

# **Installation Manual**

## **BWC EXCEL Wind Turbine and Self-Supporting Lattice Towers**

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# **Introduction**

Bergey Windpower Co., Inc. (BWC) manufactures small wind powered generators in Norman, Oklahoma and sells them through an extensive network of dealers in the United States and around the world. BWC also installs wind turbine systems in the U. S. and elsewhere. This summary of installation procedures is based on our experience with these installations, plus suggestions from our customers and representatives. The Installation Manual is intended to assist the installer in working effectively and safely.

We prefer to use metric units wherever possible, but quite often the components we supply are built to English unit dimensions. This manual, therefore, generally lists the metric dimension followed by its English unit equivalent in parentheses; e.g., 18m (60 ft). In some cases, however, it is only appropriate to list the nominal English unit, such as with the tower hardware sizes; e.g., a 3/4" washer.

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# **1) Installation Planning**

The location and height of the tower for the BWC EXCEL wind system will be important factors in determining the overall performance of the system. Average wind speed is influenced by many things and may vary considerably within a relatively small area, particularly in complex terrain. Site and tower choice, however, are often limited by such factors as zoning restrictions, property size, proximity to neighbors, customer preferences, and wiring costs. All of these factors should be taken into consideration in choosing the best tower site and height.

## **1. Legal Restrictions and Good Neighbor Relations**

One of the first steps in planning an installation is to determine the legal status of the proposed wind turbine installation in the community in which it will be installed. In most cities and some counties an installation will be subject to zoning laws, building codes and, in some neighborhoods, protective covenants. In areas requiring permits the installation must be planned months in advance to allow time for applications to be processed and required hearings to be held.

The quickest way to determine the local codes and requirements is to call or visit the office of the building inspector. Few cities have specific regulations dealing with wind turbines, but most will have height restrictions, building code requirements, and a formal process for obtaining a building permit. The most common problem encountered in the United States is a height restriction of 10.7 meters (35 feet), particularly in residentially-zoned areas. Since it is not practical to comply with this requirement the potential wind system owner must, in this case, apply for a variance. A variance is essentially permission to break a rule and it is granted following a public hearing before a Planning Board. Obtaining a variance is a major undertaking, typically costing more than \$200 and taking several months, so it is important to establish as soon as possible whether it will be necessary. Bergey Windpower Co. has a great deal of experience in working with customers and BWC dealers in variance hearings and we offer advice and assistance to those who request it. Since the BWC EXCEL wind turbine has been installed in hundreds of communities since its introduction in 1983 we have a wealth of positive experience with the unit.

In order to obtain a building permit you will usually be required to submit a plot plan and fill out an application. A plot plan is a map of your property drawn to scale, showing the boundaries, dwelling(s) and other structures, major topographic features, easements and the location and height of the proposed wind turbine tower. Often you will be required to submit plans for the tower and information on the wind turbine. In some cases you will also be required to submit an engineering

**BWC EXCEL Installation Manual, SSV Tower**

analysis of the tower to show that it is in compliance with the building code. Sometimes this analysis must be signed by a registered Professional Engineer (PE) and occasionally the Engineer must be licensed in the State where the unit will be installed. Bergey Windpower Co. has engineering analyses, PE-Certified in Oklahoma and California, for each tower it offers and copies of these analyses are available to our customers. There is a nominal charge for “wet-stamped” analyses to cover the engineer’s fee. Noise data is also occasionally required and is available from Bergey Windpower Co.

If your property size is 10 acres or more then the turbine will likely be so far from the nearest neighbors house that they will not be bothered. It is, none the less, strongly recommended that you contact your nearest neighbors well in advance of any construction to let them know that you are installing a wind turbine. Be prepared to provide information on the turbine and to answer questions concerning noise, safety and television interference. (The BWC EXCEL specifications sheet and the fact sheet “Q&A, Residential Wind Turbines” are good resources to use and distribute). We have found that giving neighbors advance notice, answering any questions they may have, and in general being responsive to any concerns they have is the best way to avoid misunderstandings and problems later. This is doubly good advice if your property size is less than 10 acres or you have to obtain a variance for a building permit. Good neighbor relations boils down to treating your neighbors the same way you would like to be treated and showing respect for their views. An example of what not to do is to put the turbine on your property line so that it is closer to a neighbors house than to your own and not give those neighbors any advance notice of your intentions.

In general, we do not recommend that a BWC EXCEL be installed on property of less than one acre in size. We say this because the impact of a large wind turbine, with a 24 or 30 meter tower, on the neighbors in such a “tight” area is significant and the potential for disputes is too great.

If you have questions about procedures, requirements or tactics, please contact us. Since so few wind systems have been installed and communities are generally unfamiliar with them, you may face some significant obstacles in gaining permission to install a unit. We appreciate the pioneering spirit and resolve demonstrated by our customers and we stand ready to help out in any way that we can.

**2. Tower Height**

The smooth flow of the wind over the land is interrupted by obstructions and topographical variations. These interruptions bring about two important phenomena: **wind shear** and **turbulence**. Wind shear describes the fact that close to the ground the wind is slowed by friction and the influence of obstacles. Thus, wind speed is low close to the ground and increases with increasing height above the ground. Wind shear is more pronounced over rough terrain and less pronounced over smooth terrain. Turbulence is essentially rough air caused by the wind passing over obstructions such as trees, buildings or terrain features. Turbulent air reduces energy output and puts greater strain on the wind turbine. The effects of both wind shear and turbulence diminish with height and can be largely overcome simply by putting the machine sufficiently high above the ground. This may be accomplished by putting the machine on the highest possible ground and on the highest feasible tower. As a minimum, the machine should be at least 12 meters (40 feet) above any obstructions within 100 meters (330 feet) in the prevailing wind direction, and preferably in all directions. Even in perfectly flat areas, we recommend that the tower be at least 24 meters (80 feet) high. In areas with trees, please bear in mind that trees grow and the tower height needs to be based on the mature height of trees in the vicinity. Further, because the power in the wind increases as the cube of the wind velocity ( $P = KV^3$  means, for example, that doubling the average wind speed increases the energy output by a factor of eight!) a small increase in average wind speed will result in a large increase in long-term energy output. Table 1 shows the influence that tower height can have on annual energy output for the BWC EXCEL wind turbine under typical inland site conditions. Wind speed may increase dramatically with tower height in hilly or wooded areas. Even in flat open areas, power production will increase significantly with tower height.

<b><u>Tower Height</u></b>		<b><u>Wind Speed at Hub Height</u></b>		<b><u>Annual Output</u></b>
<b><u>Meters</u></b>	<b><u>Feet</u></b>	<b><u>Meters/Sec.</u></b>	<b><u>Miles/Hour</u></b>	<b><u>kWh</u></b>
18	60	4.8	10.8	11,000
24	80	5.0	11.2	12,200
30	100	5.2	11.6	13,300
37	120	5.3	11.9	14,300

**Table 1: Variation in wind speed and expected annual energy output with tower height.**

Tower height can range from 18 to 37 meters (60 to 120 foot), but 24 and 30 meters (80 and 100 foot) are the most common heights. For self-supporting towers, the

marginal costs increase rapidly with increased height; higher towers do not provide improved system economics.

As a general rule-of-thumb, we recommend that you use a 30 meter (100 foot) tower for most situations.

In the United States an obstruction warning light is usually only required on towers of more than 60 meters (200 ft). An exception is towers located near the approach path of an airport. If you intend to install a wind turbine within a mile of an airport, please contact Bergey Windpower Co. for assistance in determining whether you will need to obtain FAA approval and/or need an obstruction warning light.

### **3. Tower Location**

The size and layout of the installation site may limit the tower location, height, or type. More often than not, however, there are several potential sites. In choosing the best one, the following factors should be considered:

#### **A. The proximity of the proposed site to dwellings.**

As noted before, it is a good idea for you to consult with neighbors about the installation before proceeding. The rotor system and alternator do produce a certain amount of sound. This is a low-level whirring sound that can usually be heard indoors. From a noise standpoint, the further the wind turbine is from a house the better. In general, we recommend that the turbine be installed at least 50 meters (160 feet) from the house. Most often the tower is installed 50 -150 meters (160 - 500 feet) from the owner's house. For a grid-connected system look for an out-building, such as a barn, with sufficient electrical service to allow the installation of the wind turbine electronics. Remember that all wiring elements that will conduct turbine-generated power back to the utility grid must be able to handle at least 10 kW of power.

#### **B. The local elevation at the tower site.**

Since system performance improves with increased wind turbine elevation it is sometimes best to site the tower on a hill or ridge to gain extra height. If, however, the hill or ridge is a considerable distance (more that 200 meters or 650 ft.) from the house the additional wiring costs may more than offset the performance gain to be realized

#### **C. The length of the wire run.**

The longer the wire run the larger and more expensive the wire that is required to conduct the electricity with acceptable losses. As a general rule, wire runs over 200 meters (650 ft.) if buried or 400 meters (1,300 ft.) if installed overhead should be avoided for economic reasons. Longer runs can

be accommodated with a set of step-up/step-down transformers, but the costs are quite high. A chart showing recommended wire size based on turbine type and length of wire run is included on **Appendix Page 10** of this manual. For a grid-connect system it is best to keep the wire run between the inverter and the utility grid as short as possible; try to cover most of the distance with the tower-to-inverter wiring section.

**D. General convenience.**

Often the most compelling consideration for locating the wind turbine tower is the space where it will not interfere with vehicle traffic, fence lines, crops, gardens, septic system lateral lines, power poles, etc. Since the wind turbine installation is permanent your future plans for the property should also be taken into consideration. A later section in this manual provides the layout of the foundation(s) for the SSV Towers. This information can be very useful in analyzing potential sites to determine the most convenient location.

## **2) Receiving, Handling and Identification**

### **1. BWC EXCEL Wind Turbine**

The BWC EXCEL is shipped in three pieces: two cartons plus the tail boom as an unpackaged assembly. The contents, weight and dimensions of these pieces are as follows:

1. Powerhead Carton; 480 kg, 188 cm x 91 cm x 140 cm (1,060 lbs, 74" x 36" x 55")
  - a. Mainframe/alternator assembly with tower adapter
  - b. Controller (may be shipped separately if not manufactured by BWC)
  - c. Spinner (nose cone)
  - d. Tail Fin
  - e. Blade, Spinner, Tail Fin attachment hardware
2. Blade Carton; 68 kg, 307 cm x 28 cm x 28 cm (120 lbs, 121" x 11" x 11")
  - a. Three blades
3. Tail Boom; 66 kg, 285 cm x 61 cm x 31 cm (145 lbs, 112" x 24" x 12")

Upon delivery, the boxes and contents should be checked for signs of damage. If any damage is found its extent should be noted as precisely as possible.

Photographs can be helpful in verifying claims against the carrier. BWC should be notified as soon as possible so that the necessary replacement parts can be sent.

When reporting a damaged or malfunctioning component of the system, the item's identification number should be included. Do not dispose of damaged goods until they have been inspected by the carrier's claims department.

If you have the space, the blade box, electronics box and powerhead shipping pallet should be retained in storage in case component shipping is required at some later date.

**Important Note:**

The BWC EXCEL powerhead is mounted on the shipping pallet with its alternator face down. The rear of the alternator has ventilation holes which will allow rain water to enter the alternator if the unit is stored outside and uncovered. Water in the alternator can lead to failure of the windings and weakening of some of the adhesives used in constructing the alternator. It is, therefore, very important that the powerhead be stored indoors or carefully covered with a water-proof tarp prior to installation. The corrugated paper cover used in shipping the powerhead carton is not water-proof.

**2. SSV Tower Kit**

The SSV Tower Kit will include a number of 6 m (20 ft) welded tower legs, a bundle of grounding rods, a large bundle of tower diagonal “braces” and one or more boxes/pallets of hardware and miscellaneous materials. Tower legs and braces are typically shipped directly from Rohn, and these will usually be banded together as a single bulky, heavy mass on a large pallet. Master packing lists for the SSV Tower Kits are shown in **Figure 1-A and 1-B** to assist you in determining that all auxiliary material from BWC has been received. Specific packing lists are also provided with each shipment. All major items should be properly inspected before delivery is accepted. The Rohn drawings showing the individual tower section assembly details (See Appendix) are the best source for information concerning the Rohn-supplied tower components.

The Rohn tower components are very heavy; section weights progress from 345 kg (745 lb) for the VG65W top section to 617 kg (1360 lb) for the 10N58W base section for a 120 ft tower. Individual leg components vary from 70 kg (155 lb) for the VG65W to 138 kg (305 lb) for the 10N58W. Handling these large components by hand is not recommended because of the risk of back injury. If you must move major tower parts by hand always use several helpers. The best way to move SSV tower components is with a forklift, tractor (with a front end loader), or crane.

**3. Tower Wiring Kits**

Most people chose to purchase a Tower Wiring Kit with the tower kit. The Tower Wiring Kit consists of the down -tower armored cable (with connectors and fasteners), a disconnect switch that mounts to the tower, and a surge arrestor. A master packing list for the SSV Tower Wiring Kits is shown in **Figure 2**.

**Master Parts List, HK0021, EXCEL SSV Tower Kits (Thin Slab)**

tem	BWC Part No.	Description	60 ft	80 ft	100 ft	120 ft	Function
1		SSV Installation Manual	1	1	1	1	<b>Read This First!!!</b>
2	11459-1	3/4" x 26" Anchor Stud	12	-	-	-	Tower Anchor
3	HN8011	3/4" - 10 Hex Nut, A563, Grade B	48	-	-	-	Tower Anchor
4	HN8008	3/4" Pal Nut	12	-	-	-	Tower Anchor
5	11460	SSV-60 Anchor Plate, 1/2"	3	-	-	-	Anchor Stud Locking
6	11454-3	Upper SSV-60 Template (no hole)	3	-	-	-	Anchor Stud Location
7	11459-2	7/8 x 26" Anchor Stud	-	12	12	12	Tower Anchor
8	HNC001	7/8" - 9 Nut, A563, Grade B	-	48	48	48	Tower Anchor
9	HNC002	7/8" PAL nut	-	12	12	12	Tower Anchor
10	11454-1	Upper SSV80/120 template (no hole)	-	3	3	3	Anchor Stud Location
11	11461	SSV-80/120 Anchor Plate, 1/2"	-	3	3	3	Anchor Stud Locking
12	HBA011	5/8-11 x 2 1/2" HH Bolt, A325	9	9	9	9	EXCEL Attach
13	HWA001	5/8" Flat Washer, ZPS	18	18	18	18	EXCEL Attach
14	HNA008	5/8"-11 Hex Nut, A325	9	9	9	9	EXCEL Attach
15	HNA004	5/8" Pal Nut	9	9	9	9	EXCEL Attach
16	HO3002	3/16" Furling Cable, SS (ft)	60	60	100	60	Furl EXCEL Manually
17	HM3001	3/16" Thimble, HDG	2	2	2	2	Furl EXCEL Manually
18	HM3002	3/16" Malleable Clip, HDG	4	4	4	4	Furl EXCEL Manually
19	HM6003	3/8" SS Double Eye Swivel	1	1	1	1	Furl EXCEL Manually
20	11155	Lanyard, SSV	1	1	1	1	Furl EXCEL Manually
21	HW8003	1/2" Lock Washer, ZPS	4	4	4	4	Attach Winch Plate
22	HN8003	1/2"-13 Hex Nut, ZPS	4	4	4	4	Attach Winch Plate
23	HB8031	1/2"-13 U-Bolt, 3 x 4.5 ZPS	2	0	0	0	Attach Winch Plate
24	HB8004	1/2"-13 U-Bolt, 3.5 x 5 ZPS	0	2	2	0	Attach Winch Plate
25	HB8008	1/2"-13 U-Bolt, 4.0 x 5.5" ZPS	0	0	0	2	Attach Winch Plate
26	11119	Winch Mounting Plate	1	1	1	1	Attach Furling Winch
27	HB6002	3/8"-16 Bolt, 1" L., SS	3	3	3	3	Attach Winch to Plate
28	HW6004	3/8" Flat Washer, SS	6	6	6	6	Attach Winch to Plate
29	HW6002	3/8" Lock Washer, SS	3	3	3	3	Attach Winch to Plate
30	HN6001	3/8"-16 Hex Nut, SS	3	3	3	3	Attach Winch to Plate
31	HM0010	Ground Rod	3	3	3	3	Tower Grounding
32	HM0013	Grounding Clamp	3	3	3	3	Tower Grounding
33	HM0026	Grounding Bracket	3	3	3	3	Tower Grounding
34	HO0011	Grounding Cable (ft)	15	15	15	15	Tower Grounding

**Figure 1-A. Master SSV Parts List (Thin Slab Foundations)**

**Master Parts List, HK0021, EXCEL SSV Tower Kits (Thick Slab)**

Item	BWC Part No.	Description	60 ft	80 ft	100 ft	120 ft	Function
1		SSV Installation Manual	1	1	1	1	<b>Read This First!!!</b>
2	HBC001	7/8" - 9 x 42" J-bolt, 6" hook	-	12	12	12	Tower Anchor
3	HNC001	7/8" - 9 Hex Nut, A563-B	-	24	24	24	Tower Anchor
4	HNC002	7/8" PAL nut	-	12	12	12	Tower Anchor
5	11454-1	Upper SSV80/120 template (no hole)	-	3	3	3	Anchor Bolt Location
6	11454-2	Lower SSV80/120 template (big hole)	-	3	3	3	Anchor Bolt Location
7	Rohn	3/4"-10 x 36" J-bolt	12	-	-	-	Tower Anchor
8	Rohn	3/4"-10 Hex Nut, A563-B	24	-	-	-	Tower Anchor
9	Rohn	3/4" PAL nut	12	-	-	-	Tower Anchor
10	Rohn	Upper SSV-60 Template (no hole)	3	-	-	-	Anchor Bolt Location
11	Rohn	Lower SSV-60 template (big hole)	3	-	-	-	Anchor Bolt Location
12	HBA011	5/8"-11 x 2 1/2" HH Bolt, A325	9	9	9	9	EXCEL Attach
13	HWA001	5/8" Flat Washer, ZPS	18	18	18	18	EXCEL Attach
14	HNA008	5/8"-11 Hex Nut, A325	9	9	9	9	EXCEL Attach
15	HNA004	5/8" Pal Nut	9	9	9	9	EXCEL Attach
16	HO3002	3/16" Furling Cable, SS (ft)	60	80	100	120	Furl EXCEL Manually
17	HM3001	3/16" Thimble, HDG	2	2	2	2	Furl EXCEL Manually
18	HM3002	3/16" Malleable Clip, HDG	4	4	4	4	Furl EXCEL Manually
19	HM6003	3/8" SS Double Eye Swivel	1	1	1	1	Furl EXCEL Manually
20	11155	Lanyard, SSV	1	1	1	1	Furl EXCEL Manually
21	HW8003	1/2" Lock Washer, ZPS	4	4	4	4	Attach Winch Plate
22	HN8003	1/2"-13 Hex Nut, ZPS	4	4	4	4	Attach Winch Plate
23	HB8031	1/2"-13 U-Bolt, 3 x 4.5 ZPS	2	0	0	0	Attach Winch Plate
24	HB8004	1/2"-13 U-Bolt, 3.5 x 5 ZPS	0	2	2	0	Attach Winch Plate
25	HB8008	1/2"-13 U-Bolt, 4.0 x 5.5" ZPS	0	0	0	2	Attach Winch Plate
26	11119	Winch Mounting Plate	1	1	1	1	Attach Furling Winch
27	HB6002	3/8"-16 Bolt, 1" L., SS	3	3	3	3	Attach Winch to Plate
28	HW6004	3/8" Flat Washer, SS	6	6	6	6	Attach Winch to Plate
29	HW6002	3/8" Lock Washer, SS	3	3	3	3	Attach Winch to Plate
30	HN6001	3/8"-16 Hex Nut, SS	3	3	3	3	Attach Winch to Plate
31	HM0010	Ground Rod	3	3	3	3	Tower Grounding
32	HM0013	Grounding Clamp	3	3	3	3	Tower Grounding
33	HM0026	Grounding Bracket	3	3	3	3	Tower Grounding
34	HO0011	Grounding Cable (ft)	15	15	15	15	Tower Grounding

**Figure 1-B. Master Parts List (Thick Foundations)**

**Master Parts List, HK0019, EXCEL-S to SSV Tower Wiring Kits**

Item	BWC Part No.	Description	60 ft	80 ft	100 ft	120 ft	Function
1	AXA009	60A Disconnect Switch # H362RB	1	1	1	1	Fused Disconnect
2	AXA013	3/4" Hub # B-075	1	1	1	1	Connect to switch
3	AFA015	Fuse, FRS-R-35	3	3	3	3	Fuses in Switch
4	CAB006	3 x #6 MCM Armored Cable	60	80	100	120	Down-tower cable
5	HM0012	Ty-Wrap, Nylon, Black	30	40	50	60	Tie cable to tower leg
6	EC0152	Electrical Connector (C-H #TMC285)	2	2	2	2	Connect at cable ends
7	HNB002	3/4" Electrical Nut	1	1	1	1	Lock JMC in turbine
8	HMB006	3/4" Plastic Bushing	1	1	1	1	Finish JMC in turbine
9	HB602X	3/8"-16 Guillotine U-bolt	2	2	2	2	Attach box to tower leg
10	HW6001	3/8" SAE Flat Washer, ZPS	4	4	4	4	Attach box to tower leg
11	HN6003	3/8"-16 Hex Nylon Lock-nut, ZPS	4	4	4	4	Attach box to tower leg
12	EC0153	Grounding Bar Kit #PK7GTA	1	1	1	1	Ground Bus
13	HS3014	Screw, #10-32 x 1" PHP, SS	1	1	1	1	Ground Bar
14	HN3001	Nyloc Nut, #10-32 SS	1	1	1	1	Ground Bar
15	LA603	Lightning Arrestor	1	1	1	1	Install in Switch Box
16	EC0154 *	Wire Connector ILSCO GTA-2-2	3	3	3	3	LA603 Connect
17	EC0155 *	Insulating Cover ILSCO GTC-2	3	3	3	3	LA603 Connect

\* California only

**Figure 2. Master Wiring Kit List**

## 3) Tower Safety

**The primary concern at any installation should be for the safety of the individuals involved.** Tower work is inherently dangerous, and there is always the potential for injury. If every one is careful and remains aware of the dangers, however, there should be little risk. The following rules should be observed:

1. Persons not directly involved in the installation should stay clear of the work area.
2. All persons on or in the vicinity of the tower should wear OSHA-Approved hardhats.
3. Tower work should be done by or under the strict supervision of trained personnel.
4. Never construct a tower near utility lines. If any portion of the tower or equipment comes into contact with them, serious injury or death may result.
5. Anyone working on the tower should use a lineman's belt or harness and a tool belt.
6. Never carry tools or parts in your hands while climbing the tower. The use of a hoistable tool bucket is recommended.
7. Keep the number of tower trips and the amount of work to be done on the tower at a minimum.
8. **Never stand or work directly below someone who is working on the tower.** (Some tower workers have learned this the hard way!)
9. Never work on the tower if alone at the site.
10. Never climb the tower unless the turbine is furled and the alternator locked by a short circuit. The best location for the short circuit jumpers is in the tower-base disconnect switch box.
11. Stay clear of the tower during any threat of thunderstorms, high winds, tower icing, or severe weather of any kind.

## 4) SSV Tower

### 1. Description

The Rohn self-supporting (SSV) tower is an attractive option to guyed-lattice towers because it requires no guy cables and therefore affects a smaller area of terrain. The relatively small footprint means, however, that foundations must be very substantial. A typical installation with a self-supporting tower will be more expensive than a corresponding guyed lattice or tilt-up tower, and a crane will be required to raise the tower and turbine. The tower does permit inspection and minor service work on the turbine to be performed by climbing the tower. Since the tower sections are hot-dip galvanized the SSV tower is highly protected against corrosion and will never need to be painted. The basic configuration for the SSV tower is shown in **Figure 3**. Drawings with component lists for individual tower sections are included in the Appendix, pages A-1 through A-7.

### 2. Concrete Foundations

#### A. Layout

The required anchor bolt layout is shown in **Figure 4**, Drawing No. 11465. It is important to recognize that tower height is increased, in 20 foot increments, by adding new sections to the base of the tower structure. Each additional section is stronger and heavier, with a larger spread between the tower legs. Foundation size also increases with tower height.

The most common foundation consists of a single large, square concrete pad with three anchor groups. The pad must be deep enough to extend below maximum frost depth. The thin pads shown in **Figures 5 and 6** (Drawings 11463-80-C and 11463-90-D) are designed specifically for regions with warm climate and low soil strength. Note that the size of these thin pads also depends on wind conditions at the turbine site. Other foundations may be used where deep frost occurs; drilled-and-bell piers, hybrid pier-pads, and thick pads are available options. The thick pad foundation is shown in **Figure 7** (Drawing 11464). These alternate foundations, designed by Rohn for use with the SSV tower, are shown in the Appendix, Rohn Drawing No. D830157. Drawings for Rohn foundations are supplied with each turbine shipped from the factory. The different foundation options have significant differences in concrete volume, reinforcing steel complexity, and excavation technology. Consult local codes, soil data summaries and excavation contractors to develop a practical and economical plan for a tower foundation.

NOTE: The “thin” foundations require anchor studs and ½ steel anchor plates. All other foundations use longer J-bolt anchors with a sheet metal template near the hooked section to stabilize the bolts while concrete is poured. All towers also use thin upper templates to align bolts properly.

When the tower is ordered from BWC, specify the type of foundation to be installed. BWC will supply one of these anchor systems as part of the tower kit. Usually, it is best to arrange for shipment of the J-bolts or studs several weeks before turbine shipment, to allow construction and curing of the foundation(s) prior to tower and turbine delivery.

Assembly of the anchor studs and anchor plates is shown in **Figure 8**; a similar diagram for the J-bolts is shown in **Figure 9**. Construction and use of a triangular fixture to properly locate and orient groups of anchor bolts is shown in **Figure 10**. Each tower kit includes 3 thin, metal patterns that are used to control the arrangement of bolts in each anchor group. These patterns, labeled “A.B. Setting Template” in Figure 6, may also be used as guides when drilling the triangular placement fixture. (Note that J-bolt anchors include a second set of sheet metal patterns that control below-grade arrangement of the bolt groups. These patterns are distinguished by a large round hole in the center of each pattern. This fifth hole allows concrete to move easily through the pattern and into the space between the bolts.)

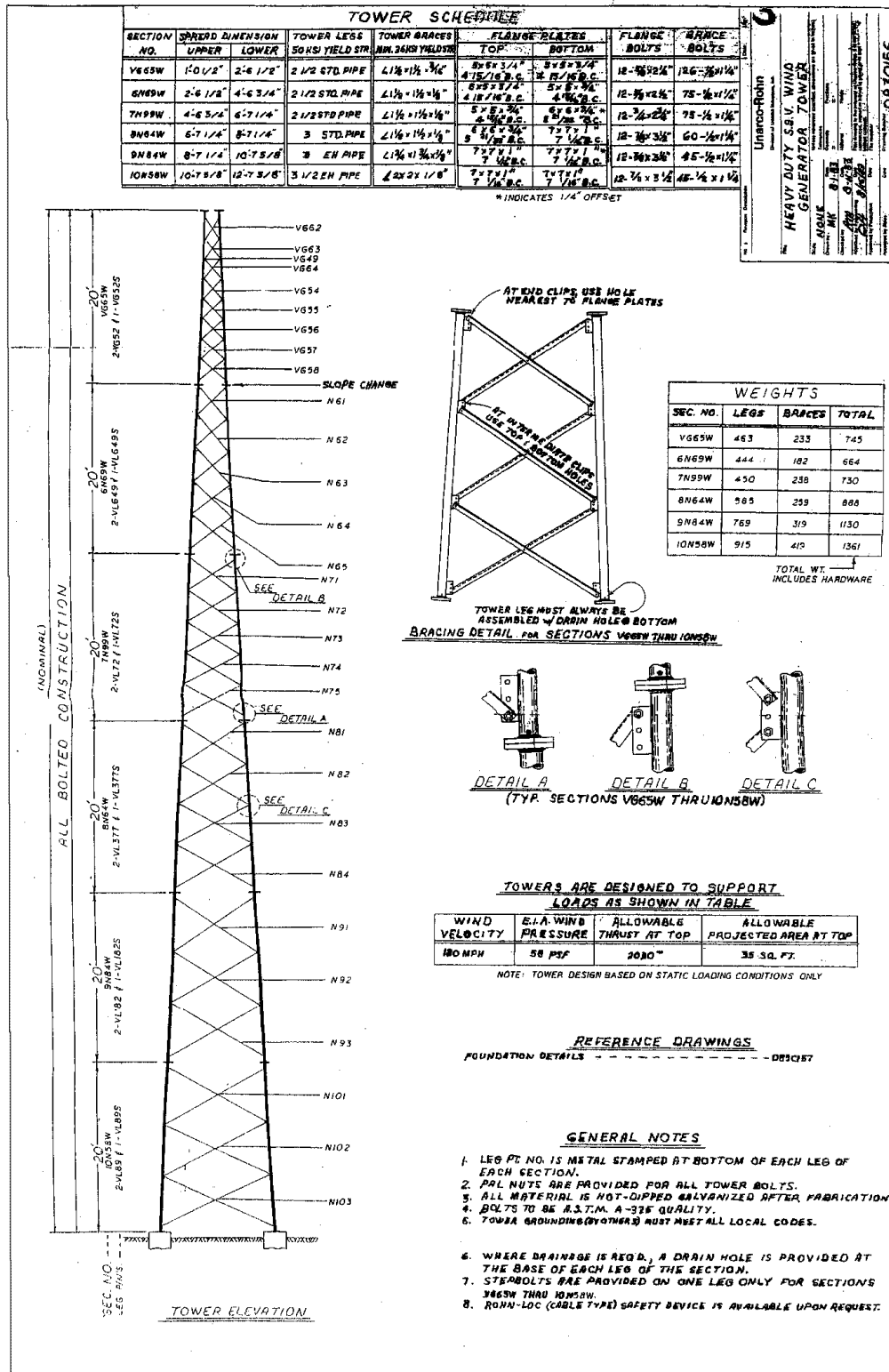


Figure 3. Tower Elevation and Schedule

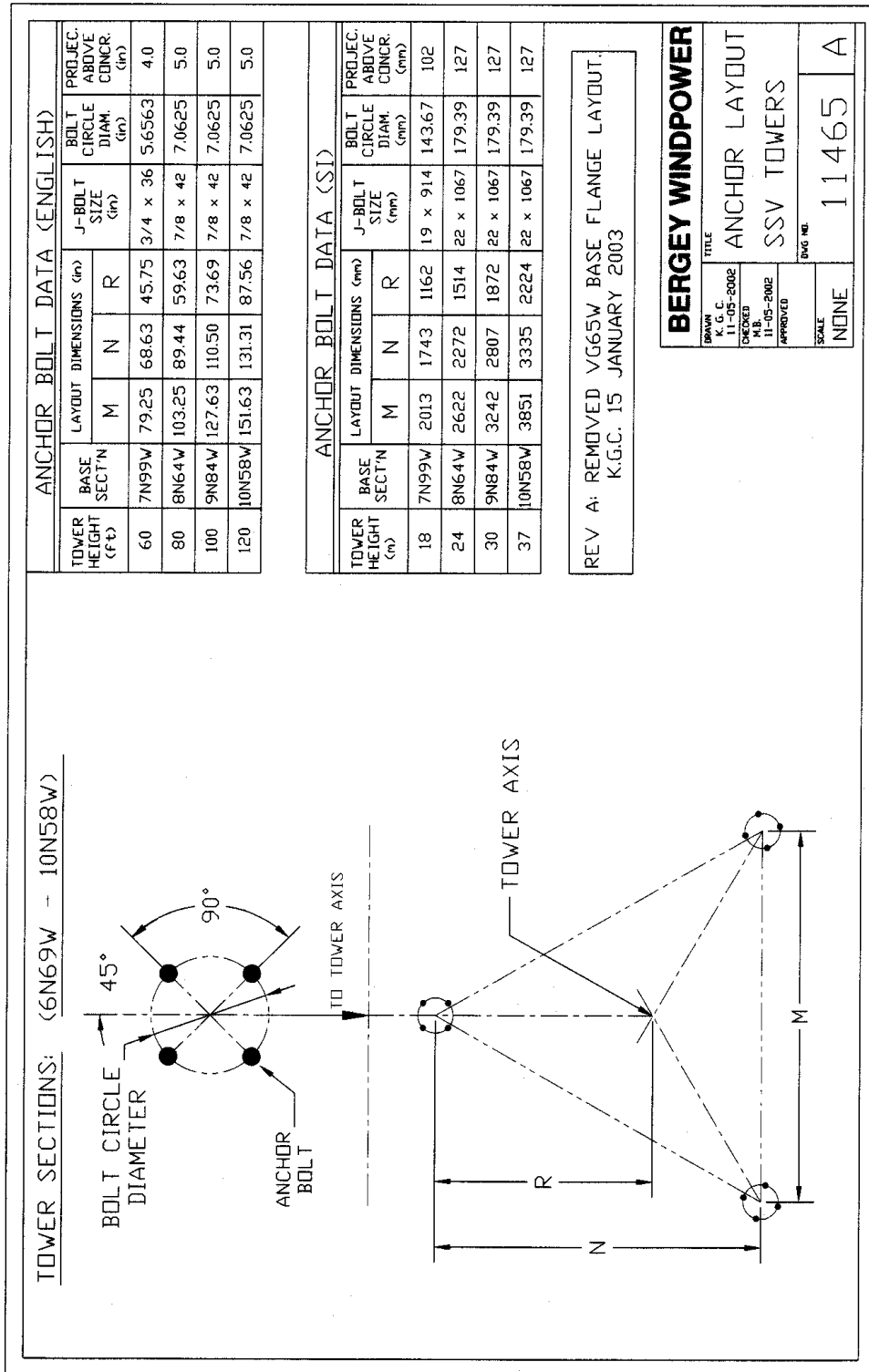


Figure 4. Layout of Anchor Bolts

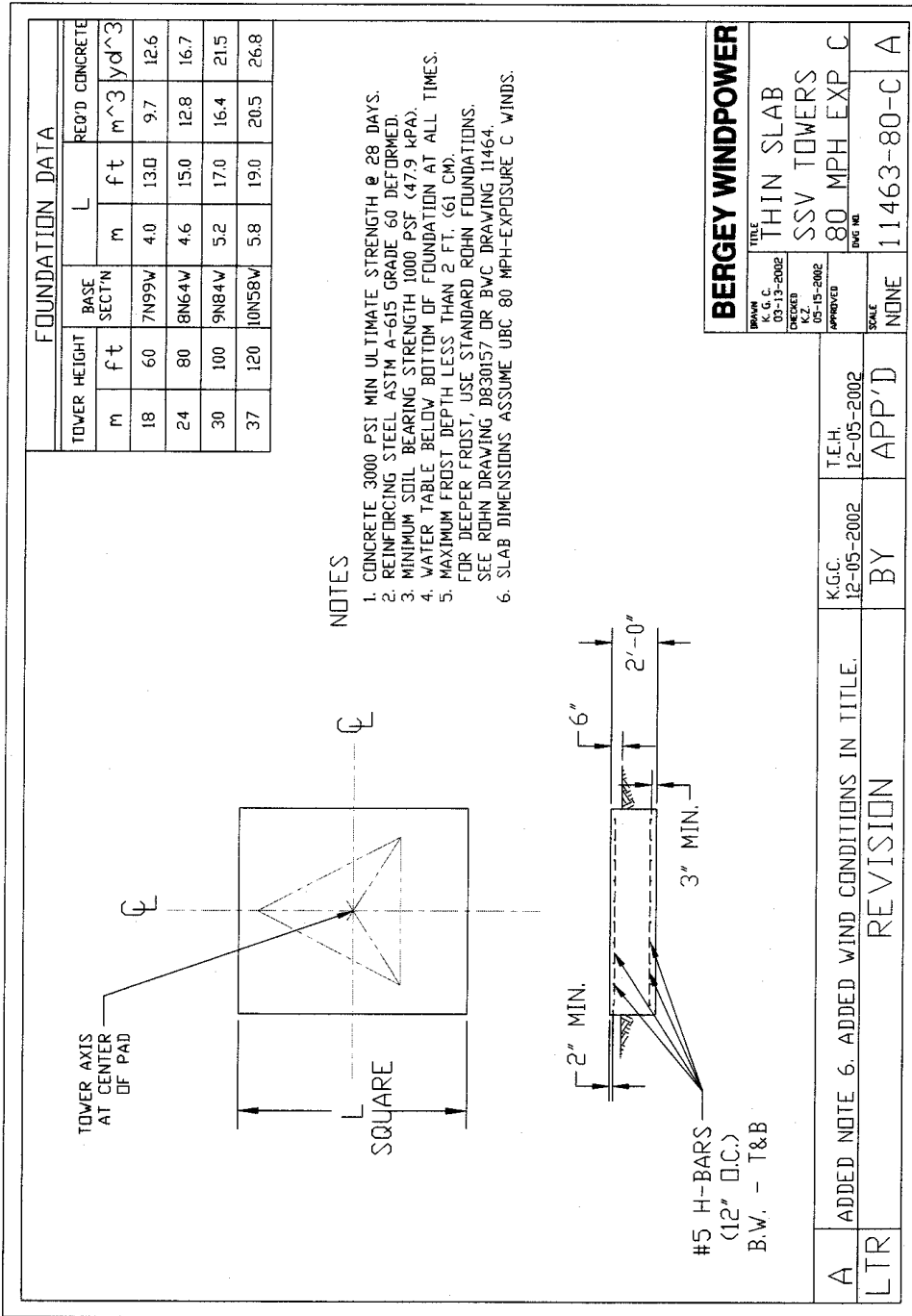


Figure 5. Thin Slab Foundation - Moderate Winds

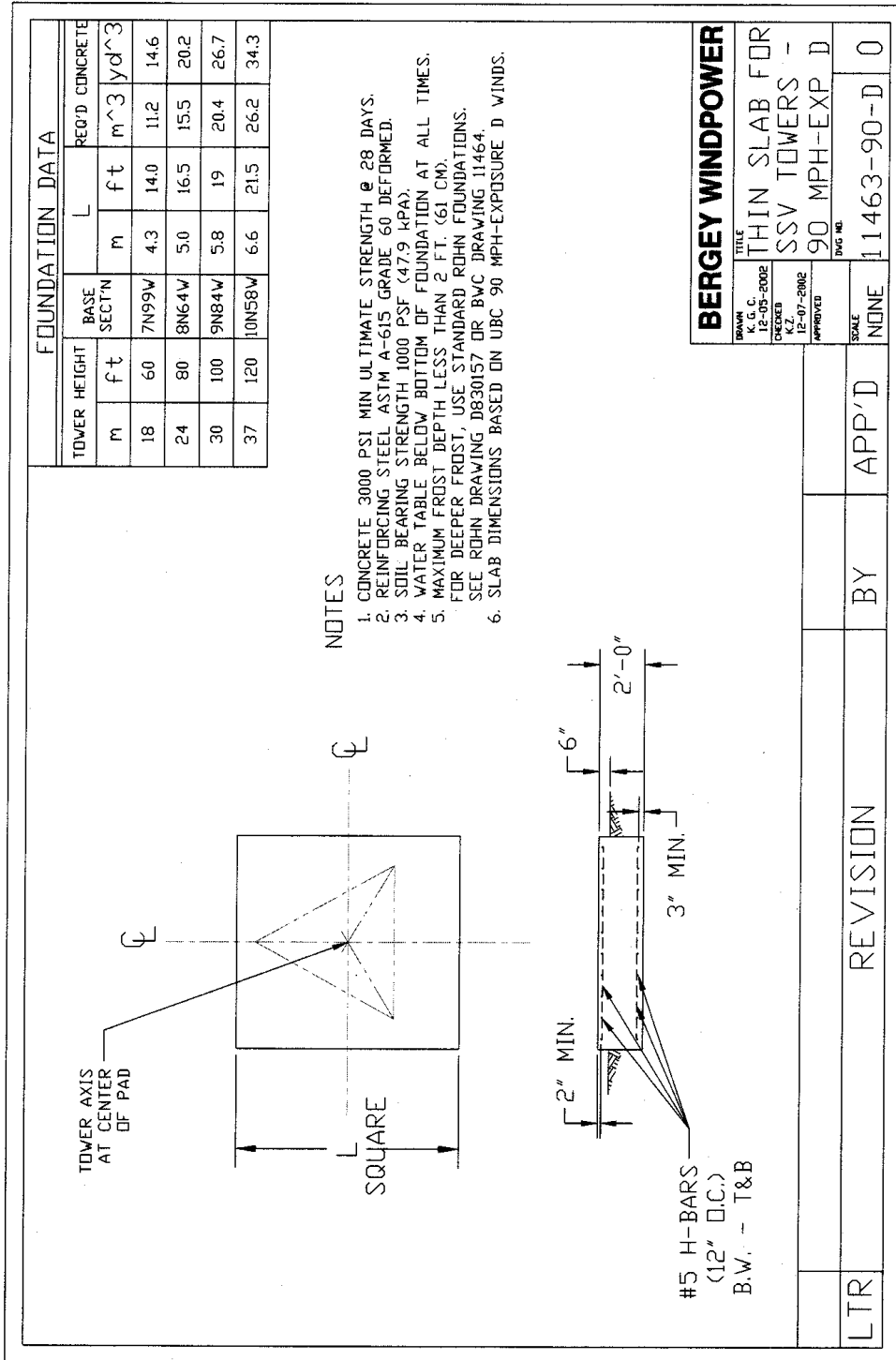


Figure 6. Thin Slab Foundation - High Winds

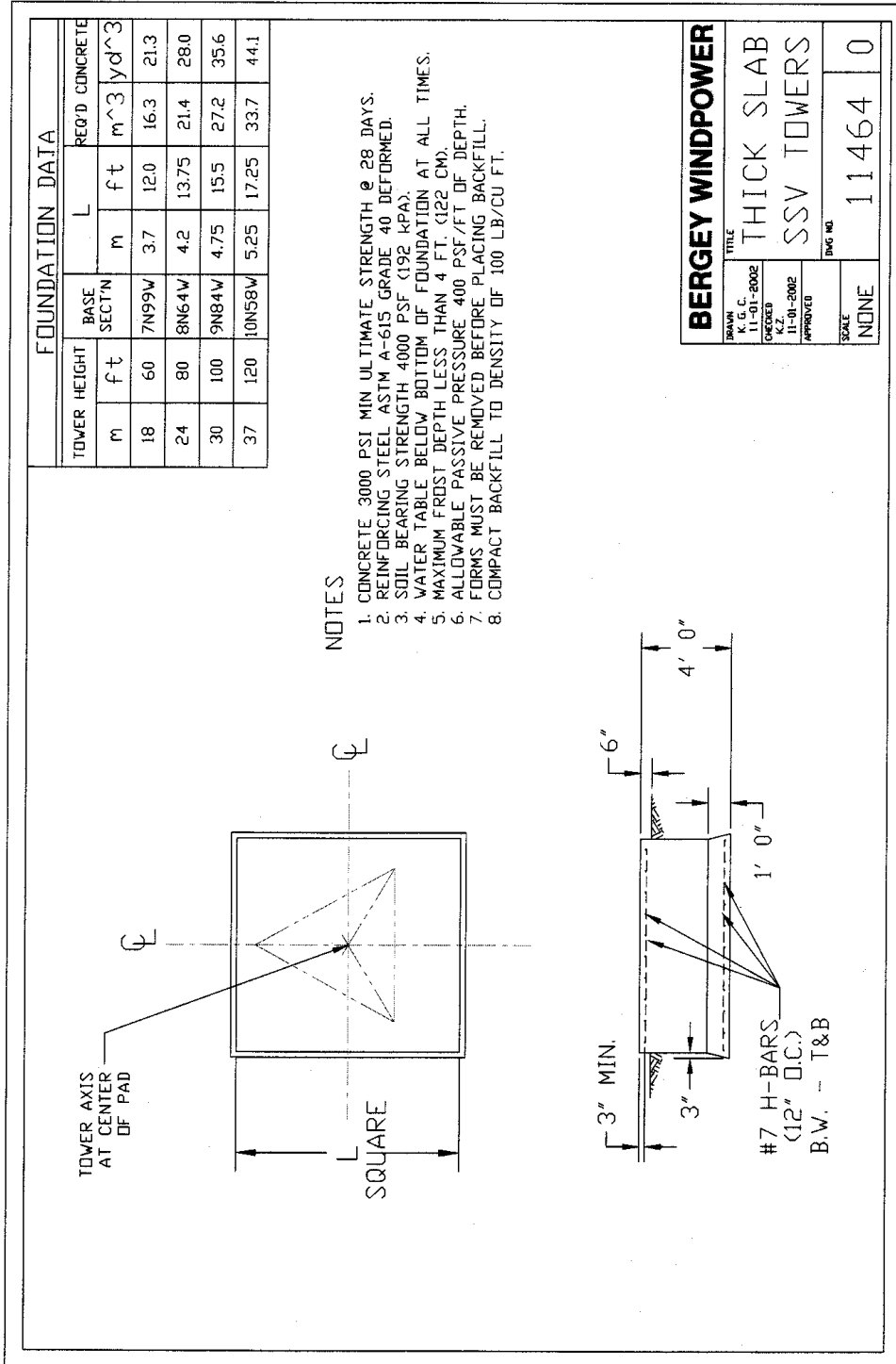
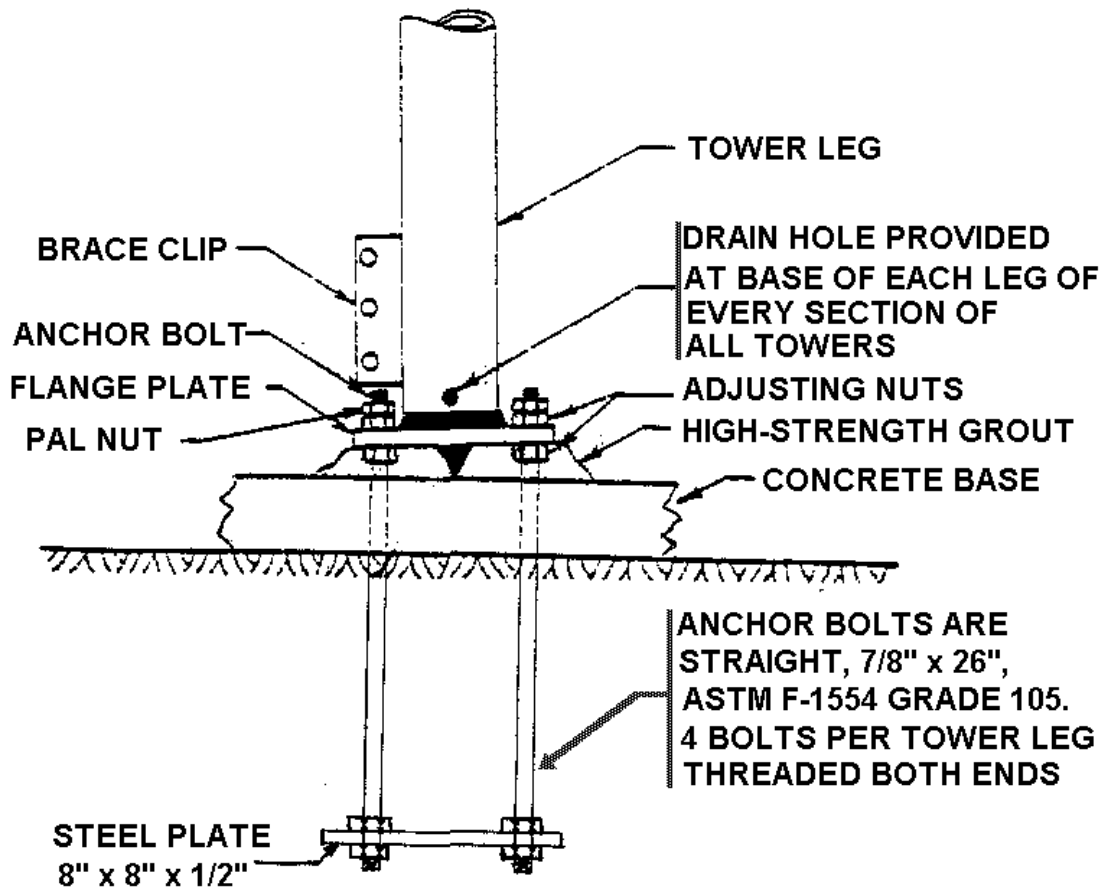
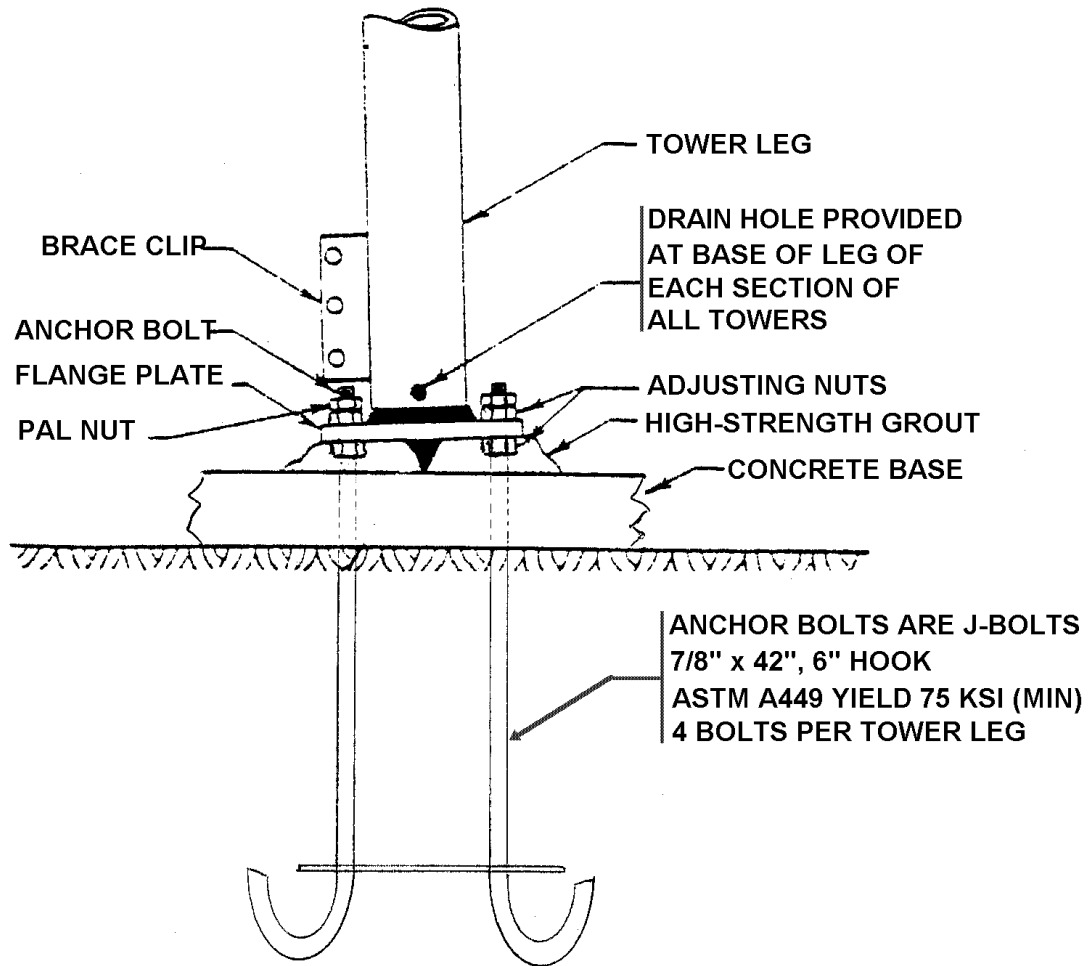


Figure 7. Thick Slab Foundation



ANCHOR STUD DETAIL FOR 80 - 120 FT SSSL TOWERS

Figure 8. Assembly of Anchor Studs and Plates



**ANCHOR J-BOLT DETAIL, 80 - 120 FT SSSL TOWERS**

Figure 9. Assembly of Anchor J-Bolts and Template

The sequence for construction of the foundations is described below:

1. Excavate soil and build forms as required. Forms are used above-grade only for all foundations except the pier-pad system.
2. Install rebar, anchor bolts, conduit and any other required accessories that are to be placed in the foundation(s).

**NOTE: IT IS IMPERATIVE THAT ANCHOR BOLTS BE ACCURATELY LOCATED AND LEVELLED! Use an accurate fixture, as shown in Figure 10 (Rohn Drawing C711017), to locate anchor bolts. Install template with clearance above top surface plane of foundation to allow for proper finishing of foundation top surface. Tie anchor bolts firmly to avoid movement when concrete is poured. Assure proper concrete cover over all rebar.**

**NOTE: Grease upper threads on studs and J-bolts to facilitate removal of concrete that is splashed onto the threads.**

**NOTE: Be sure to follow the anchor bolt layout shown in Figure 4 (Drawing 11465). The EDGE of the tower leg flange faces toward the center axis of the tower.**

**NOTE: Anchor bolts that extend too far above the concrete surface will interfere with brace bolts used to assemble the tower base section. If the pad is properly poured and level, 4.5 - 5" of bolt extension should be sufficient.**

**NOTE: The electrical disconnect switch for the turbine will be attached to one of the tower legs. Be sure to install electrical conduit to carry an underground wire run to the tower leg where the disconnect will be installed. Keep this conduit at least 6" away from any anchor bolts.**

**NOTE: Do NOT install grounding rods so that they pass through the concrete foundation(s). Rods that pass through concrete will damage the foundation in normal service. It is best to drive ground rods AFTER the foundation(s) have cured. Ground cable clamp connections should be ABOVE ground level for inspection and maintenance.**

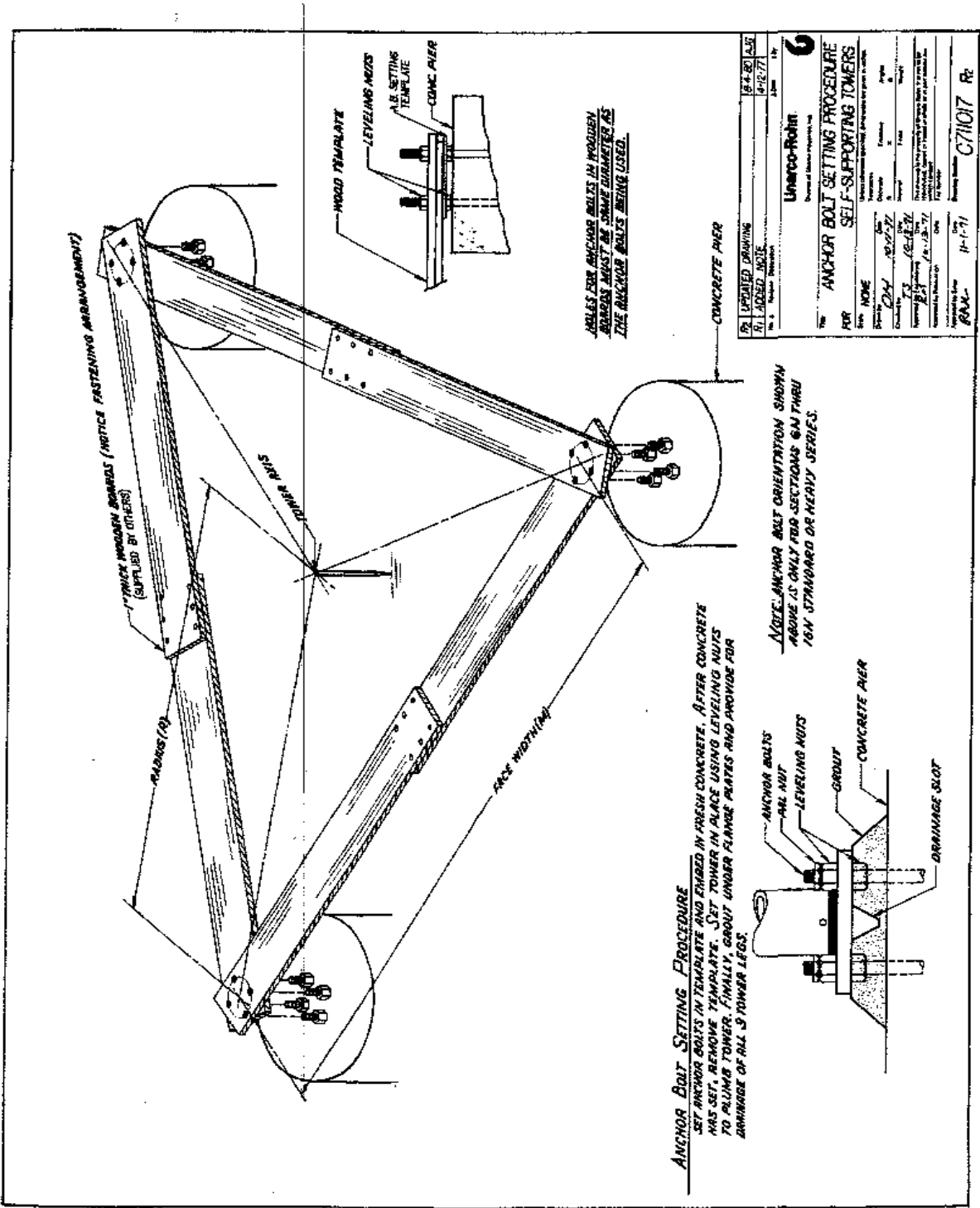


Figure 10. Triangular Anchor Bolt Fixture

3. Order concrete. When ordering concrete refer to the specifications given on blueprints or drawings. Let the supplier determine the proper mix of cement, sand, gravel, etc. to meet the strength and stiffness requirements.
4. Pour concrete. **Vibrate concrete during the pour** to assure that it fills properly around rebar and anchor bolts. Finish the foundation making sure it is level with a slight top surface crown to provide drainage.

**NOTE: Do not remove templates or forms until concrete is cured and hard. Any attempt to do so may disturb the anchor bolts and reduce their effectiveness.**

5. Allow concrete to cure. Minimum cure time for the concrete is 14 days; tower erection must not occur before this cure interval. For maximum strength 28 days is recommended. Cold weather causes concrete to cure more slowly; surface finish and ultimate strength are affected by the cure process. For specific recommendations on controlling concrete cure, refer to a standard construction manual that includes concrete techniques.
6. Remove templates and forms after at least 1 week of cure, and backfill if necessary. Backfill with cohesive soil compacted to at least 100 lb/cu ft.
7. Clean concrete from anchor bolt threads.
8. Drive anchor rods into the ground near each tower leg location. Rods should be driven until the top of the rod is at least 3" below ground level. (This operation can be done at any time before the tower is raised. If rods are set now, it is recommended that they be marked with wooden stakes and/or flagging so they may be easily located later.)

## **3. Tower Assembly**

Assembly drawings and instructions are shipped by the manufacturer with each tower. Study these carefully before starting any assembly . Standard procedure is to assemble the tower and turbine completely on the ground, then lift the entire EXCEL-and-tower structure into place on the anchor bolts. This will require a crane with lifting capacity to handle the combined weight of turbine and tower, and a convenient area of reasonably level ground for assembly of the tower-turbine combination.

NOTE: Use of standard wrenches to snug the brace bolts is recommended. Use of a torque-controlled impact wrench to accomplish final tightening of all fasteners is highly recommended, and will speed the assembly process immeasurably.

### **A. Assemble Tower Sections**

1. **Figure 11** shows a list of tools required or recommended for assembly of the SSV towers and attachment of the BWC EXCEL turbine. **Figure 12** shows a summary of torque recommendations for hot-dip galvanized bolts. All tower bolts are coarse-thread, hot-dipped ASTM A325 bolts.
2. When fully assembled the tower should be lying on the ground, next to the foundation(s), on the opposite side from where the crane will be stationed. The point on the tower where the crane sling will attach should be aligned with the central axis of the foundation.
3. Lay out ALL tower legs and cross pieces (“braces”) on the ground in their approximate assembled positions. Be sure that all step legs are aligned on the tower.

**Note: Each tower leg has a part number stamped into one of the flanges at the end of the leg. The leg MUST be installed with this stamped flange AT THE BOTTOM. The tower cannot be properly assembled if any of the legs are upside-down!**

**Note: Documentation delivered with the tower includes Assembly Detail drawings for each tower section. Braces are used in each tower section in the same top-to-bottom order given in the bill of material shown on these drawings.**

**Note: All cross braces have a hole near the center. This hole is NOT in the center. Cross braces can only be installed in one orientation (short hole-hole distance upward).**

**Tool List for EXCEL-SSV Tower Systems**

<b>No. Reqd.</b>	<b>Description</b>	<b>Application</b>
2	<b>Wrench, 7/16" (1 socket?)</b>	3/16" Malleable clips
2	<b>Wrench, 1/2" (1 Socket?)</b>	Grounding hardware
2	<b>Wrench, 9/16" (1 Socket?)</b>	Winch attachment hardware
2	<b>Wrench, 3/4" (1 socket?)</b>	Winch plate U-bolts
1	<b>Wrench, 7/8"</b>	Tower brace bolts, 1/2"
1	<b>Wrench, 1 1/16"</b>	Tower flange bolts, 5/8"
1	<b>Wrench, 1 1/4"</b>	Tower flange bolts, 3/4"
2	<b>Wrench, 1 5/8" (Crescent wrenches?)</b>	Armored cable connectors
1	<b>Wrench, 1 7/16"</b>	Tower flange bolts, 7/8"
1	<b>Socket, 7/8"</b>	Tower brace bolts, 1/2"
1	<b>Socket, 1 1/16"</b>	Tower flange bolts, 5/8"
1	<b>Socket, 1 1/4"</b>	Tower flange bolts, 3/4"
1	<b>Socket, 1 7/16"</b>	Tower flange bolts, 7/8"
1	<b>Deep socket, 1 1/8"</b>	Turbine blade attachment nuts
1	<b>Ratchet to fit sockets above</b>	
1	<b>Torque wrench to fit sockets above</b>	
2	<b>Nylon sling, double eye, 5-ton work load</b>	Lift tower-turbine combination
1	Torque-calibrated portable driver for sockets	
2	Drift pins (bull pins)	Align section flanges
2	Vice--grip pliers, large	Align section flanges
1	Hack saw	Cut armored cable
1	Tool for armored cable prep	Armored cable connections
1	Channel-lock pliers	Electrical nut & grommet
1	Jack or chain hoist, 500 lb capacity	Support upper tower leg
1	Twist drill, 13/16" or 15/16"	Drill grounding plate bracket
1	<b>Wrench, 5/16" (nut-driver?)</b>	Terminal block cover screws

Figure 11. Recommended Tools for SSV Tower Installation

**Torque Specifications for Bolts**

Note: All bolts are ASTM A325 Hot-dip Galvanized

Diameter (in)	Pitch (threads per inch)	Torque Range	
		(ft-lb)	(N-m)
1	14	585	793
1	8	495	671
7/8	14	405	549
7/8	9	350	475
3/4	16	250	339
3/4	10	205	278
5/8	18	145	197
5/8	11	120	163
9/16	18	95	129
9/16	12	80	108
1/2	20	75	102
1/2	13	60	81
7/16	20	50	68
7/16	14	40	54
3/8	24	30	41
3/8	16	25	34
5/16	24	14	19
5/16	18	12	16
1/4	28	7	9
1/4	20	6	8

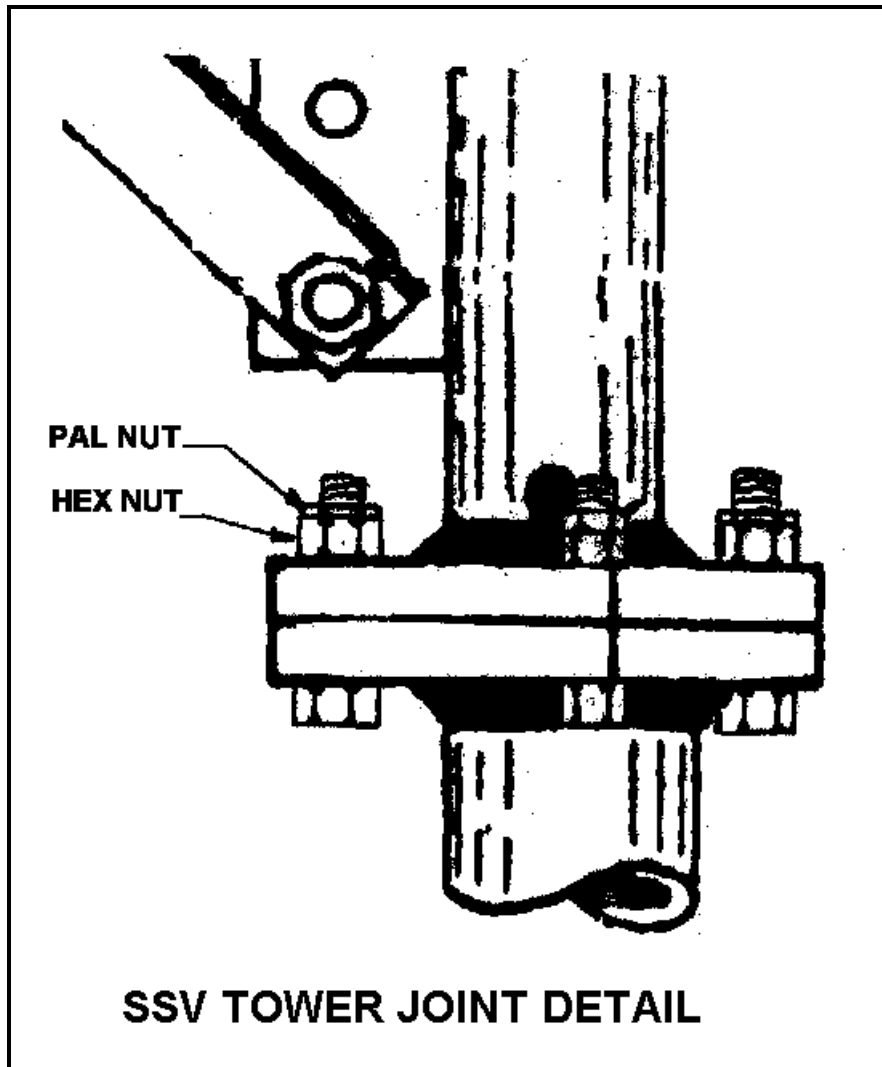
These values are calculated to provide bolt pre-load tension with a 25% safety factor below bolt yield stress.

Torque is reduced 15% due to HDG finish.

Figure 12. Torque Specifications for Tower Bolts

4. Assemble each section
  - a. **Start with the top section!**
  - b. Tower legs are usually bowed due to the manufacturing weld process. This bow will be pulled out as the section is assembled, but force will be required.
  - c. Use of jacks, a scaffold or an A-frame to hold the upper leg in place will be required. This can require a support over 10 ft high for the bottom section of a 120 ft tower!
  - d. Support the two lower legs with blocks at each end and in the middle to level them and keep them from bowing.
  - e. Bolts used for all brace connections are  $\frac{1}{2}$ " x  $1 \frac{1}{4}$ " A325. These will require 7/8" wrenches.
  - f. Install the braces. Insert the bolts for the braces so that **all nuts will go on the outside of the tower. The end of the brace stamped with a part number is oriented toward the top of the tower. (The hole is NOT in the middle!)**
  - g. Do not tighten any of the hardware until the tower is erected and securely anchored.
  - h. Leave all brace hardware finger-tight until the tower is erected.
  
5. Attach the sections to each other. Flange bolts should be tightened to final torque specification. We suggest that all PAL nuts be installed after the tower is installed on the foundations; **install PAL nuts only after a nut has been tightened to final torque specification.**
  - i. Drift pins and vice grips will be required to align flanges before bolts can be inserted.
  - j. A jack, bumper crane, come along or a 4x4 post, may be needed to push or pull legs into position when the drift pins can't be started.
  - k. Bolts used for the flange joints on the VG65W and 6N69W sections are  $\frac{5}{8}$ " x  $2 \frac{1}{2}$ " A325, requiring  $1 \frac{1}{16}$ " wrenches. The  $\frac{3}{4}$ " bolts for the 7N99W lower flange joint require  $1 \frac{1}{4}$ " wrenches. The lowest tower sections (8N64W, 9N84W and 10N58W for 80- 100- and 120 ft towers) use 7/8" bolts in their bottom flange connections. These bolts require  $1 \frac{7}{16}$ " wrenches.

**Note: Install flange connection bolts with nuts on the top, as shown below.** This allows detection of loose or missing bolts in a quick ground-level inspection. Twelve bolts are required at each tower joint level.



### B. Install furling lanyard, cable and winch.

1. Determine which tower leg will support the electrical fused disconnect switch. (The electrical conduit stubs out of the concrete near the base of this leg.) The winch cannot be attached to this leg.
2. Attach the winch mounting plate, included with the tower hardware kit, to one of the bottom tower legs using two U-bolts provided in hardware kit HK0019. Be sure to orient the winch plate properly. Refer to **Figure 13**. Locate the plate so it will be at a convenient height above ground when the tower is installed. The recommended mounting height for the

furling winch is 1.3 - 1.5m (4 - 5 ft.).

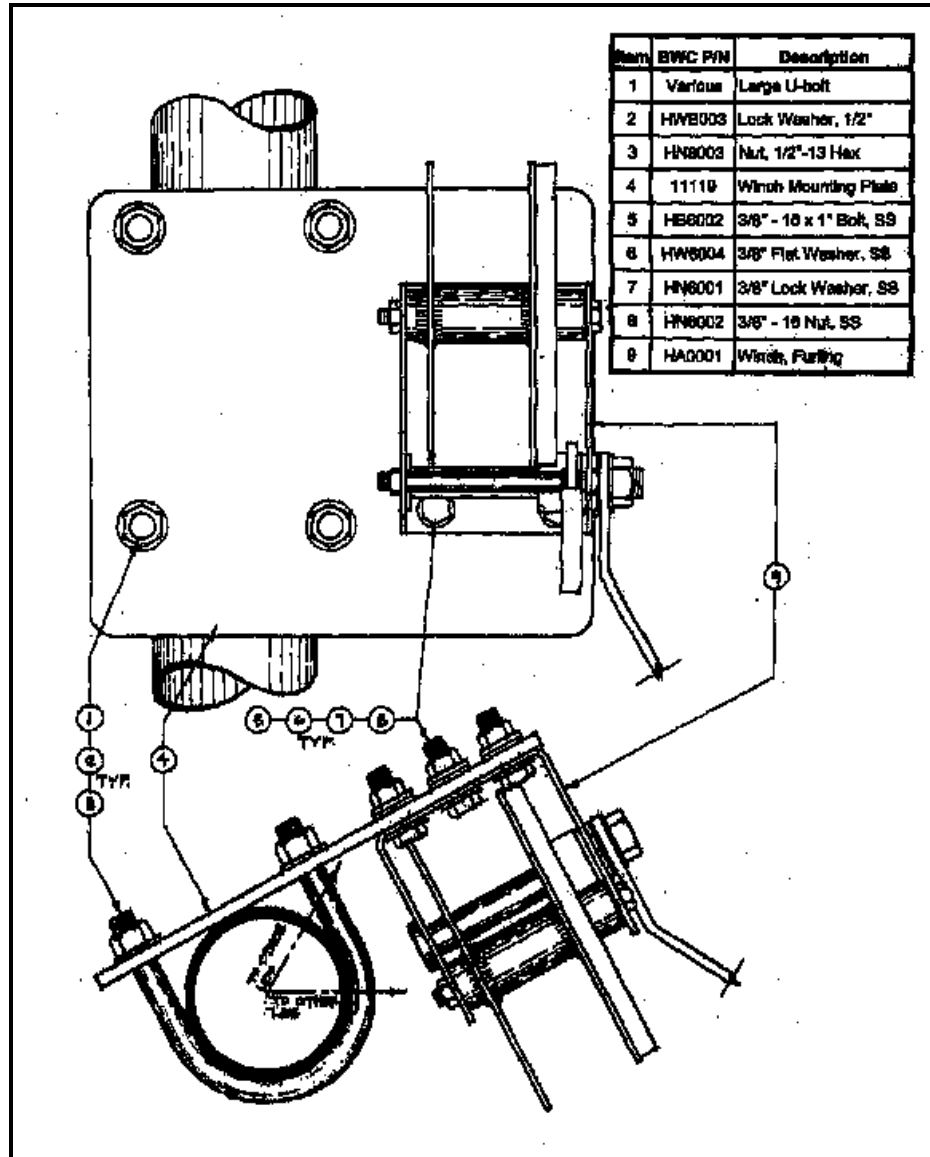


Figure 13. Winch Mounting on SSV Towers

3. Mount the winch to the plate using three 3/8"x1" hex bolts with flat washers, lock washers and hex nuts. **Note that the winch is mounted INSIDE the tower, so the winch drum is oriented toward the center of the tower.** Before tightening the U-bolts that fasten the mounting plate it is advisable to turn the handle on the winch and check that it rotates freely (i.e. that it does not hit the braces or brace clips of

the tower).

- Attach the furling cable lanyard as shown in **Figure 14, Detail A**. The lanyard is required to assure that the furling cable remains centered in the upper tower section, then angles properly to the winch drum. The lanyard attachment eye-bolt replaces the standard 1/2" bolt at the crossing of the two VG58 braces on the tower face OPPOSITE TO the winch. These are the lowest braces in the top (VG65W) section.

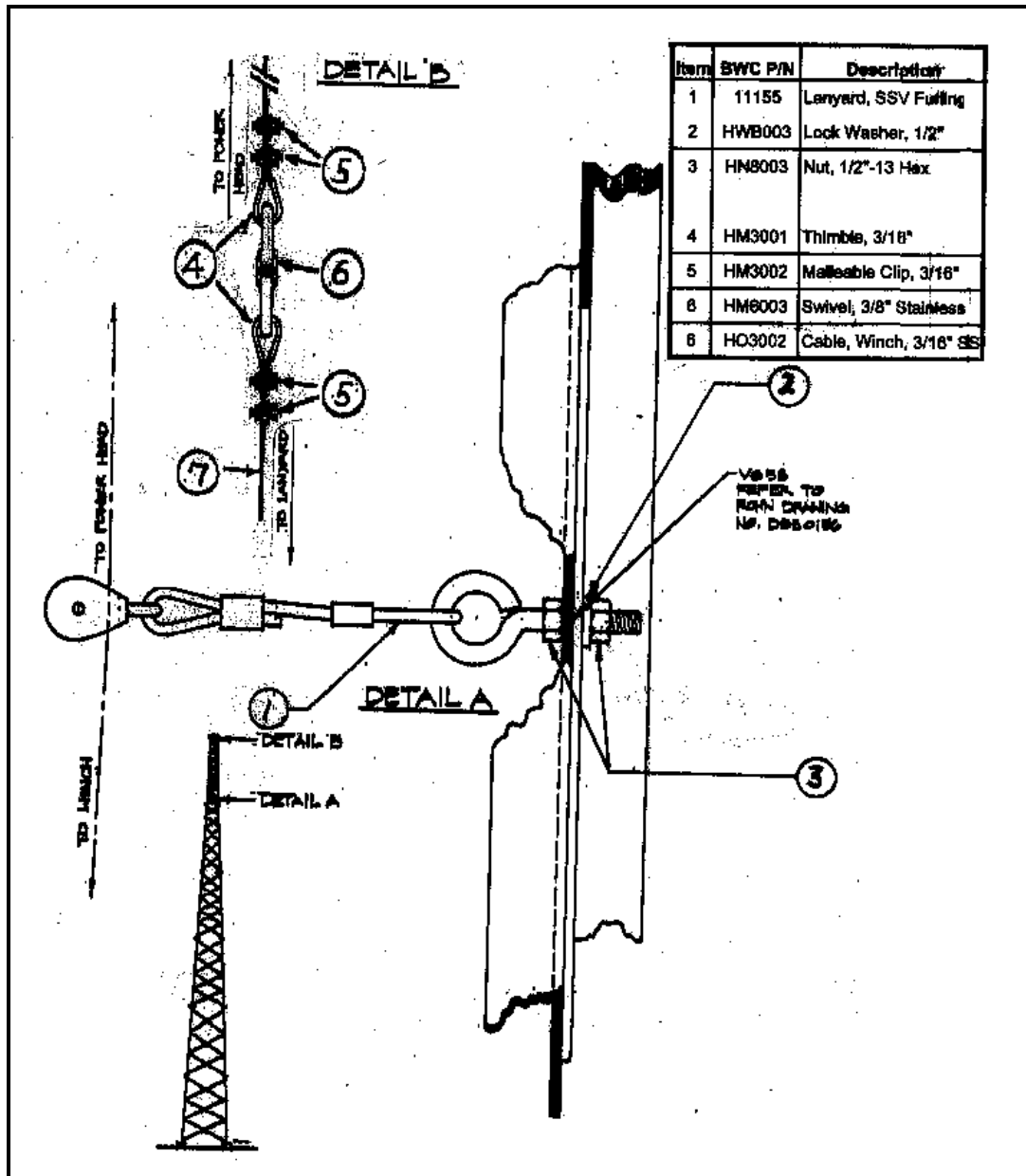


Figure 14. Furling Cable and Lanyard Details

5. Feed the furling cable through the tower, starting from the tower base section. Run the cable through the lanyard pulley, then attach the end to the heavy stainless swivel provided in the tower kit. Use a thimble loop in the furling cable as shown in **Figure 14, Detail B**. The swivel will later be connected to the turbine furling cable; for now it will hold the down-tower furling cable secure in the lanyard pulley.
6. Attach the lower end of the furling cable to the winch by threading the cable through the long slot in the side of the cable drum and securing the cable end as shown in **Figure 15**. There are two alternative attachment methods; BWC recommends the method using the cable clamp provided with the winch.

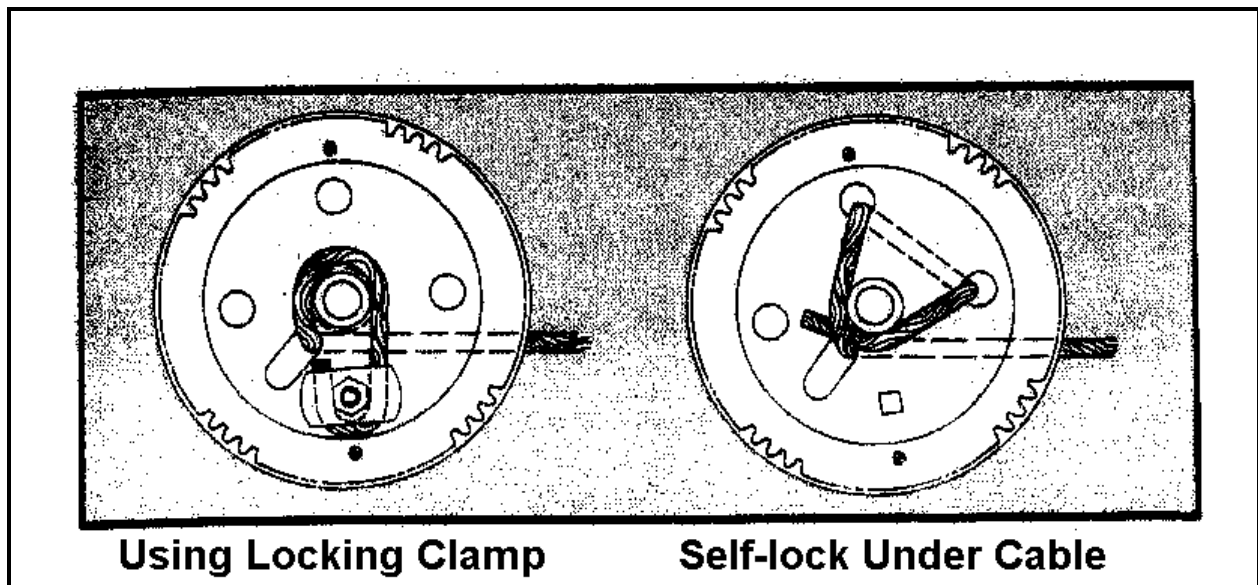


Figure 15. Attachment of Furling Cable to Winch

### C. Install Tower Wiring and Disconnect Switch

1. Pull the armored electrical cable (or other customer-supplied electrical cable) through the center of the tower, starting from the base section.

**Note: Do not use conduit for tower wiring unless internal strain relief is provided for the conductors.**

2. Attach the disconnect switch to the appropriate tower leg using the two U-bolts supplied with the tower wiring kit. If a wiring kit was not purchased from BWC, the customer must supply the appropriate switch, and all hardware required to make mechanical and electrical connections. (Refer to packing list Figure 2.) The switch box must be drilled to accommodate appropriate U-bolts. Locate the disconnect at a height suitable to the customer. **Figure 16** shows typical attachment of the disconnect switch.

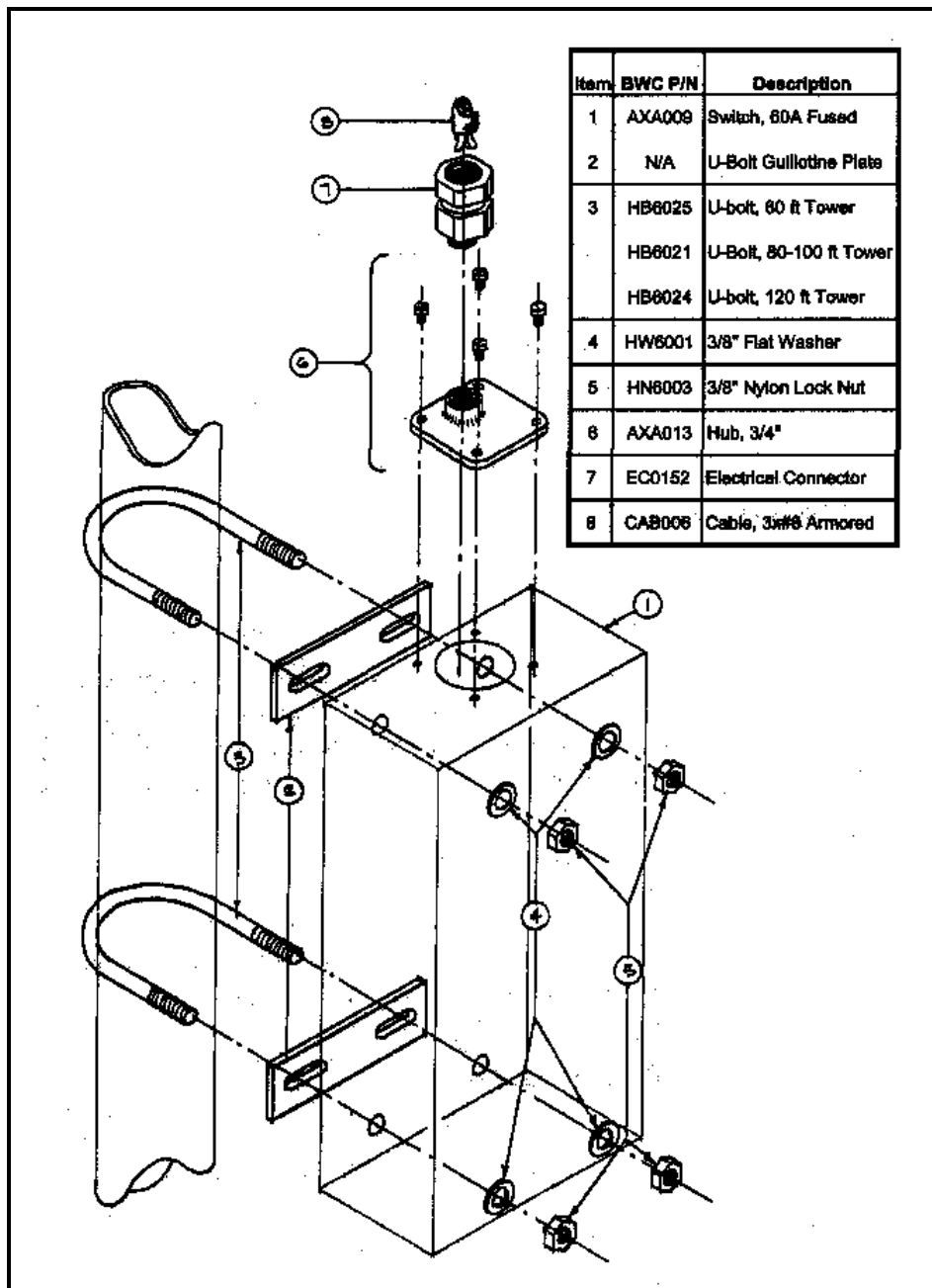


Figure 16. Attachment of Disconnect Switch

Note: The tower is now ready for attachment of the EXCEL turbine at ground level. Crane rental cost is minimized because all possible work is done before the crane arrives on-site.

If some of the steps above could not be accomplished, perhaps because of the tower position on the ground, they can be accomplished after the crane has raised the tower top to allow attachment of the turbine.

## 5) Wind Turbine Assembly and System Erection

### 1. Wind Turbine Assembly

The recommended procedure for completing the installation is to attach the wind turbine to the tower, complete the tower wiring, attach the furling cable, and then raise the tower/turbine as a complete assembly. This procedure requires a light duty crane with a lifting capacity of at least 3,600 kgs (8,000 lbs. or 4 tons) at a working height equal to or greater than the tower height. After the loosely-bolted tower has been properly set and fastened on the anchor bolts, the ½" tower lattice bolts are tightened to recommended torque (60 ft-lb). This section assumes that the optional BWC Tower Wiring Kit is purchased with the tower.

The recommended procedure is as follows:

1. Shortly before the crane is scheduled to arrive, attach the tail fin to the tail boom using the hardware provided in the turbine kit HK0002. Lay the tail boom on a work surface with the fin mounting plate upward. Position the tail fin on the mounting plate, with the trailing edge bend upward. Eight bolts (3/8"-16 x 1"), 16 flat washers and 8 nyloc nuts are used. Recommended torque is 20 ft-lb. Set the tail assembly aside for later use.

**Note:** BWC supplies stainless steel fasteners and anti-seize compound for the stainless. **Anti-seize compound MUST be used on all stainless steel fasteners!**

2. Also before the crane arrives, put leveling nuts on all anchor bolts. The tower flanges tip a few degrees toward the center of the tower, so the six nuts closest to the center will determine the level of the tower. Do your best to get these six nuts set on the same level plane, with about an inch of separation between nut and concrete surface. The other six nuts (the outside ones) should be screwed down far enough that they will not contact the flanges.
3. Position the crane so it will be **DOWNWIND** of the tower during the lift. (The tail will orient toward the crane boom, keeping the rotor blades away from the cable.) The boom should lean outward to make initial contact with the tower lifting point; boom movement must then be TOWARD the crane's center of gravity as the lift and tower placement occurs. (During the lift the base of the tower will skid across the ground as it moves toward the foundation.)

4. Have the crane attach its lifting cable to the tower at a point just below the top flange joint. Attach to only one leg at this time so that the two bottom legs will remain level when the tower is lifted..
5. Lift the tower until the top is chest high; prop it with a scaffold, jack stands or a strong, stable stack of timbers. The prop should be located at least 4 ft below the top of the tower. (For a 100 ft tower the force applied to the props will be more than 4000 lb.) After the tower is SECURELY propped, remove the crane line.
6. Use the crane to lift the powerhead, still attached to the shipping skid, clear of the ground using a double-eye nylon strap. Slip one eye over each end of the tail pivot pin and onto the mainframe; hook the crane line to the center of the strap and lift. The shipping nuts can now be removed from the blade studs so the skid can be pulled off and set aside.
7. Direct the crane to move the powerhead until the tower adapter plate meets the tower top flanges. Be careful to avoid damaging the turbine furling cable. Use one or two large drift pin(s) to line up the nine attachment holes as shown in **Figure 17**. (Note that one hole in each tower top flange is not used. Note also that the tower can be so distorted at this time that it can be a real challenge to get the holes to align properly.) Bolt the turbine in place using 9 bolts, 5/8" x 2 1/2", with hex nuts, PAL nuts and washers as required. Remember - nuts go on top! This hardware is included in the Tower Hardware Kit HK0021. Use the flat washers provided, as necessary, to be sure there is enough bolt thread to allow full clamp-up with the nuts. Torque the hex nuts to 120 ft-lb; PAL nuts are tightened until they JUST begin to deform. Disconnect from the crane after the turbine is bolted securely.

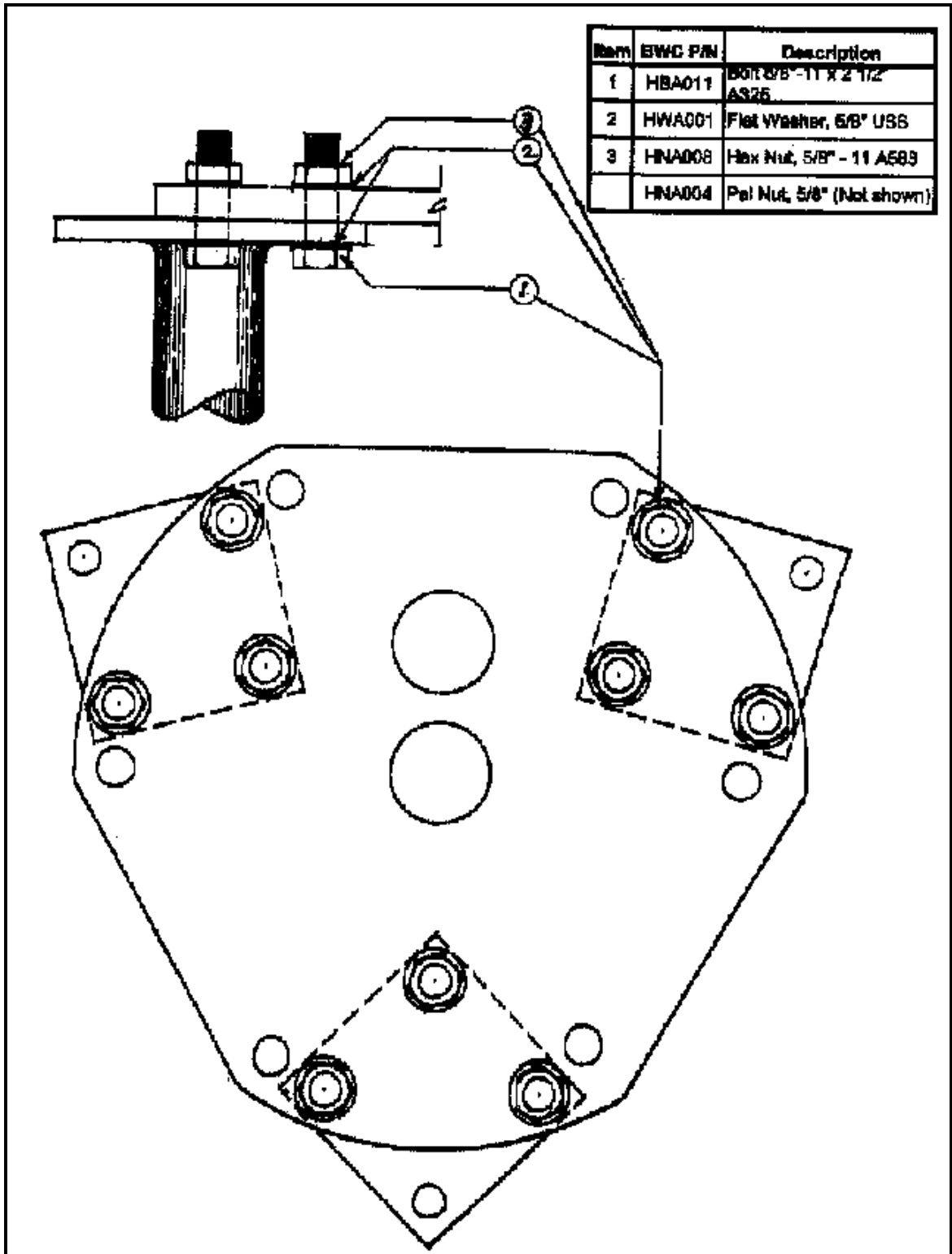


Figure 12. Attachment of Excel Turbine to SSV Tower

8. Make electrical connections to the turbine as follows:
  - a. Remove the stainless steel cover of the terminal block housing.
  - b. Strip the tower top end of the armored cable as shown in **Figure 18**, being very careful not to cut the insulation on the three conductors. A special tool may be purchased for this task at most electrical supply distributors.

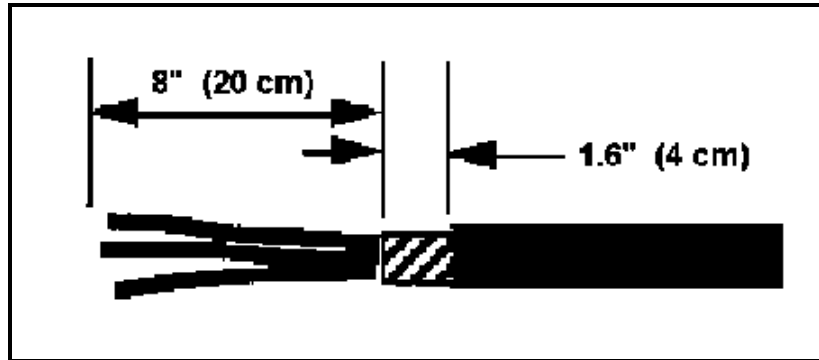


Figure 18. Armored cable end preparation

- c. Complete instructions for use of the supplied Crouse-Hinds cable fittings are included in the Appendix, pp 9-10. **DO NOT DISASSEMBLE THE FITTING.** **Figure 19** below shows the proper position of the cable elements in the fitting. It is best to install the connector on the cable first, then install the assembly into the junction box. Insert prepared cable into the fitting until armor rests against armor stop. (If conductors are too large to fit through the non-metallic armor-stop reducer, remove it using a screw driver.) **THE METALLIC ARMOR MUST NOT GO BEYOND THE ARMOR STOP.** Tighten both the intermediate body and the nut to 500 in-lb (42 ft-lb). Insert the fitting, through the large off-center hole in the tower top plate, into the bottom of the terminal block area. Add the electrical locknut and tighten securely. **INSTALL THE PLASTIC INSULATING GROMMET!** The grommet is required to avoid chafing and, eventually, short circuits in the tower wiring.
- d. Trim each of the conductors to a length that will allow formation of full 360° strain relief loops to each terminal connection. Strip each of the three conductor wires back 3/4" (2 cm), apply anti-oxidation compound to the bare copper and make connections to the terminal block. All three wires are equivalent; there is no polarity.

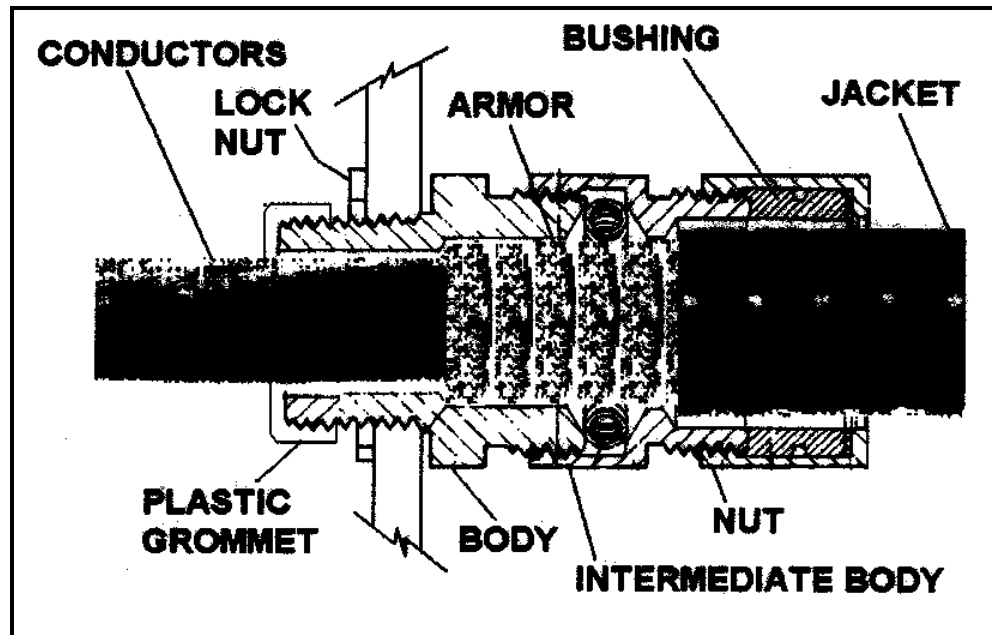


Figure 19. Installed connector and cable

- e. Perform tests for continuity, ground faults, etc. Correct any problems, then replace the terminal block cover. The system should appear as shown in **Figure 20** below.
9. Form a gentle S-bend in armored cable so that it rests along the same tower leg to which the disconnect switch is mounted.
  10. Starting from a point 4 ft below the tower top, use large plastic wire ties every 4 ft to secure the cable to the tower leg. Shape the cables around flanges to avoid chafing; use a wire tie immediately above and below each flange joint. Continue this process until the cable has been shaped around the lowest flange joint.
  11. Prepare the lower end of the armored cable as shown in **Figure 18** above, leaving enough free conductor to make the electrical connections in the disconnect box, and connect tower wiring to the disconnect switch. The BWC wiring kit includes a weather-tight hub for entrance into the top of the disconnect, as shown in **Figure 16**. The armored cable connector screws into the hub; an insulating grommet is not required.

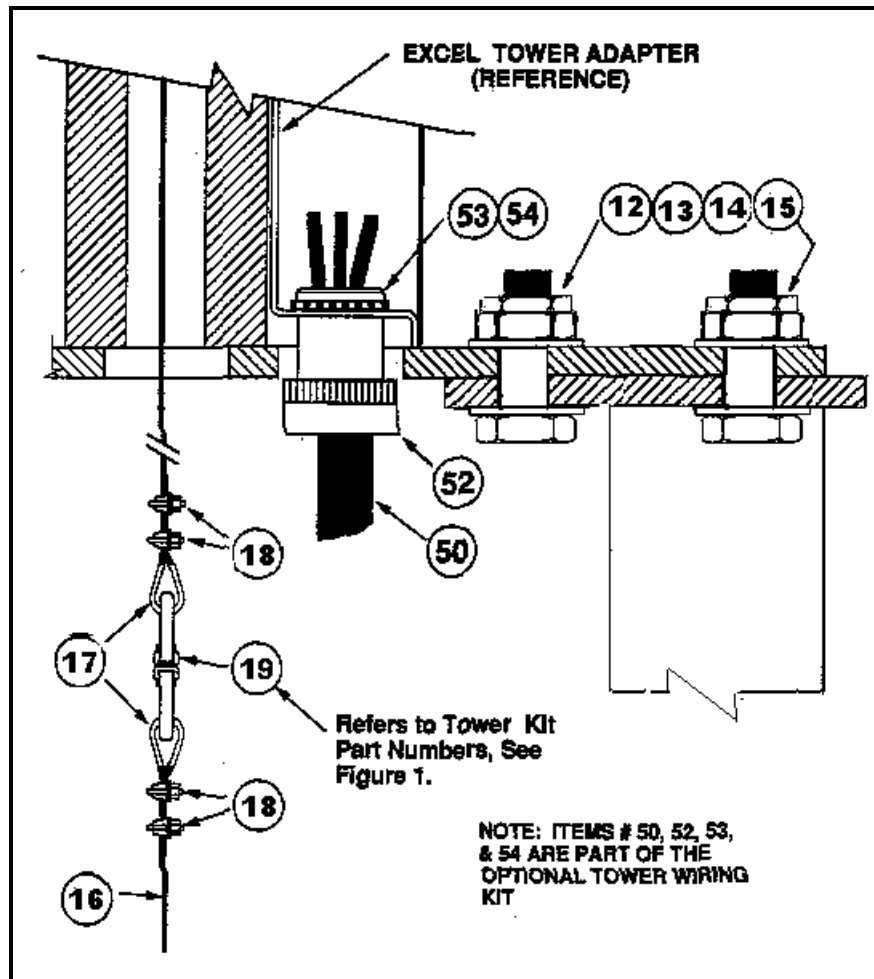


Figure 20. Tower-turbine connections diagram

12. A 3-phase surge arrester such as a Delta LA-603 (included in the tower wiring kit) should be connected to the system at this time. The three wires of the arrester should be connected to the lower (load) set of switch box terminals, along with the tower wiring conductors. There is no polarity in these connections; all three wires are equal.
13. Install jumpers between the three lower (load) terminals on the switch box, to provide a short-circuit. Put the switch in the "ON" position, effectively short-circuiting the tower wiring and alternator. Use the furling winch to pull up all slack in the winch cable. These two steps will prevent rotation of the alternator and rotor during the tower lifting operation.

14. Connect the 3/8" double-eye swivel and winch cable to the EXCEL turbine furling cable as shown in **Figure 20** above, using the thimbles and malleable clips found in hardware kit HK0014. Be sure the winch cable passes through the lanyard pulley. Hold tension on the cable while taking up most of the slack with the winch. Leave several feet of slack in the cable until the tail boom is connected to the turbine.
15. Attach the tail boom to the powerhead. This is a job that requires at least three people. (The crane can be used to lift and position the tail boom if helpers are not available.)
  - a. Remove the retaining bolt and washer from one end of the tail pivot pin, which is shipped already in place on the tail boom.
  - b. Use a drift pin and hammer to knock the pin most of the way out of the tail boom. The pivot pin must be pulled out until it does not protrude into the space between the bronze tail pivot bushings.
  - c. Get the tail boom orientation correct by making sure that the furling cable and damper attachment brackets on the tail boom are aligned with the damper and furling cable on the powerhead. The fin will be on TOP.
  - d. Hold the tail boom in a position so the end with the fin is angled up ~ 15° and align the tail bushings with those of the powerhead, then insert the tail pivot pin as shown in **Figure 21**. The pin may need tapping through, but keep in mind that the stainless steel pin is very soft and can be easily damaged. Use a block of wood or rubber mallet on the pin.
  - e. After the pin is in place reinstall the washer and retaining bolt & nut.
  - f. Release the tail boom and allow it to swing down (about 45°). It may be necessary to put cardboard on the ground to avoid scraping the paint on the fin. (A piece of 2x4 or a pipe inserted into the end of the tail boom will also work to keep the fin off the ground.)
  - g. Make sure the fork on the damper strut is centered on the "upper" tail boom connection tab. Adjust the tail boom tab by slightly bending if necessary, but this should not be required. Attach the damper strut and furling cable to the tail boom using clevis pins and cotter pins provided in Tail Assembly Hardware Kit HK0002.

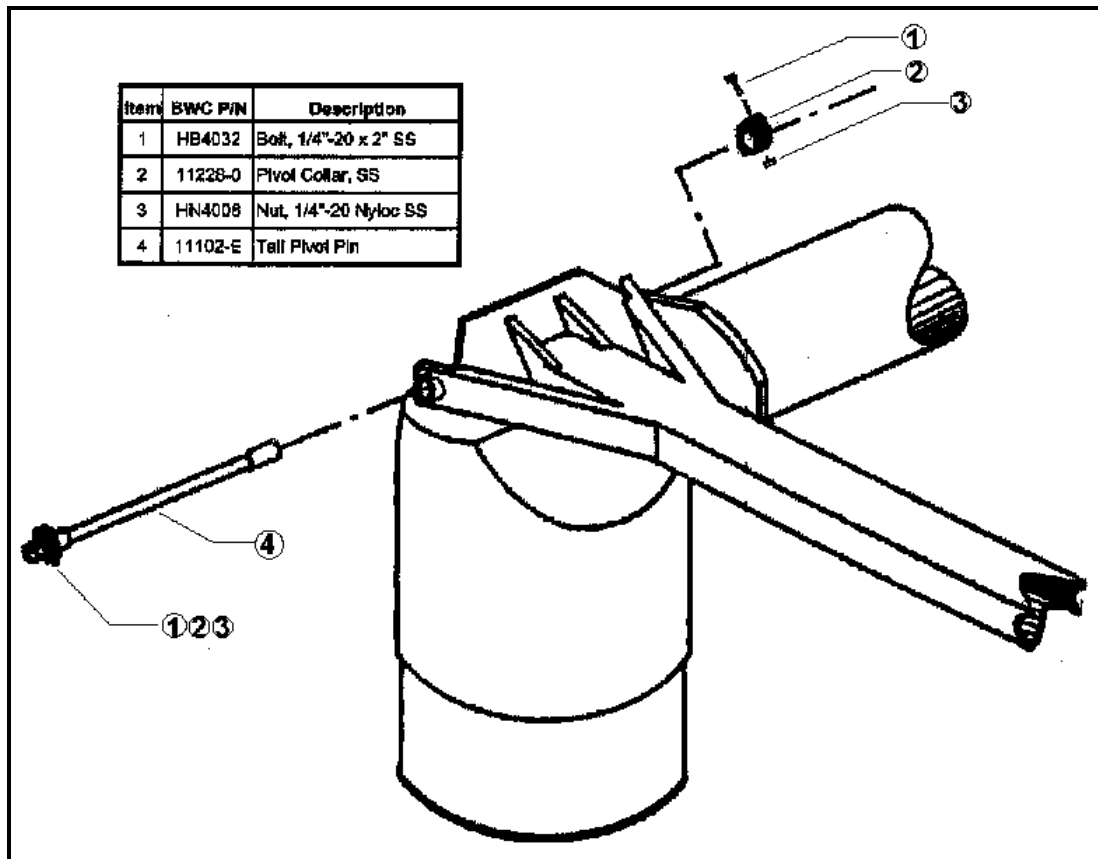


Figure 21. Excel Tail boom and Pivot pin

- h. Attach crane lifting line at final lifting position, **AT LEAST 10 ft BELOW TOWER TOP**. Use two equal length chokers attached to the top leg and one other leg. **TWO LEGS MUST SHARE THE LIFTING LOAD!** Never use an open hook when rigging this lift, and assure that all cables and slings are in good condition.
16. Attach the three blades to the powerhead as shown in **Figure 22**, with the hardware provided in Blade and Spinner Hardware Kit HK0003. A 1-1/8" deep socket and torque wrench will be required. Follow the sequence of steps below. Note that at least two workers are needed.
- a. Rotate the alternator until one of the blades can be held horizontal by two workers and set onto the four mounting studs in the alternator. Push the blade onto the studs; it will stay in place on the studs, but the outboard end will need to be supported. Put a stainless steel washer and a flanged locknut on each of the four blade studs, then tighten each nut to a snug fit. Use the torque wrench to set each blade nut to 150 ft-lb torque. Do not tighten beyond this torque value.

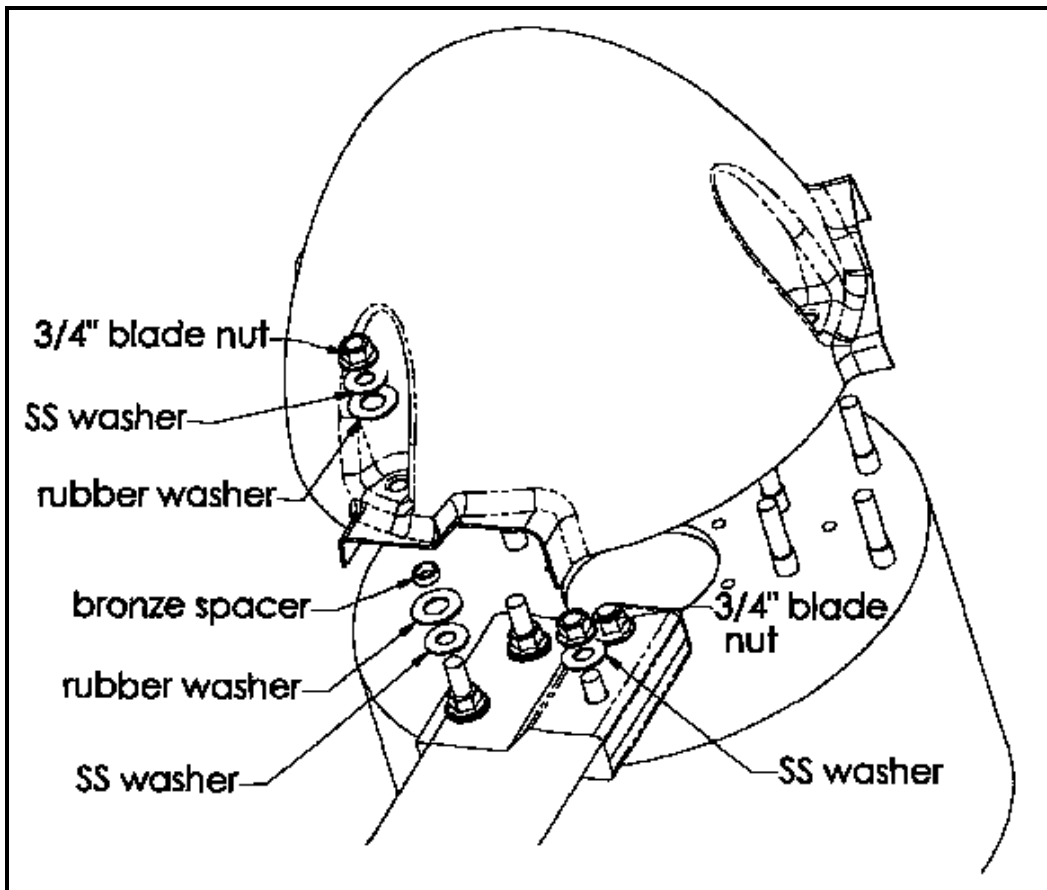


Figure 22. Excel Blade & Spinner Attachment

- b. While being careful to avoid damaging the attached blade on the ground, rotate the alternator until another blade can be set in place on the studs. A third worker may be required to support the first attached blade during this process. Attach washers and flange nuts, then torque to 150 ft-lb. Repeat the process for the third rotor blade. (It may be necessary to raise the tower slightly to allow attachment of all rotor blades.)

17. Attach the spinner to the powerhead as shown in **Figure 22**, making sure that all hardware is ordered and positioned properly. The recommended procedure is as follows:

- a. Use a dab of silicone caulk to position the lower stainless washer and rubber washer in place on each of the three attachment studs.
- b. Set the spinner in position on the studs, then insert the first bronze spacer. Be sure this spacer fits **INSIDE** the rubber washer, not on top of it. The spacer must sit firmly against the stainless washer. (The rubber washer tends to drop downward and get under the

spacer. Slide it back upward until the spacer fits down inside the washer and rests solidly against the stainless washer underneath.)

- c. Lock the first spacer in position by adding the upper rubber washer and stainless washer, then snug the stack with the upper blade nut. Make sure the spacer rests against the upper stainless washer, not against the rubber washer.
- d. Repeat steps (b.) and (c.) for the other spinner attachment studs. Be sure that all three bronze spacers are properly positioned within the rubber washers.
- e. Tighten the three spinner attachment nuts to 50 ft-lb.

**NOTE: Do not be alarmed by a bit of cracking noise when the spinner attachment nuts are tightened. This is caused by flattening and deformation of the spinner material, and is to be expected. Torque the nuts to the full 50 ft-lb value.**

## **2. Raising the Tower**

1. Put an adjusting nut on each anchor bolt. Nuts on the 6 inner anchor bolts will determine initial tower position, because the base flanges tilt slightly toward the center of the tower. Try to get all six of them level at a height approximately 1" above the concrete surface. Screw the outboard nuts down until they are slightly below the inner nuts.
2. Raise the tower slowly and carefully to the vertical position. Be careful to avoid fouling rotor blades with the crane cable. Rotate the tower so the disconnect switch is properly oriented, then guide the base flanges onto the anchor bolts. Secure the tower with 6 upper adjusting nuts, but do not add PAL nuts at this time.

**NOTE: If all legs do not align properly with the bolts, start one or two legs onto the bolts then use a chain hoist or come-along to pull the remaining leg(s) into place. The hoist can be attached to a truck tow ring for support. DO NOT HAMMER THE ANCHOR BOLTS INTO ALIGNMENT!**

NOTE: The turbine should be short-circuited and fully furled; the rotor should not be free to rotate at this time, but the turbine will yaw to allow the tail to be downwind.

3. Level the tower as required, using the adjusting nuts closest to the center of the tower. When the tower is perfectly plumbed, raise the remaining 6 lower adjusting nuts to firmly contact the bottom surface of the base flanges. Add the remaining upper adjusting nuts. Torque the upper adjusting nuts to 100 ft-lb and add PAL nuts to all anchors.
4. Put one of the grounding brackets, P/N HM0026, on the lowest brace bolts of each tower leg as shown in **Figure 23** (following section).

### **3. Secure and Ground the Tower**

1. Climb the tower to detach the lifting slings. The crane is no longer required.

**NOTE: WHILE WORKING ANYWHERE ON THE UPPER TOWER SECTION, EXERCISE CAUTION AT ALL TIMES TO AVOID CONTACT WITH THE TURBINE ROTOR BLADES.**

2. Starting at the top of the tower, inspect ALL connections and hardware; tighten as needed using an accurate torque wrench. Assure that all locking hardware and PAL nuts are in place.
3. **Remove the step bolts from the upper and lower 15 feet of the tower.** Leave the bolts with the owner, to be stored in a location that is both safe and accessible. Make a note of the location to be included with the installation record.
4. Grout the spaces between the concrete surface and the base flanges with high-strength grout in accordance with the manufacturer's specifications. (See Figure 8 or 9.)
5. Ground each tower leg by connecting a length of braided copper ground wire (P/N HO0011) between the tower leg and the ground rod located close to the leg. Avoid sharp bends in the grounding cable. Connections are made using the ground bracket (HM0026) and the ground rod clamp (HM0013). Note that all clamp connections should be above ground level for inspection and future service..

**CAUTION: Before starting the next operation, be sure the turbine rotor is not spinning. The voltage in a spinning alternator can get very high in "open-circuit" operation. Handling the alternator output wires poses a serious shock hazard. BWC does NOT recommend tying blades to the tower except in an emergency.**

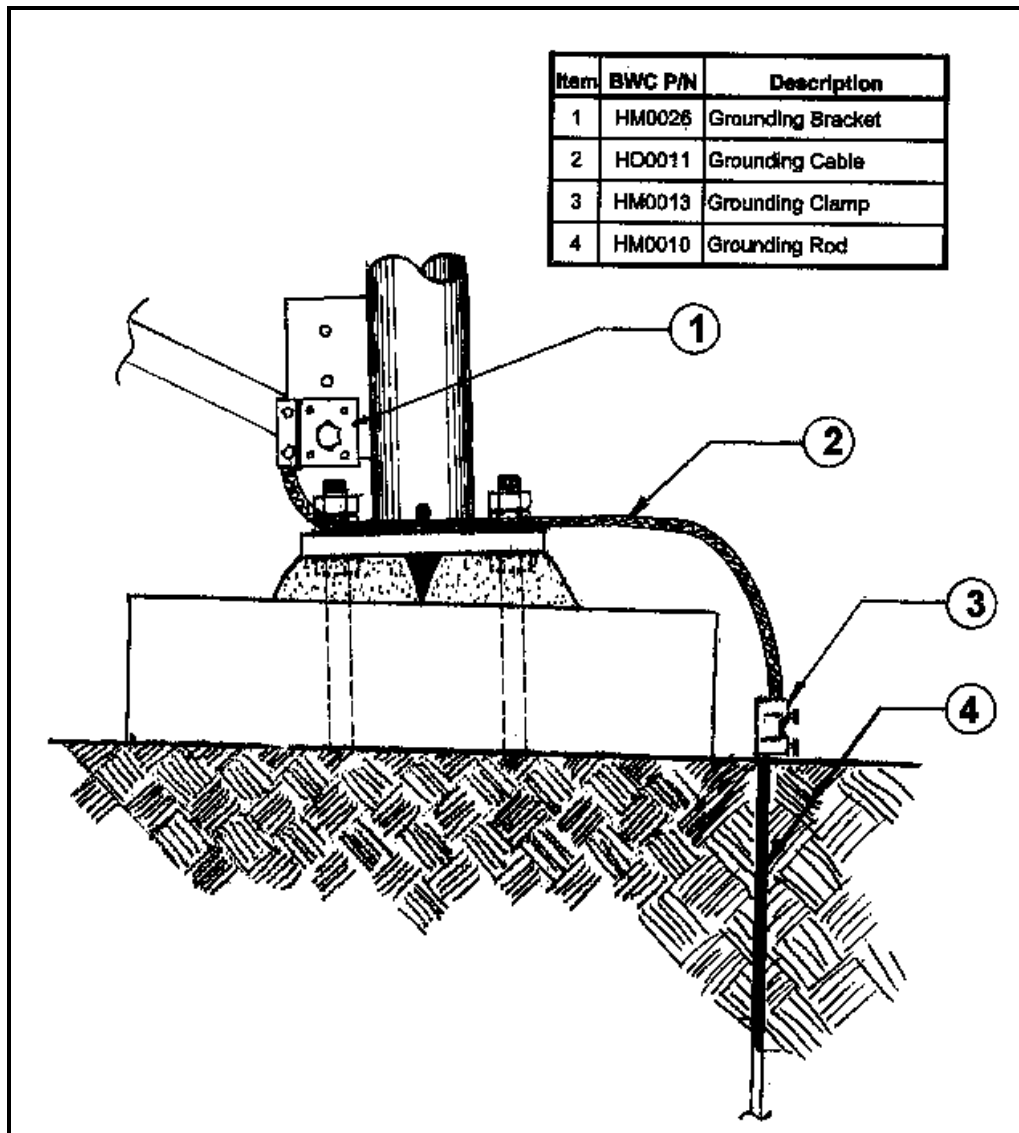


Figure 23. Tower Grounding Diagram

6. Ground the switch box with a length of bare copper wire. A small hole is provided in the back panel of the disconnect switch to allow connection of the ground bus bar (P/N EC0153) supplied with the tower wiring kit. Connect a bare copper ground wire between one of the lugs on the bus bar and the clamp on the nearest ground rod.

## 6) Wire Runs and Controllers

The three-conductor wire run between the tower disconnect switch and the EXCEL control unit (GridTek, VCS-10, or PCU-10) can be made either buried or aerially. If buried the use of conduit is highly recommended. Also the installation of a separate bonding wire (#8 bare copper) in the power leads conduit, connecting the tower ground to the control unit ground, is required. Wiring practice should conform to the U.S. National Electric Code or other appropriate national wiring standards. All wiring and connections must be rated for 600 VAC.

### 1. Fusible Links

BWC recommends the use of fused disconnect switches on EXCEL-S and EXCEL-R installations to protect against alternator damage in the event that a short circuit develops. For the EXCEL-PD, however, BWC does not recommend that fuses be used. In the EXCEL-PD system the direct connection between alternator and pump motor could give rise to damaging current levels if only one fuse were to blow. An overload relay and a three-phase contactor are installed in the PCU to provide over-current protection without risking single-phase operation. Do not use fused disconnects or fuses on EXCEL-SPD installations.

### 2. Determining Conductor Sizes

**Figure 24 and Appendix page 11** show a wire sizing guide for the three versions of the BWC EXCEL. These recommended conductor sizes will keep electrical losses below 10% at full power and below 2% at average power levels. Aluminum wire can also be used by going up 2 AWG sizes over the recommended copper wire sizes; e.g., when #4 AWG copper wire is recommended, #2 aluminum wire may be substituted. Recommended conduit sizes are also given in the Wire Size Table.

### 3. Installing the Wire Run

Most installations will use an underground wire run. We do not recommend direct burial wire runs. The wiring should always be installed in a protective water-tight electrical grade PVC plastic conduit. NEC requirements specify 0.5 m (18 inch) burial depth for conduit in normal locations, and 0.6 (24 inch) depth below a roadway. If the wires are run across a field that will ever be plowed then the recommended depth is 1m (3+ ft).

BWC recommends a procedure where the conduit is installed first and the three power wires and bond wire are pulled through the conduit by hand or with a winch. Use electrical grade PVC conduit and a good quality PVC cement to construct the conduit string. At either end use watertight connectors to transition to watertight flexible conduit for connection to the disconnect switch at one end and the controller at the other end.

All required cables, including the bond wire, must be pulled through the conduit in a single operation. An electrical “sock” with attached string is first pulled through the conduit using vacuum; the string is then used to pull a strong, flexible rope. The rope is connected to the electrical cable bundle using an appropriate steel-mesh grip designed specifically for pulling cable through conduit. Special conduit lubricant is applied liberally as the cable is fed into the conduit by one worker, while another worker pulls the rope until the cables emerge from the conduit. Continue to pull/feed cable until there is enough free cable to make all required connections.

Note: If instrumentation wires are also run, we recommend that they be installed inside separate conduit.

#### **D. Controllers and Electronics**

The BWC EXCEL turbine is available in separate models for grid-interconnection, battery charging, or water pumping. Each version is supplied with a controller or power conditioning system designed for the specific application. Instructions for installing the GridTek (grid-interconnect), VCS-10 (battery charging), and PCU-10 (water pumping) controllers can be found in the Owners Manual for each model. The EXCEL controller should be installed indoors. If this is not possible please consult with the BWC factory to determine an appropriate outdoor enclosure. EXCEL controllers should not be installed where they can be splashed with water or might be exposed to the gases given off by batteries. It is best to plan the wire runs into and out of the control unit before deciding on where it is to be mounted.

# BWC EXCEL Wire Size Recommendations

Turbine Model	Maximum 3-Phase AC Amps	Fuse Size, Amps	Wire Run Length, including Tower Height					
			30m 100 ft	60m 200 ft	90m 300 ft	120m 400 ft	150m 500 ft	200m 600 ft
BWC EXCEL-S 240 VAC, 1Ø	34	35	#6 AWG 13.3 mm <sup>2</sup>	#6 AWG 13.3 mm <sup>2</sup>	#6 AWG 13.3 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>
BWC EXCEL-R/48 240-48 VDC Step-Down	34	35	#6 AWG 13.3 mm <sup>2</sup>	#6 AWG 13.3 mm <sup>2</sup>	#6 AWG 13.3 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>
BWC EXCEL-R/120 120 VDC	47	60	#6 AWG 13.3 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#2 AWG 33.6 mm <sup>2</sup>	1 AWG 42.4 mm <sup>2</sup>	1/0 AWG 55.3 mm <sup>2</sup>	2/0 AWG 67.5 mm <sup>2</sup>
BWC EXCEL-R/48 120-48 VDC Step-Down	54	60	#6 AWG 13.3 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#3 AWG 26.7 mm <sup>2</sup>	1 AWG 42.4 mm <sup>2</sup>	1 AWG 42.4 mm <sup>2</sup>	1/0 AWG 55.3 mm <sup>2</sup>
BWC EXCEL-PD Variable Voltage	30	None	#6 AWG 13.3 mm <sup>2</sup>	#6 AWG 13.3 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#2 AWG 33.6 mm <sup>2</sup>	#2 AWG 33.6 mm <sup>2</sup>	1/0 AWG 55.3 mm <sup>2</sup>

\* Notes: Listed wire sizes will provide no more than a 10% loss at rated power.

Calculating Circular Mills (cm)  
Required (use for longer runs):

$$(K \times I \times L) / Vd = \text{cm}$$

Where: Vd = 5.5 for Excel-S  
 Vd = 2.5 for Excel-R/120  
 Vd = 3.3 for Excel-R/48

### Recommended Conduit Sizes:

(includes #8 bond wire, assumes no more than two 90 degree bends in the conduit string)

Wiring	PVC Conduit Size
3 x #8	1 1/2"
3 x #4	1 1/2"
3 x #2	1 1/2"
3 x 1/0	2"
3 x 2/0	2"

Last revision: 9-Apr-03

Figure 24. Excel Wiring Recommendations

## 7) Commissioning

Before the EXCEL wind turbine system is allowed to operate a number of system checks must be made:

### 1. Furling Winch and Damper Operation

**Purpose:** This test determines whether the manual furling system, including the tail damper, is operating properly. The tail damper is a device in the turbine that acts like a one-way shock absorber. Its purpose is to keep the tail from slamming against its stops when it unfurls.

**Tools and Equipment Required:**

None

**Procedure:**

A. Furl the turbine using the simple procedure outlined in the turbine Owner's Manual. Please use caution when operating the winch - proper control of the handle must be maintained at all times. The tail should come around freely, but then firm up when it hits its stop after rotating 70 degrees. Note that the tail will not rotate around 90 degrees, so it will not be parallel with the blades at its stopping point.

**NOTE: Do not over-tighten the furling cable. Stop cranking the winch as soon as the abrupt change in required torque occurs.**

B. While firmly grasping the furling winch handle, rapidly unwind the furling cable. The tail damper should prevent the tail from unfolding as fast as the cable becomes available; this will cause the furling cable to go slack for a few seconds. If you do not see the cable go slack, there may be a problem with the damper.

### 2. Alternator Output Check

**Purpose:** This test determines whether the output of the turbine, as measured at the base of the tower, is balanced on all three electrical phases.

**Tools and Equipment Required:**

1. Volt-ohm meter

**Procedure:**

A. Set the volt-ohm meter to the 500 or 1,000 volts AC scale.

Note: This test requires that the turbine will run unloaded (with no electrical load). **It will not harm or endanger the turbine to allow it to spin up without a load, no matter what the wind speed may be.**

B. Switch the disconnect switch box at the base of the tower to “OFF” then open the switch box cover. Use the volt-ohm meter to measure the AC voltage between each of the three phases. The readings should be similar, though they will not be the same because of speed changes in the turbine. The output voltage of the turbine changes with changing rotor speed. Be careful, the output voltage of the turbine can be very high and poses a shock hazard.

D. Close the disconnect switch and turn the switch to “ON.”

**3. Power Wiring Check**

**Purpose:** This test determines whether the wiring from the turbine to the controller has continuity and is adequately insulated.

**Tools and Equipment Required:**

1. 6” piece of #4 or #6 AWG insulated copper wire, stripped 3/4” at each end.
2. Flat-blade screwdriver
3. 3m (10 ft) length of 1/4” diameter or larger rope.
4. 500 V Meggar (insulation breakdown tester)
5. Volt-ohm meter

**Procedure:**

A. Furl the wind turbine and stop the rotor using the alternator shorting technique given later in this section.

B. Climb the tower and use a piece of rope (1/4" diameter or larger, ~3m (10 ft) long) to tether the lowest blade to the tower so that the turbine rotor cannot rotate. Any rotation of the blades while checking the input wiring will lead to false readings.

C. Remove the shorting leads and switch the disconnect switch "ON."

D. Take readings at the end of the wire run towards the controller. (If the three power wires from the turbine have already been connected to the “INPUT” terminals of the controller, they must be removed for this test.)

E. Using a 500 V Meggar (insulation breakdown tester) check the resistance between each lead and ground (three tests). Refer to the end of this section for detailed instructions on the use of a Meggar. All readings should be 50 M or higher. If any of the readings are below 100 M the fault must be traced and corrected. The most likely problems are an inadequately insulated connection or a cut in the insulation of the wire.

F. With a Volt-Ohm Meter (VOM) or good quality multi-meter, check the continuity between the leads. With the alternator in the circuit the resistance between phases should be low.

G. Release the blade tether then switch the disconnect switch to "OFF".

H. Reconnect the input wires to the controller.

Additional commissioning tests may be required for the controller and its output wiring, please refer to the Owner's Manual for a list of these tests.

## **Special Topics**

### **Procedure for Stopping the Wind Turbine Prior to Climbing the Tower**

1. Furl the wind turbine.
2. Switch the tower disconnect switch to "OFF."
3. Remove all three conductors from the "INPUT" terminal block of the controller. Connect them together and make sure the connection is insulated.
4. Stand at the base of the tower and wait for a lull in the wind. When the rotor has slowed, switch the disconnect switch to "ON." The alternator should come to a smooth stop with no "growling". If it does not, switch the disconnect switch to "OFF," wait for the wind speed to drop further and try again.

**YOU MUST SWITCH TO "OFF" IF THE ROTOR DOES NOT STOP IN 15 SECONDS OR LESS TO AVOID SERIOUS ALTERNATOR DAMAGE. NEVER LET A SHORT-CIRCUITED ALTERNATOR RUN FOR A PERIOD LONGER THAN 15 SECONDS!**

5. Climb the tower and attach a rope tether between the lowest blade and the tower.

**Use of Meggar in Finding Ground Faults**

1. Clip the black lead to ground.
2. Touch the orange lead to the conductor being tested.
3. Push the gray button on the Meggar. Do not hold the button down for longer than 60 seconds.
4. If the reading is below the minimum recommended value (typically 50 M $\Omega$ ), isolate the ground fault by checking the ground wiring, tower wiring and wind turbine separately. To isolate a ground fault in the alternator it will be necessary to disconnect the alternator leads from the slip-ring brush assembly. Be sure to check the surge arrestors, where normal response to a powerful surge can cause a short-circuit to ground.

## 8) Inspections and Maintenance

The BWC EXCEL installation should be inspected 30 days and then again 180 days after installation. Following these two inspections the installation should be inspected every two years and after any particularly severe weather. Inspection should be done on days when the wind is below 7 m/s (16 mph).

### A. Check List for Inspections

1. Inspect each of the anchor bolt connections. Ensure that all hardware is secure and all drain holes are open. Check condition of grout under base flanges.
2. Furl the wind turbine and check that the damper restricts the tail's unfurling to a period of at least five (5) seconds when the winch cable is rapidly released.
3. Furl the turbine and short the alternator using the procedure given in the "Special Topics" section above. Climb the tower. Always use proper safety belts and lanyards.
4. Inspect the blades for:
  - A. Cracks near the hub.
  - B. Condition of the leading edge protection tape.
  - C. Tip, leading edge or trailing edge damage.
5. Remove the spinner and hang it from the machine. Check the torque on the blade nuts; the recommended value is 150 ft-lbs. Check the front bearing for seal integrity and grease loss. Reattach the spinner, adding hardware as described earlier in section 4.4.16, and torque spinner nuts to 50 ft-lb. (Be sure to get rubber washers and bronze spacers properly positioned.)
6. Open the hatch on the nacelle. Use a small rope to lash the hatch open.
7. Inspect the flange connection between the mainframe and alternator. Check the torque on each of the bolts; the recommended value is 100 ft-lbs.
8. Check the rear alternator bearing for seal integrity and grease loss.
9. Inspect the mainframe for cracks.

10. Remove the slip-ring cover plate. Make the following inspections:
  - A. Check brushes for ease of movement in the brush holder.
  - B. Check slip rings for signs of arcing damage.
  - C. Check that no grease from the yaw bearings has leaked on to the slip-rings, and thoroughly clean any grease from the rings.)
11. Inspect damper. Minor leakage around the front seal is acceptable.
12. Inspect the furling cable (particularly at the ball end/fork attachment to the tail boom) and furling cable conduit. Be alert for fraying where the cable enters the conduit.
13. Check for cracks or loose hardware on the tail boom and fin.
14. Check the tail pivot pin, pin retainer bolts, and tail pivot bushings. (A worn bushing will leave a large gap between the pin and bushing.)
15. Close the nacelle and check that all of its fasteners are secure.
16. While descending the tower, inspect the following:
  - A. Check that the tower wiring is properly secure.
  - B. Check all fasteners. Replace missing PAL nuts.
  - C. Look for any cracks in the tower structure.
  - D. Check the furling cable and associated lanyard.
17. Check the furling winch and make sure that the furling cable is not twisted. If the cable is twisted, check the swivel.
18. Check the connections on all ground rods and hardware. Be sure all contact surfaces are clean and free of oxidation.
19. Inspect the surge arrestor(s). Any sign of scorching or heat should trigger replacement.
20. Remove the alternator shorting connection. Check the disconnect switch.
21. Switch the disconnect switch to "OFF" and unfurl the wind turbine. Listen to the sound of the machine as it speeds up. No mechanical sounds, such as a "clunking" or "banging," should be heard. Also watch for any new or significant vibration. The turbine operation should be very smooth.
22. Inspect the wire run, particularly all electrical connections.

23. Use a Meggar to check the three-phase wiring from the turbine to the controller (the procedure is the same as used for commissioning).
24. Use a VOM to check that voltage on the three legs of the AC output of the wind turbine are balanced.
25. Check the controller per the instructions provided in the Owners Manual.

NOTE: A service inspection checklist can be found in the Appendix.

## **9) Trouble-Shooting Problems**

Refer to the Owners Manual for the specific model of turbine you own for a guide to the causes and remedies for operational problems.

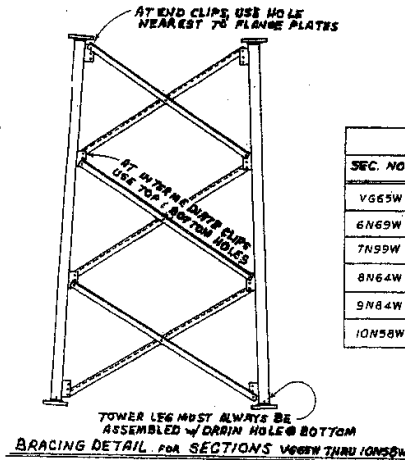
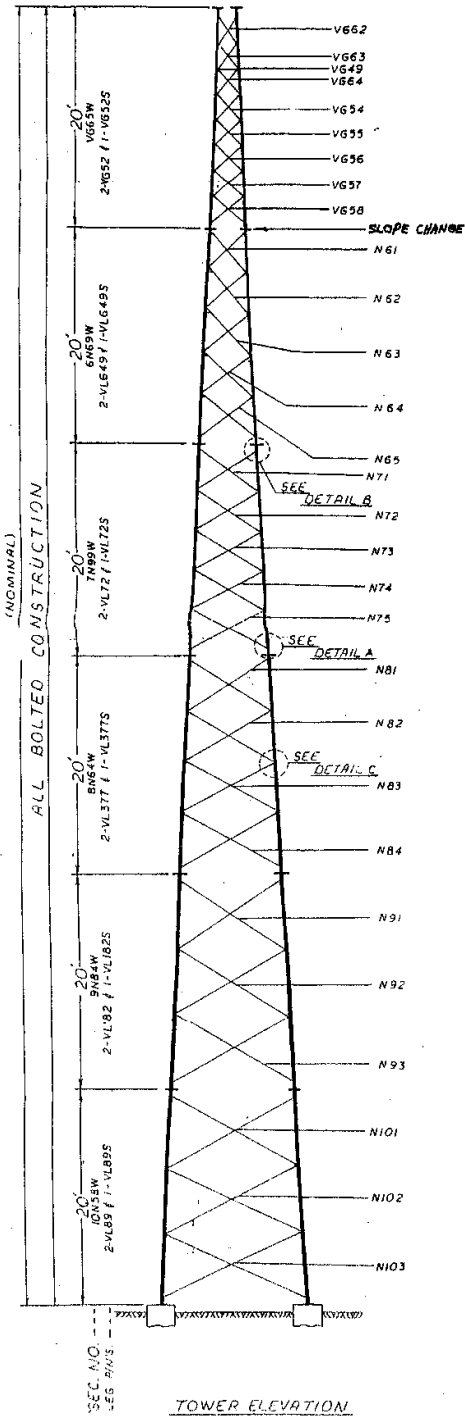
For special assistance please contact the Service Department at Bergey Windpower Company:

Telephone:	405-364-4212
FAX:	405-364-2078
Email:	<a href="mailto:service@bergey.com">service@bergey.com</a>

# **Appendix**

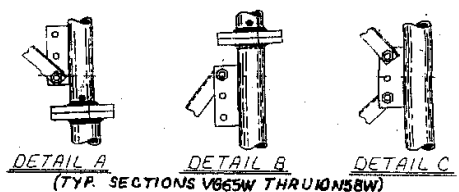
SECTION NO.	SPREAD DIMENSION		TOWER LEGS 50 KSI YIELD STR.	TOWER BRACES 50 KSI YIELD STR.	FLANGE PLATES		FLANGE BOLTS	BRACE BOLTS
	UPPER	LOWER			TOP	BOTTOM		
V665W	10'-0 1/2"	2'-6 1/2"	2 1/2 STD. PIPE	1 1/2 x 1 1/2 x 3/16"	8 x 8 x 3/4" 4 15/16 R.C.	8 x 8 x 3/4" 8 15/16 R.C.	12-7/8 x 3/4"	12-7/8 x 1 1/4"
6N69W	2'-6 1/2"	4'-6 3/4"	2 1/2 STD. PIPE	1 1/2 x 1 1/2 x 1/8"	8 x 8 x 3/4" 4 15/16 R.C.	8 x 8 x 3/4" 4 15/16 R.C.	12-7/8 x 3/4"	75-1/2 x 1 1/4"
7N99W	4'-6 3/4"	6'-7 1/4"	2 1/2 STD. PIPE	1 1/2 x 1 1/2 x 1/8"	8 x 8 x 3/4" 4 15/16 R.C.	8 x 8 x 3/4" 4 15/16 R.C.	12-7/8 x 3/4"	75-1/2 x 1 1/4"
8N64W	6'-7 1/4"	8'-7 1/4"	3 STD. PIPE	1 1/2 x 1 1/2 x 1/8"	8 x 8 x 3/4" 4 15/16 R.C.	7 x 7 x 1" 7 1/8 R.C.	12-7/8 x 3/4"	60-1/2 x 1 1/4"
9N84W	8'-7 1/4"	10'-7 5/8"	3 EH PIPE	1 1/2 x 1 1/2 x 1/8"	7 x 7 x 1" 7 1/8 R.C.	7 x 7 x 1" 7 1/8 R.C.	12-7/8 x 3/4"	45-1/2 x 1 1/4"
10N58W	10'-7 5/8"	12'-7 3/8"	3 1/2 EH PIPE	2 x 2 x 1/8"	7 x 7 x 1" 7 1/8 R.C.	7 x 7 x 1" 7 1/8 R.C.	12-7/8 x 3/4"	45-1/2 x 1 1/4"

\* INDICATES 1/4" OFFSET



WEIGHTS			
SEC. NO.	LEGS	BRACES	TOTAL
V665W	463	233	745
6N69W	444	182	664
7N99W	450	238	730
8N64W	985	259	888
9N84W	769	319	1130
10N58W	915	419	1361

TOTAL WT. INCLUDES HARDWARE



**TOWERS ARE DESIGNED TO SUPPORT LOADS AS SHOWN IN TABLE**

WIND VELOCITY 120 MPH	E.I.A. WIND PRESSURE 58 PSF	ALLOWABLE THRUST AT TOP 2020"	ALLOWABLE PROJECTED AREA AT TOP 35 SQ. FT.
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NOTE: TOWER DESIGN BASED ON STATIC LOADING CONDITIONS ONLY

**REFERENCE DRAWINGS**  
FOUNDATION DETAILS - DB9C157

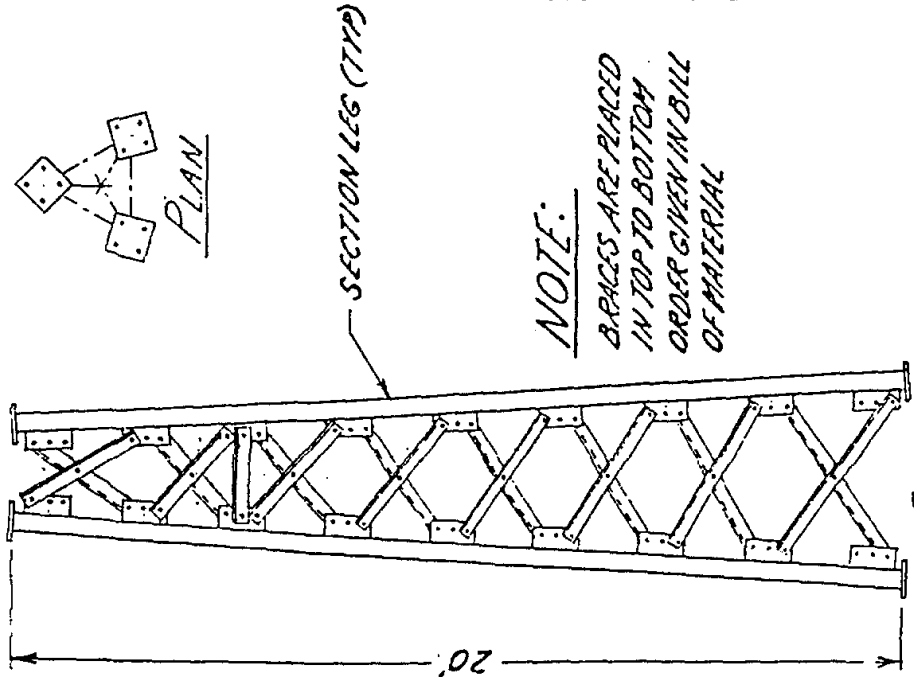
- GENERAL NOTES**
- LEG PT. NO. IS METAL STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
  - PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
  - ALL MATERIAL IS HOT-DIPPED GALVANIZED AFTER FABRICATION.
  - BOLTS TO BE A.S.T.M. A-325 QUALITY.
  - TOWER GROUNDING (BY OTHERS) MUST MEET ALL LOCAL CODES.
  - WHERE DRAINAGE IS REQ'D, A DRAIN HOLE IS PROVIDED AT THE BASE OF EACH LEG OF THE SECTION.
  - STEERBOLTS ARE PROVIDED ON ONE LEG ONLY FOR SECTIONS V665W THRU 10N58W.
  - ROHN-LOC (CABLE TYPE) SAFETY DEVICE IS AVAILABLE UPON REQUEST.

BILL OF MATERIAL				
ITEM	QUAN	PART No.	DESCRIPTION	DWG. No.
1	2	VG52	LFC (PIPE 2 1/2 STD)	C781397
2	1	VG52S	STEP LEG	"
3	6	VG62	DIAG. BRACE (1 1/2 X 1 1/2 X 3/8)	"
4	6	VG63	"	"
5	3	VG69	HOR. BRACE (1 1/2 X 1 1/2 X 3/8)	C780716
6	6	VG64	DIAG. BRACE (1 1/2 X 1 1/2 X 3/8)	C781397
7	6	VG54	"	"
8	6	VG55	"	"
9	6	VG56	"	"
10	6	VG57	"	"
11	6	VG58	"	"
12	126	210017GA	1/2 X 1 1/4 BOLT ASSY. (BRACE)	C770404
13	12	210033GA	3/8 X 2 1/2 BOLT ASSY. (FLANGE)	"

MISC. INFO.

FLANGE PLATE		SPREAD				
OFFSET	* BEVEL (BOT)	P/N	SIZE (BOTTOM)	P/N	SIZE (TOP)	SPREAD
—	2 1/2 STD	5C	5 X 5 X 3/4	5C	1'-0 1/2"	2'-6 1/2"

\* 2 1/2" REV @ TOP



NOTE:

BRACES ARE PLACED IN TOP TO BOTTOM ORDER GIVEN IN BILL OF MATERIAL

GENERAL NOTES:

1. LEG PIN IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
4. FLANGE BOLTS (\*) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DWG. OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

VG65W Section Details

Top Section - VG65W

**BILL OF MATERIAL**

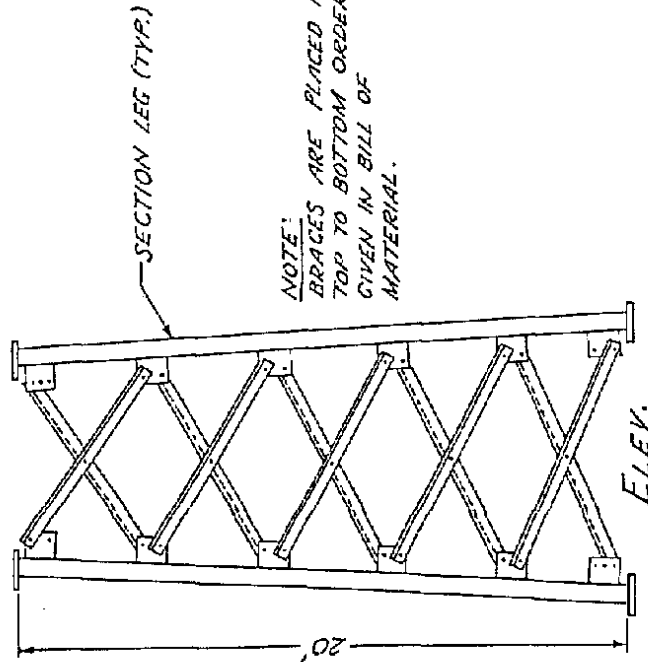
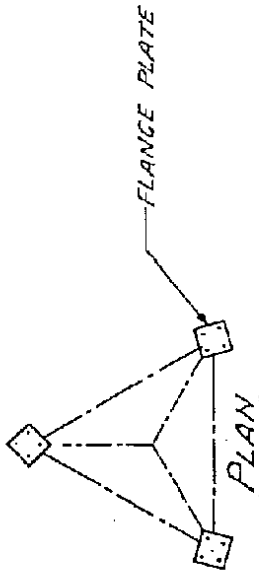
ITEM QUAN.	PART No.	DESCRIPTION	DWG. No.
1	N61	LEG (PIPE 2 1/2 STD.)	B790B29
2	N62	STEP LEG ( " " " )	"
3	N63	DIAG. BRACE (L 1/2 X 1/2 X 3/8)	SK 691001B7
4	N64	" " ( " " " )	"
5	N65	" " ( " " " )	"
6	N66	" " ( " " " )	"
7	N67	" " ( " " " )	"
8	2100176A	1/2 X 1/4 BOLT ASS'YS (BRACES)	G770404R2
9	210033GA	3/8 X 2 1/2 " (FLANGES)	"

**MISC. INFO.**

FLANGE PLATE				SPREAD	
OFFSET	BEVEL	SIZE (TOP)	P/N	SIZE (BOTTOM)	P/N
—	3/8 @ TOP	5X5X 3/8	SC	5X5X 3/8	SC
					2'-6 1/2"
					4'-6 3/4"

\* CANNOT BE USED WITH SECT. 5N.

**6N69W Section Details**



NOTE:  
BRACES ARE PLACED IN TOP TO BOTTOM ORDER GIVEN IN BILL OF MATERIAL.

**GENERAL NOTES:**

1. LEG PIN IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
4. FLANGE BOLTS (\*) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DWG. OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

**Second Section - 6N69W**

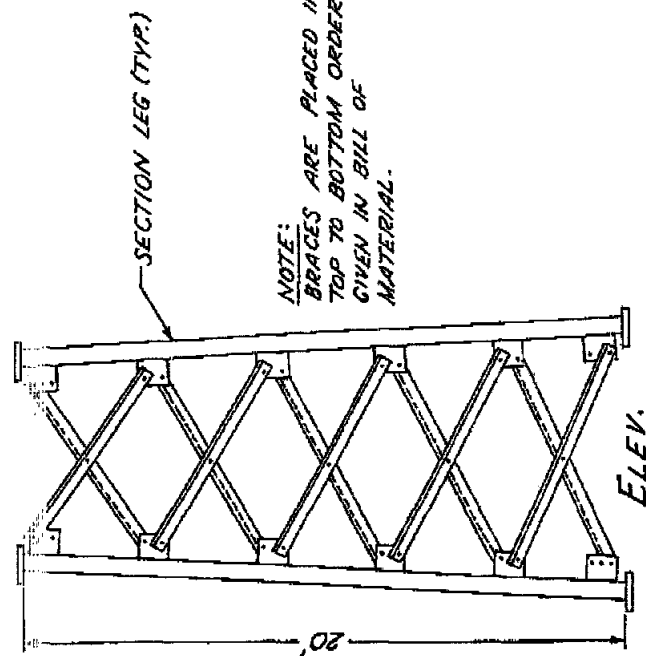
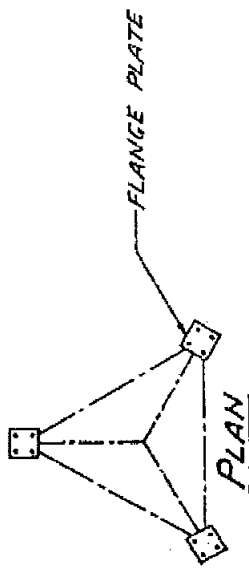
**BILL OF MATERIAL**

ITEM	QUAN.	PART No.	DESCRIPTION	DWG. No.
1	2	N172	LEG (PIPE 2 1/2 STD.)	SK 7302388R3
2	1	N172S	STEP LEG ( " " " )	"
3	6	N171	DIAG. BRACE (L / R) ( 1/2 x 1/2 )	SK 691001R7
4	6	N172	" " ( " " )	"
5	6	N173	" " ( " " )	"
6	6	N174	" " ( " " )	"
7	6	N175	" " ( " " )	"
8	75	210017GA	5/8 x 1/4 BOLT ASSY. (BONES)	CT700404R2
9	12	210050GA	3/4 x 2 3/4 " " (RANGES)	"

**MISC. INFO.**

FLANGE PLATE		SPREAD					
OFFSET	BEVEL	SIZE (TOP)	P/N	SIZE (BOTTOM)	P/N	TOP	BOTTOM
1/4"	---	5/8 x 3/4	SC	6 x 6 x 3/4	6A	4'-6 3/4"	6'-7 1/4"

7N99W Section Details



NOTE:  
BRACES ARE PLACED IN  
TOP TO BOTTOM ORDER  
GIVEN IN BILL OF  
MATERIAL.

- GENERAL NOTES:**
1. LEG PIN IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
  2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
  3. STEP BOLTS ARE PROVIDED FOR ONE LEG ONLY.
  4. FLANGE BOLTS(\*) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DWG. OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
  5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

**Third Section - 7N99W (Base of 60 ft Tower)**



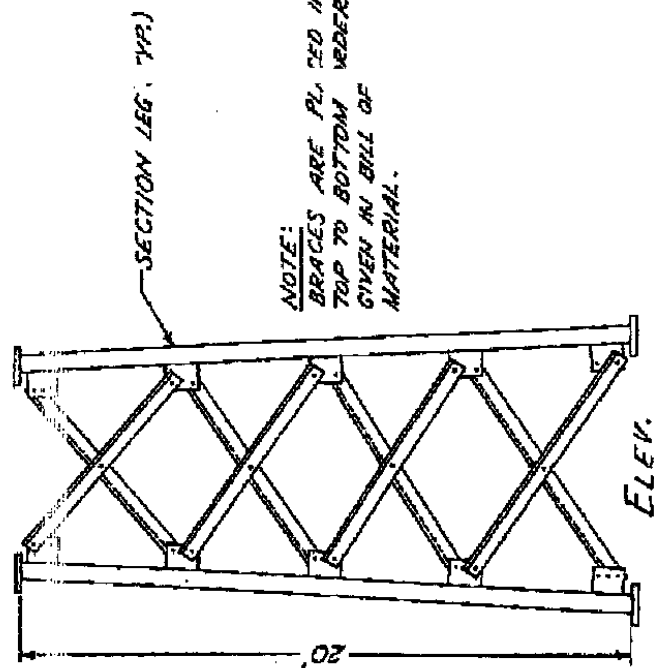
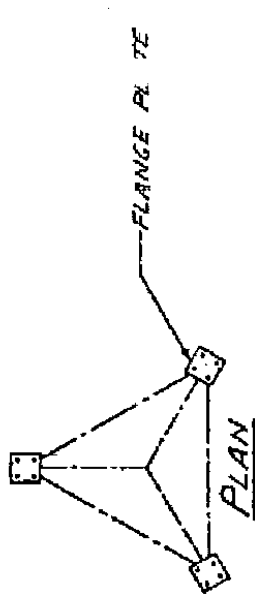
**BILL OF MATERIAL**

ITEM QUAN.	PART No.	DESCRIPTION	DWG. No.
1	NL377	LEG (PIPE 3 STA.)	B770A16
2	NL377S	STEP LEG ( " " )	"
3	N81	DIAG. BRACE (2 1/2" x 1/2" x 6')	SK871001R7
4	N82	" " ( " " )	"
5	N83	" " ( " " )	"
6	N84	" " ( " " )	"
7	210017 GA	3/8" x 1/4" BOLT ASSY. (BRACES)	C770A04R2
8	210065 GA	3/8" x 3/4" " (FLANGES)	"

**MISC. INFO.**

FLANGE PLATE		SPREAD					
OFFSET	BEVEL	SIZE (TOP)	FIN (BOTTOM)	SIZE (BOTTOM)	FIN	TOP	BOTTOM
—	—	6 X 6 X 3/4	60	7 X 7 X 1	70	6'-7 1/2"	8'-7 1/2"

8N64W Section Details



**NOTE:**  
BRACES ARE PLACED IN TOP TO BOTTOM ORDER GIVEN IN BILL OF MATERIAL.

- GENERAL NOTES:**
1. LEG PIN IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
  2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
  3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
  4. FLANGE BOLTS (A) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DWG. OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
  5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

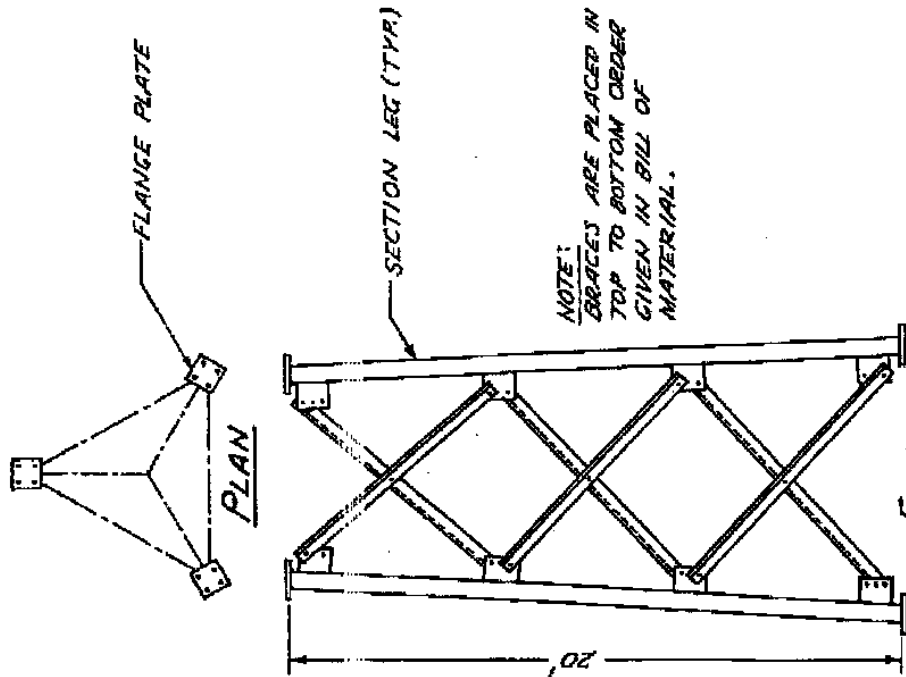
Fourth Section - 8N64W (Base of 80 ft Tower)

**BILL OF MATERIAL**

ITEM	QUAN.	PART No.	DESCRIPTION	DWG. No.
1	2	VL102	LEG (PAIR 3 X-STR)	B750120 R2
2	1	VL102S	STEP LEG ( " " )	"
3	6	N91	DIAG. BRACE (L/2 X 1/2 X 1/2)	SKL91001 R7
4	6	N92	" " ( " " )	"
5	6	N93	" " ( " " )	"
6	45	21007GA	1/4" BOLT ASSY. (BRACES)	C770404 R2
7	12	21063 GA	1/2" X 3/8" " (FLANGES)	"

**MISC. INFO.**

FLANGE PLATE		SPREAD					
OFFSET	BEVEL	SIZE (TOP)	PIN	SIZE (BOTTOM)	PIN	TOP	BOTTOM
1/2"	—	717X1	7D	717X1	7A	8'-7 1/2"	10'-7 1/2"



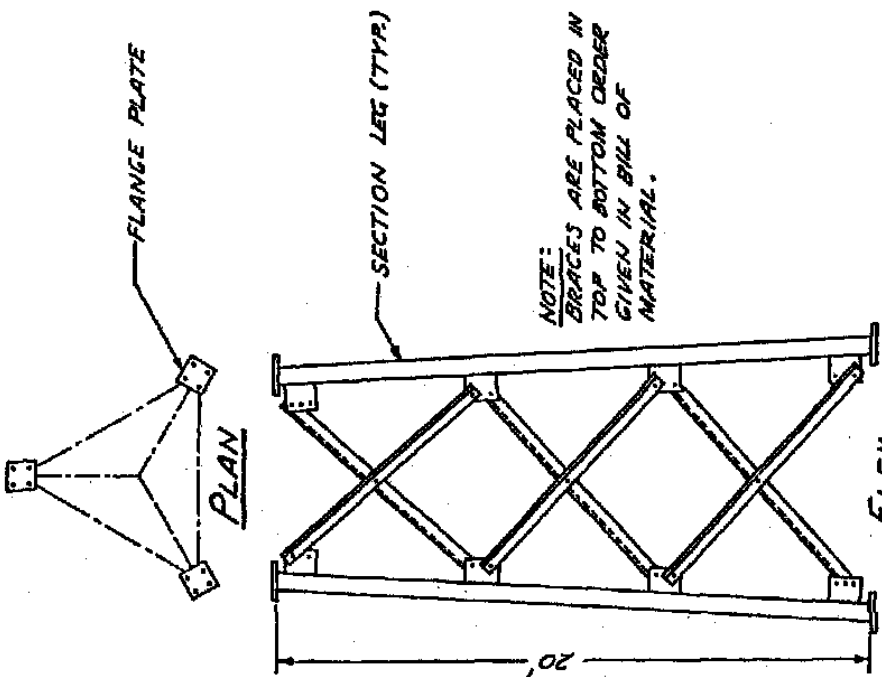
- GENERAL NOTES:**
1. LEG PIN IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
  2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
  3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
  4. FLANGE BOLTS (\*) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DWG. OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
  5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

**SECTION 9N84W DETAILS**

**Fifth Section - 9N84W (Base of 100 ft Tower)**

BILL OF MATERIAL			
ITEM QUAN.	PART No.	DESCRIPTION	DWG. No.
1	VL89	LEG (PIPE 3 1/2" X 5/16")	SK 750899 B R 23
2	VL895	STEP LEG ( " " " )	"
3	N101	DIAG. BRACE (L 2 X 2 X 1/4)	SK 091001 R 7
4	N102	" " ( " " )	"
5	N103	" " ( " " )	"
6	210017 GA	1/2" X 1/4" GROUT ASSY. (BRACES)	CT770404 R 2
7	210063 GA	3/4" X 3/4" " " (FLANGES)	"

MISC. INFO.					
FLANGE PLATE			SPREAD		
OFFSET	BEVEL	SIZE (TOP)	P/W	SIZE (BOTTOM)	P/W
---	---	7 1/2 X 1	7 F	7 1/2 X 1	7 F
					12-7 1/2"



SECTION 10N58W DETAILS

- GENERAL NOTES:
1. LEG PIN IS STAMPED AT BOTTOM OF EACH LEG OF EACH SECTION.
  2. PAL NUTS ARE PROVIDED FOR ALL TOWER BOLTS.
  3. STEP BOLTS ARE PROVIDED ON ONE LEG ONLY.
  4. FLANGE BOLTS (N) GIVEN IN BILL OF MATERIAL ARE FOR FLANGE PLATES AT BOTTOM OF SECTION. IF THE SECTION IS USED AS A BASE SECTION SEE THE TOWER ASSEMBLY DWG. OR ANCHOR BOLT LAYOUT FOR CORRECT SIZE AND QUANTITY OF ANCHOR BOLTS.
  5. BEVEL FOR FLANGE PLATES IS FOR BOTTOM FLANGE PLATES ONLY UNLESS OTHERWISE NOTED.

Sixth Section - 10N58W (Base of 120 ft Tower)

**ASSEMBLY BOLT INSTALLATION:**

ALL TOWER ASSEMBLY BOLTS ARE TO BE INSERTED OUT AND/OR UP (I.E. WITH NUTS AND PAL NUTS ON OUTSIDE OF TOWER FACE AND/OR ON TOP OF FLANGE PLATES) UNLESS PROHIBITED BY LACK OF CLEARANCE.

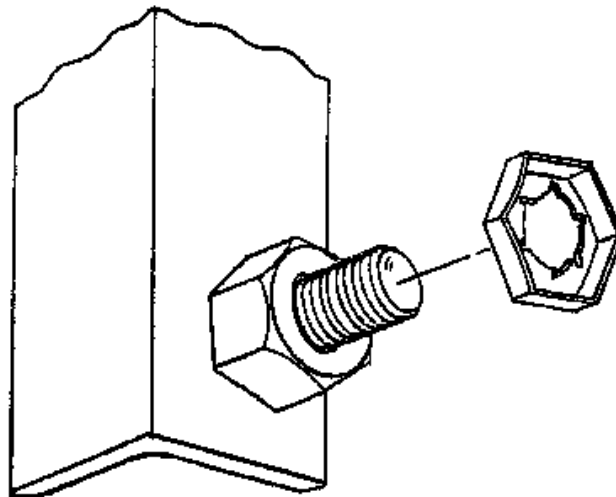
ALL ASSEMBLY AND ANCHOR BOLTS ARE TO BE TIGHTENED IN ACCORDANCE WITH ANSI/EIA-222-D SECTION 1.1.3.2 - (WHERE HIGH-STRENGTH BOLTS ARE USED FOR BEARING-TYPE CONNECTIONS, AS A MINIMUM, THE BOLTS SHALL BE TIGHTENED TO A "SNUG TIGHT" CONDITION AS DEFINED IN THE AUGUST 14, 1980, AISC, "SPECIFICATION FOR STRUCTURAL JOINTS USING ASTM A325 OR A490 BOLTS").

FLAT WASHERS ARE TO BE INSTALLED WITH BOLTS OVER SLOTTED HOLES.

CAUTION: DO NOT OVER-TORQUE! GALVANIZING ON BOLTS, NUTS AND STEEL PARTS MAY ACT AS A LUBRICANT, THUS OVER-TIGHTENING MAY OCCUR AND MAY CAUSE BOLTS TO CRACK OR SNAP OFF.

**PAL NUT INSTALLATION:**

PAL NUTS ARE TO BE INSTALLED AFTER NUTS ARE TIGHT AND WITH EDGE LIP OUT. (SEE PICTURE.) PAL NUTS NOT REQUIRED WHEN SELF-LOCKING NUTS ARE PROVIDED.



**Application of PAL Nuts**



**TERMINATOR™  
Cable Fitting**

**SAVE THESE INSTRUCTIONS  
FOR FUTURE REFERENCE**

**IF1183**

**Installation &  
Maintenance Information**

**APPLICATION**

TMC series Terminator™ cable fittings are designed for use with Type MC jacketed metal clad, interlocked armor, and continuous corrugated armor cables in ordinary locations.

TMC series Terminator cable fittings are installed to provide a means for passing Type MC, metal clad, jacketed cable into an enclosure, panelboard or other equipment; to form a mechanical watertight termination and to provide ground continuity between cable armor and metal enclosures.

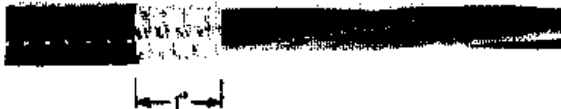
TMC series Terminator cable fittings are UL Listed for ordinary wet locations according to UL Standard 514B. They may also be used in hazardous locations with Type MC cables when installed in accordance with NEC requirements.

NPT Size	Cat. No.	Cable Range Over Armor (Inches)
1/2"	TMC165	.440" - .850"
3/4"	TMC285	.600" - .850"
1"	TMC3112	.800" - 1.120"
1-1/4"	TMC4140	1.100" - 1.400"
1-1/2"	TMC5181	1.280" - 1.610"
2"	TMC6208	1.570" - 2.060"
2-1/2"	TMC7247	1.930" - 2.470"
3"	TMC8302	2.450" - 3.020"
3-1/2"	TMC9352	2.950" - 3.520"
4"	TMC10402	3.500" - 4.020"

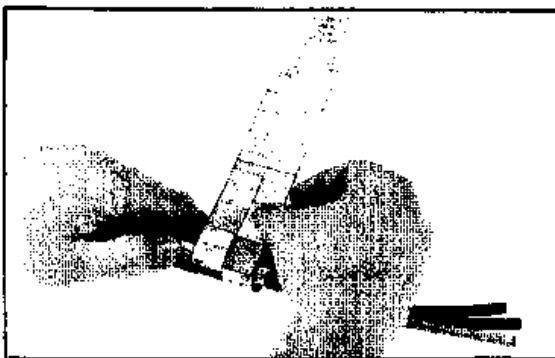
Table 1.

**INSTALLATION**

1. Remove the jacket and armor from the cable to expose a sufficient length of conductors required for the job. Leave approximately 1" of armor exposed.



2. Using the cable gauge and sizer supplied with the Terminator, measure the cable armor and select the proper cable fitting. Place the bottom of the gauge on the exposed cable armor and hold the gauge with your thumb. Wrap gauge lightly around armor. The arrows at the bottom of the gauge indicate which catalog number will be required to terminate the cable. In the example below a TMC3112 would be used.



**Note:** If a cable gauge and sizer is not available, determine the O.D. of the cable armor and choose the appropriate fitting using Table 1

3. Refer to Table 2 or the steps on the cable gauge and sizer to determine the proper amount of armor to be exposed. Remove additional jacket if necessary.

NPT Size	Amount of Cable Armor to be Exposed (Dim. A)
1/2"	1-5/8"
3/4"	1-5/8"
1"	1-5/8"
1-1/4"	1-3/4"
1-1/2"	2-1/4"
2"	2-3/4"
2-1/2"	3-1/2"
3"	4-1/4"
3-1/2"	4-1/4"
4"	4-1/4"

Table 2.  
Amount of Cable Armor to be Exposed



**NOTE:** Inspect the armor and use a file to remove any burrs.

4. Examine the fitting to make sure that neither the spring nor the bushing is precompressed. Refer to Figure 3. If they are, loosen the body and the nut to allow the spring and bushing to return to their maximum diameter. **DO NOT DISASSEMBLE.** It is not necessary to disassemble any of the components of the fittings.
5. Install fitting in a threaded opening or fasten in a siphole with a sealing locknut. Use a wrench to securely tighten the body.

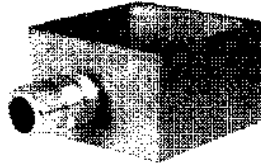


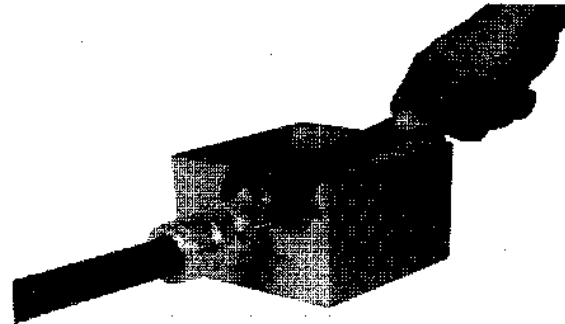
Figure 1.  
TMC Installed in Junction Box

- Insert prepared cable into fitting. If conductors do not pass through the armor stop reducer, remove the reducer using a screw driver or similar tool. Reducer can be removed without disassembling the fitting. Reinsert cable until the armor rests against the armor stop.

**CAUTION**

Make certain the metallic cable armor does not go beyond the armor stop.

- Due to the variation of the cable manufacturing processes, in some instances armor might tend to pass through armor stop. If this condition exists, use electrical insulation tape, and wrap end of armor to produce a diameter sufficient to stop protrusion of armor through armor stop.
- Completely tighten the intermediate body. Then completely tighten the gland nut. Refer to Table 3 for torquing requirements.
- Verify continuity between cable armor and enclosure.

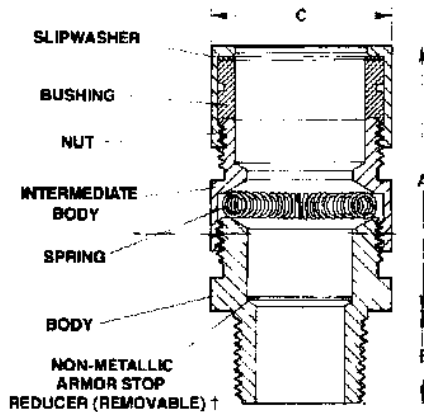


Completed Installation

NPT Size	Tightening Torque (Pound-Inches)	
	Body	Nut
1/2"	300	300
3/4"	500	500
1"	700	700
1-1/4"	1,000	700
1-1/2"	1,200	700
2"	1,600	700
2-1/2"	1,600	700
3"	1,600	700
3-1/2"	1,600	700
4"	1,600	700

Table 3.  
Tightening Torque

**DIMENSIONS**



NPT Size	Cat. No.	Cable Range Over Armor (inches)	A (inches)	B (inches)	C* (inches)
1/2"	TMC165	.440" - .650"	2-3/8	3/4	1-3/8
3/4"	TMC285	.600" - .850"	2-5/8	25/32	1-5/8
1"	TMC3112	.800" - 1.120"	2-5/8	15/16	2
1-1/4"	TMC4140	1.100" - 1.400"	2-3/4	31/32	2-7/16
1-1/2"	TMC5161	1.280" - 1.810"	2-3/4	31/32	2-3/4
2"	TMC8206	1.570" - 2.060"	4-1/2	1	3-7/2
2-1/2"	TMC7247	1.930" - 2.470"	4-3/4	1-7/16	4
3"	TMC8302	2.450" - 3.020"	4-7/8	1-7/16	4-7/8
3-1/2"	TMC9352	2.950" - 3.520"	5-3/8	1-5/8	5-3/8
4"	TMC10402	3.500" - 4.020"	5-1/2	1-5/8	5-7/8

\* "C" dimension is across the hex.

† As shown for 1/2"-1-1/4" sizes, at end of nipple for 1-1/2"-4" sizes.

*All statements, technical information and recommendations contained herein are based on information and tests we believe to be reliable. The accuracy or completeness thereof are not guaranteed. In accordance with Crouse-Hinds "Terms and Conditions of Sale", and since conditions of use are outside our control, the purchaser should determine the suitability of the product for his intended use and assumes all risk and liability whatsoever in connection therewith.*



**CROUSE-HINDS  
ELECTRICAL  
CONSTRUCTION  
MATERIALS**

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IF1183  
Revised 6/89

# BWC EXCEL Wire Size Recommendations

Turbine Model	Maximum 3-Phase AC Amps	Fuse Size, Amps	Wire Run Length, including Tower Height					
			30m 100 ft	60m 200 ft	90m 300 ft	120m 400 ft	150m 500 ft	200m 600 ft
BWC EXCEL-S 240 VAC, 1Ø	34	35	#6 AWG 13.3 mm <sup>2</sup>	#6 AWG 13.3 mm <sup>2</sup>	#6 AWG 13.3 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>
BWC EXCEL-R/48 240-48 VDC Step-Down	34	35	#6 AWG 13.3 mm <sup>2</sup>	#6 AWG 13.3 mm <sup>2</sup>	#6 AWG 13.3 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>
BWC EXCEL-R/120 120 VDC	47	60	#6 AWG 13.3 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#2 AWG 33.6 mm <sup>2</sup>	1 AWG 42.4 mm <sup>2</sup>	1/0 AWG 55.3 mm <sup>2</sup>	2/0 AWG 67.5 mm <sup>2</sup>
BWC EXCEL-R/48 120-48 VDC Step-Down	54	60	#6 AWG 13.3 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#3 AWG 26.7 mm <sup>2</sup>	1 AWG 42.4 mm <sup>2</sup>	1 AWG 42.4 mm <sup>2</sup>	1/0 AWG 55.3 mm <sup>2</sup>
BWC EXCEL-PD Variable Voltage	30	None	#6 AWG 13.3 mm <sup>2</sup>	#6 AWG 13.3 mm <sup>2</sup>	#4 AWG 21.2 mm <sup>2</sup>	#2 AWG 33.6 mm <sup>2</sup>	#2 AWG 33.6 mm <sup>2</sup>	1/0 AWG 55.3 mm <sup>2</sup>

\* Notes: Listed wire sizes will provide no more than a 10% loss at rated power.

Calculating Circular Mills (cm)  
Required (use for longer runs):

$$(K \times I \times L) / Vd = cm$$

Where: Vd = 5.5 for Excel-S  
Vd = 2.5 for Excel-R/120  
Vd = 3.3 for Excel-R/48

### Recommended Conduit Sizes:

(includes #8 bond wire, assumes no more than two 90 degree bends in the conduit string)

Wiring	PVC Conduit Size
3 x #8	1 1/2"
3 x #4	1 1/2"
3 x #2	1 1/2"
3 x 1/0	2"
3 x 2/0	2"

Last revision: 9-Apr-03