft 5 in
49 ft	9 ft 9 in	95 ft	9 ft 6 in
50 ft	10 ft	96 ft	9 ft 7 in
51 ft	8 ft 6 in	97 ft	9 ft 7 in
52 ft	8 ft 8 in	98 ft	9 ft 8 in
53 ft	8 ft 10 in	99 ft	9 ft 9 in
54 ft	9 ft	100 ft	10 ft
55 ft	8 ft 2 in	101 ft	9 ft 2 in
56 ft	9 ft 4 in	102 ft	9 ft 3 in
57 ft	9 ft 6 in	103 ft	9 ft 4 in
58 ft	9 ft 8 in	104 ft	9 ft 5 in
59 ft	9 ft 10 in	105 ft	9 ft 6 in
60 ft	10 ft	106 ft	9 ft 7 in
61 ft	8 ft 8 in	107 ft	9 ft 8 in
62 ft	8 ft 10 in	108 ft	9 ft 9 in
63 ft	9 ft	109 ft	9 ft 10 in
64 ft	9 ft	110 ft	10 ft
65 ft	9 ft 3 in	111 ft	9 ft 3 in
66 ft	9 ft 5 in	112 ft	9 ft 4 in
67 ft	9 ft 7 in	113 ft	9 ft 5 in
68 ft	9 ft 8 in	114 ft	9 ft 6 in
69 ft	9 ft 10 in	115 ft	9 ft 7 in
70 ft	10 ft	116 ft	9 ft 8 in
71 ft	8 ft 9 in	117 ft	9 ft 9 in
72 ft	9 ft	118 ft	9 ft 10 in
73 ft	9 ft 2 in	119 ft	9 ft 10 in
74 ft	9 ft 3 in	120 ft	10 ft
75 ft	9 ft 4 in	121 ft	9 ft 3 in

Using this nylon string and spacing method above, mark the location of the line posts, remove the string to get it out of the way of the auger or post hole digging tools, and dig the line postholes, usually 6"-8" wide, and 18" – 24" deep.

Note: If the line posts you are supplied with are the same length as your terminal posts, you will need to shorten them, or dig the line post holes 4-inches deeper (34") than the terminal posts that will require additional labor and concrete materials.

Restraining the line near the ground on the side of the posts that the fence fabric will be on, and insert a small spacer between the string and the post; for discussion purposes use a 1/4-inch spacer. Set another similar string line at the top of the terminal posts, 4" from the top with a 1/4-inch spacer on the fence fabric side, and use it as a reference line for the top of your line posts.

Install line posts so the fabric face of the line posts line up with the fabric face of the terminal post. This means the outside faces of the line posts will be about 1/4" inside the string line, and the top of the line post should be even with the string (*Figure 4-5*). While regularly checking side plumb with a level, set the line posts using concrete as described in step 2. Crown the footings like you did to the terminal posts.

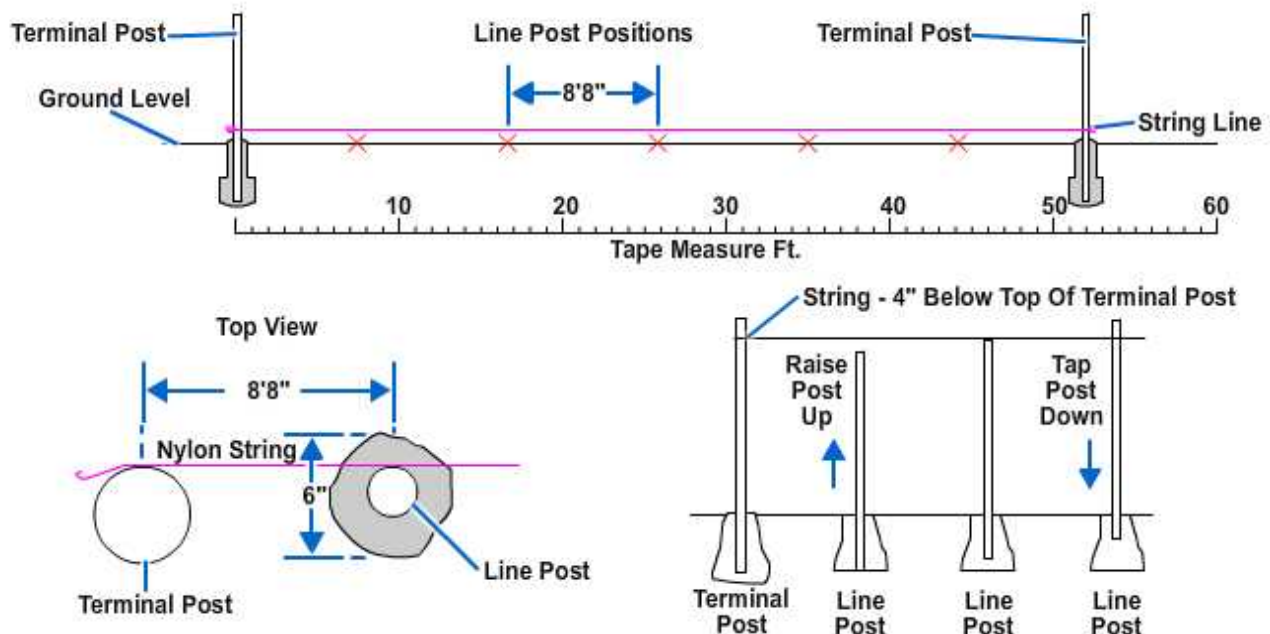


Figure 4-5 — Setting line posts.

4.0.0 TERMINAL POST FITTINGS

After concrete footings sufficiently harden, slip the tension bands evenly onto the terminal posts. Rule of thumb is to use one less tension band than the height of the fence fabric, for example 3 bands for a 4 foot fence, 4 bands for a 5 foot fence and so on. The long flat surface of the tension band should face toward the outside of the fence. Next, add rail end bands. Take care not to spread or distort the fittings. Ensure, all bolt heads for bands are on the outside of fence and the threaded ends are on the inside. Now apply all post caps to terminal posts (*Figure 4-6*).

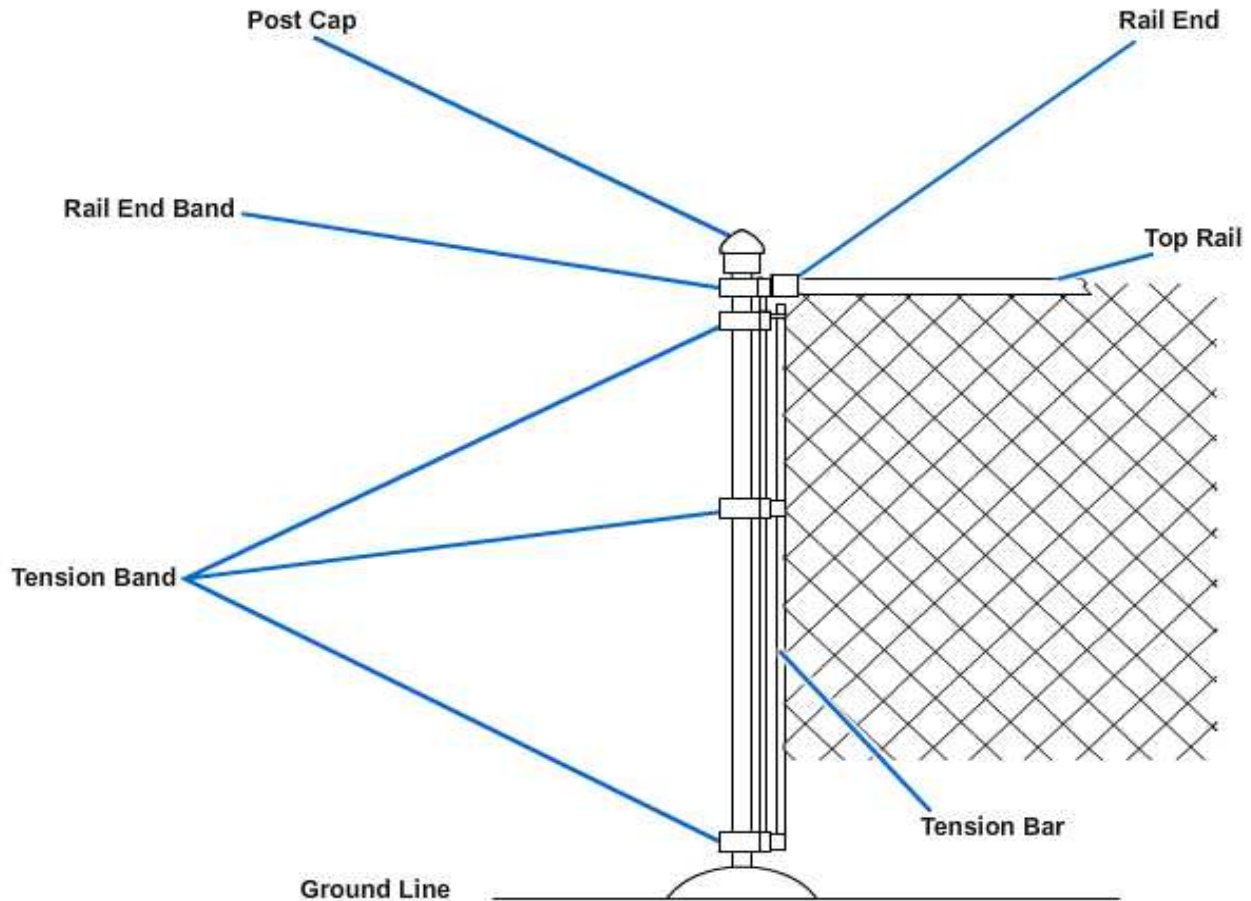


Figure 4-6 — Terminal post fittings.

5.0.0 TOP RAILS

Place eye-top, also called loop cap, (*Figure 4-7*) fitting on the end of each line post. The flat side of the eye-top should be toward the outside of the fence. Some loop caps lean in one direction, install these loop caps with the lean toward the outside of the fence. Slide top rail through a couple loop caps and butt the end firmly into the rail end cup on the 1-piece terminal post cap. If you have the 3-piece terminal post cap (dome cap, brace band & rail end cup), adjust height of rail end cup if necessary.



Figure 4-7 — Top rail fittings.

Some top rails are the same diameter on both ends and some are swaged. If you are using the top rail with both ends the same diameter you must use a rail sleeve to join the two pipes together. If you are using a swaged top rail, first, fit the nonswedged end into the rail end cup at the end or corner posts. Add sections of rail, sliding each non-swedged end onto a swaged end. Be certain to push rails toward your beginning point to 'seat' them all the way into each other by pushing firmly.

Cut excess rail off with hacksaw or pipe cutter. Mark the cut-off point carefully so the rail will fit snugly into the rail end cup. Any slack in your entire length of rail will allow the chain link, when stretched tight, to pull the end posts in towards each other.

Install the top rail in all stretches of fence. Visually check the height of line posts. If you followed the guidance in topic three, and did not allow the post to settle further in the wet concrete, all post should be at the proper height. However, if a post is too high, remove the rail and cap, and trim as necessary. If a post is 1/4" too short, you may also cut a sliver of pipe, the same diameter size as the line post and slip it under the loop cap. Secure rail end cup in place with a carriage bolt.

6.0.0 TENSION WIRES

If the project calls for a base wire or tension wire, for each section of fence, stretch a piece of base wire from one terminal post to the next. Base wire should be installed 2" off the ground and on the same side that the fabric will be going on. Attach the base wire to the line posts with aluminum tie wires. Under this scenario, you will need to attach the fence fabric to the tension wire after stretching the fabric. An alternative method is to stretch the fence fabric first, then weave the base wire through the links and tighten it to the terminal posts. The second method provides a more secure fencing on the lower section.

7.0.0 HANGING FENCE FABRIC

Starting at a terminal post, unroll chain-link fabric on the ground along the outside of the fence line to next terminal post. Then, slide a tension bar through the first row of chain-link. Fasten the tension bar to the tension bands (already on the post) using 5/16" x 1 1/4" carriage bolts with their heads to the outside of the fence (*Figure 4-8*). Ensure the tension bands are evenly spaced on the post.

Now, walk along the fabric, stand the wire up along the framework, taking out the slack as you go and loosely tie it along the top rail about every 20 feet. This is only to keep the chain link from falling as you get further away from the terminal post (*Figure 4-9*).

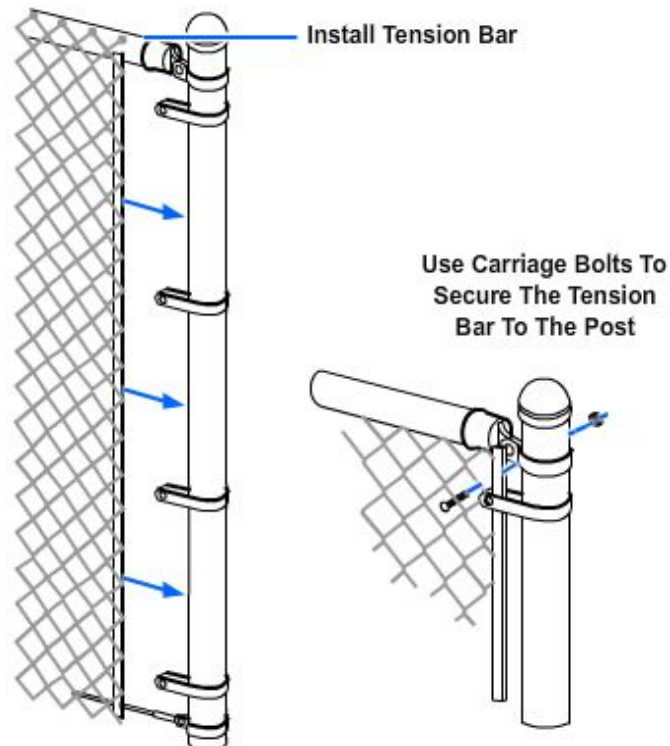


Figure 4-8 — Installing a tension bar.

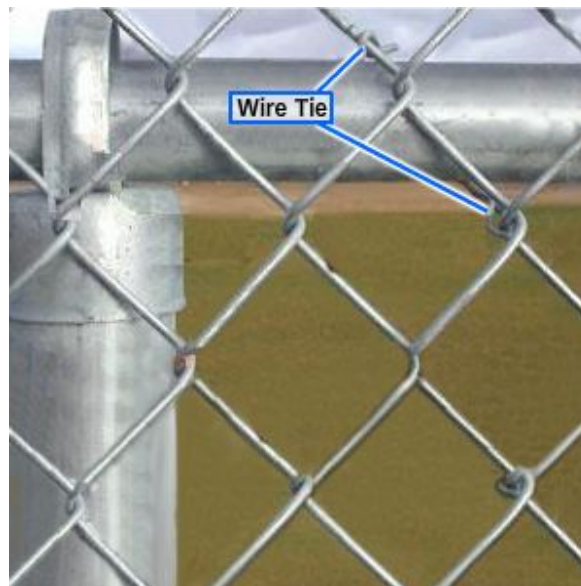


Figure 4-9 — Using wire ties.

Next, separate enough fabric from the roll to span the opening between the terminal posts. It is not necessary to cut wire.

NOTE

To remove excess fabric, open the top and bottom loops (knuckles) of a single strand of wire with pliers at the desired point of separation. Unwind the strand up through the links until the fabric comes apart.

If you need to splice sections of fabric, it can be done easily. Remove as many strands as necessary to provide a proper mesh. Using a single strand of wire removed from the end of fabric; join the two sections by winding the loose strand down, corkscrew style, through the end links. Join and tighten the knuckles at top and bottom to secure (*Figure 4-10*).

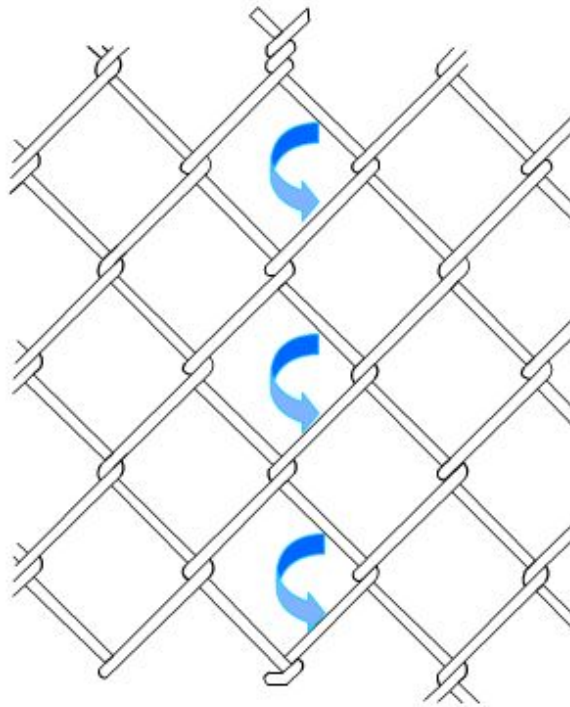


Figure 4-10 — Splicing fabric.

8.0.0 STRETCHING FENCE FABRIC

The next move is to stretch the fence fabric from the terminal post you already attached toward the opposite terminal post.

Let the wire extend past the terminal post you are about to tie off to. Attach your come-a-long at the mid-point on this terminal post, and extend the come-a-long cable out about 8 feet or so.

NOTE

Come-a-long must be on the inside of the fabric and framework.

Drop a tension bar down through the chain link fabric and attach it to the come-a-long with an A-Frame (stretch tool) (*Figure 4-11*). If you do not have the A-Frame stretch tool, you can simulate one with something as simple as a piece of rope, wire or chain.

Begin stretching the chain link by pulling on the come-a-long ratchet bar. Make sure you are not snagged on the ground or grass and that the loose tie wires you just installed along the top rail are not obstructing a clean and full stretch from one end to the other. Do not over-stretch the wire. You have achieved the desired tightness when you can squeeze the fabric with your fingers no more than 1/4".

After stretching to desired tightness, you may be left with 4 to 5 feet of loose chain link wire at the end of the stretch. Pull this wire as tight as you can manage by hand. Remove excess wire by opening the top and bottom knuckles on a run of fabric, and twist the fabric wire in a counterclockwise direction until the wire is completely detached.

Insert a tension bar, install the bands, and release the tension on the come-a-long.



Figure 4-11 — Stretching fabric.

9.0.0 FABRIC TIES

Fabric ties are used to secure chain link fabric to posts and horizontal rails. Use the same amount of ties per line post as you did tension bands per terminal post. This is typically one less than the height of fence installed; a 4' high fence has three tie wires per line post spaced evenly, a 5' high fence has four tie wires per line post and so forth. Top rails usually have five tie wires between each line post, averaging one tie every two feet. Finally, securely tighten nuts on all brace and tension bands.

If you will be using prefabricated wire ties they are labeled according to the diameter of the pipe you will be using, for example, you would order 2" wire ties if you are using 2" pipe, 3" for 3" pipe and so on.



Figure 4-12 — Line post fabric tie.

10.0.0 GATES

The same installation procedure is used on both single walk and double drive gates.

For walk through gates, your gate opening should be 4" wider than the actual gate frame width. Common openings (inside post to inside post) for Walk gates: 39", 48", 61", 73", 97"(Figure 4-13)

For drive through gates, your gate opening should be 6" wider than the combined actual gate frame widths. Common openings (inside post to inside post) for Drive gates: 10', 12', 14', 16', 20'(Figure 4-14)

All gates are 3" shorter than stated height. This is for ground clearance.

Apply post (male) hinges to gate post. To prevent removal of the gate, install the top post hinge with the pin pointing down and the bottom post hinge with the pin pointing up. Set gate in place, aligning top of gate with top of fence. Adjust hinges to allow for full swing, position the gate latch at a convenient height, then tighten all bolts securely.

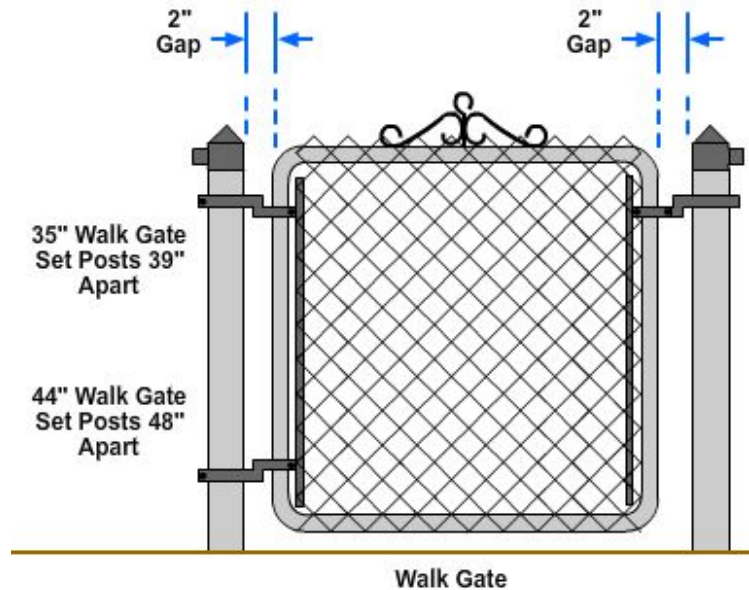


Figure 4-13 — Walk through gate.

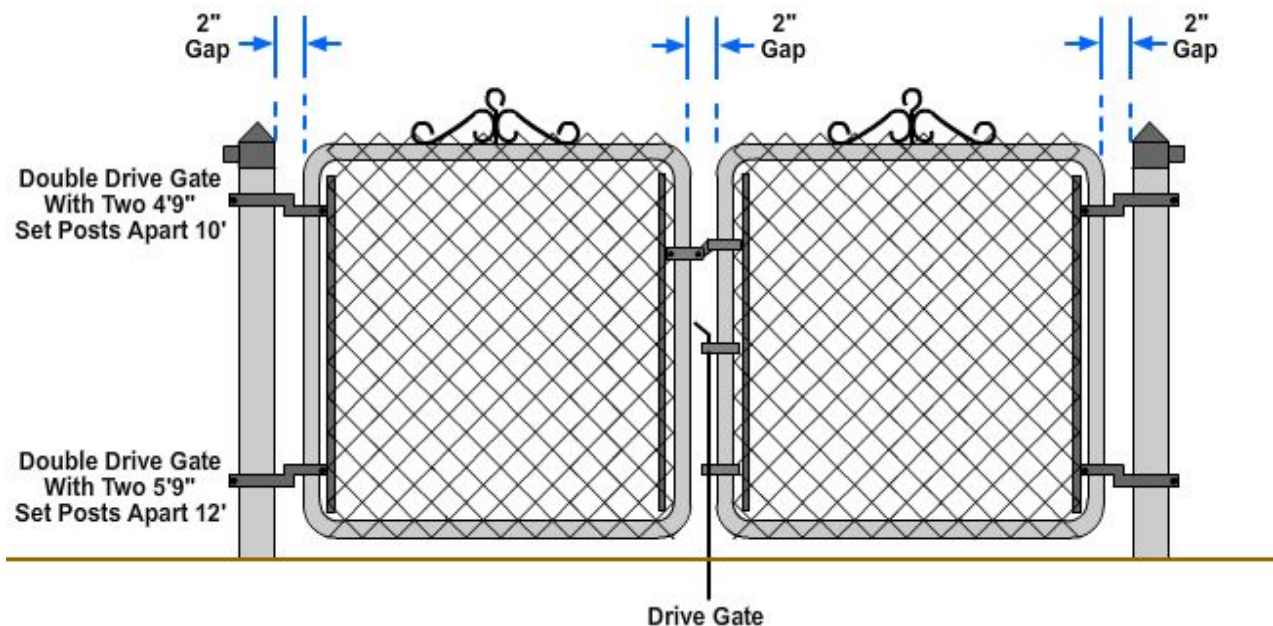


Figure 4-14 — Drive through gate.

In the case of a double swing gate, unless the ground is perfectly level, install the gate closest to the ground first. Hang second gate level to the first. Although you may 'step' the gates for a tight fit to the ground, it looks best to install them level to one another.

Install double gate drop rod/latch assembly.

Install center stop for double swing gate. Close the double gate, making certain the two leaves are lined up (straight w/ fence line). Mark the ground where the center stop needs to be installed. You may simply use a cut-off piece of pipe as a center stop by driving it into the ground. Proceed slowly, checking the gate to make certain you are driving the pipe straight.

You may also use a prefabricated center stop and cement it for a better appearance. If the center stop is in a concrete drive, simply drill a hole in the concrete larger than the drop rod diameter. Be sure to drill clear through the concrete drive to allow water to drain. Always make a larger hole (or pipe size) than the diameter of the drop rod to allow for gate sag, posts shifting, ice and other factors.

Install gate holdbacks if desired. Open gate(s) to the desired 'open' position. Cement or drive a 2" O.D. post a couple inches beyond this point. Install holdback at correct height using U-bolts provided. Install all post caps.

NOTE: Any fence crossed by overhead power lines in excess of 600 volts needs to be grounded. Ground each side of the gate and the point at which the power line crosses the fence. Guidelines to grounding can be found in Unified Facilities Guide Specifications (UFGS)-32 31 26 "*Wire Fences and Gates*".

Summary

This chapter discussed the layout procedures for terminal and line posts, the 3-4-5 method of making perpendicular angles, as well as the assembly and hanging of the fence fabric. It also discussed terminal post fittings, top rails, tension wires, and how to stretch fence fabric. The chapter concluded with topics on fabric ties and installing single and double gates. As always, use the manufacturer's operator manuals for the specific setup and safety procedures of the equipment you will be using and wear the proper personal protective equipment.