NRG TallTower™
Installation Manual and Specifications

For 10 m, 20 m, 30 m, 30 m HD, 30 m SHD, 40 m, 40 m HD, 50 m, 50 m HD, 60 m NRG TallTowers™
Specifications are subject to change without notice.
Installation of guyed towers is inherently dangerous. To minimize risks, read and follow the tower installation instructions explicitly. Installation in agricultural areas may pose a threat to low flying crop dusting aircraft. Notify appropriate parties and install warning devices as needed. NRG Systems, Inc. assumes no responsibility or liability in connection with any act, error, omission, or for any injury, loss, accident, delay, inconvenience, irregularity or damage related to any TallTower installation.

DANGER: YOU CAN BE KILLED
IF THIS TOWER COMES NEAR ELECTRIC POWER LINES
FOR YOUR SAFETY, FOLLOW THESE INSTALLATION INSTRUCTIONS.
Table of Contents
Note that page numbers correspond to the printed version of this manual; these may differ slightly in the pdf version of the manual.

Table of Contents ............................................................................................................................................. 3

WARNINGS ........................................................................................................................................................ 5

Typical Wind Monitoring Site .......................................................................................................................... 6

Description .......................................................................................................................................................... 7

Tools Required .................................................................................................................................................... 7

Installation of Anchors and Base Plate .............................................................................................................. 7

Figure 1: Tower Site Layout ..............................................................................................................................9
Table 1: Tower and Anchor Layout Dimensions ................................................................................................. 9
Figure 2: Winch Anchor Placement .................................................................................................................... 10
Figure 3: TallTower Base Plate Assembly (for 3.5 inch dia. towers) .................................................................. 11
Figure 4: TallTower Base Plate Assembly (for 4.5 inch dia. towers) ................................................................. 12
Figure 5: TallTower Base Plate Assembly (for 6 inch and 8 inch dia. towers) .................................................. 13
Figure 6: 10 m TallTower Assembly ................................................................................................................ 15
Figure 7: 20 m TallTower Assembly ................................................................................................................ 16
Figure 8: 30 m TallTower Assembly ................................................................................................................ 17
Figure 9: 30 m HD TallTower Assembly ......................................................................................................... 18
Figure 10: 30 m SHD TallTower Assembly .................................................................................................... 19
Figure 11: 40 m TallTower Assembly ............................................................................................................. 20
Figure 12: 40 m HD TallTower Assembly ........................................................................................................ 21
Figure 13: 50 m TallTower Assembly ............................................................................................................. 22
Figure 14: 50 m HD TallTower Assembly ...................................................................................................... 23
Figure 15: 60 m TallTower Assembly ............................................................................................................. 24

Tower Assembly ............................................................................................................................................... 25

Table 2: Tower Assembly Sequence ................................................................................................................ 26

Place Side Guys .................................................................................................................................................... 27

Assemble the Gin Pole ....................................................................................................................................... 28

Figure 16: TallTower Gin Pole and Safety Wire Assembly ............................................................................... 28
Figure 17A: Booster Gin Pole Set Up (for raising 8 inch dia. x 50 foot gin pole used for 60 m tower) ............... 29
Figure 17B: 60 m ‘Booster’ Gin Pole .............................................................................................................. 30
Figure 18: 60 m Tower Installation .................................................................................................................. 31
Figure 19: 60 m ‘Booster’ Gin Pole .................................................................................................................. 32

Attach the Winch .................................................................................................................................................. 33

Figure 20: Using the X1 Winch Kit ................................................................................................................... 33
Figure 21: Using the S9000 Winch Kit ................................................................................................................ 34

Guy Wire Tensioning While Raising TallTower .................................................................................................. 34

Tower Lift Crew ................................................................................................................................................... 35

Tower Tilt-Up ...................................................................................................................................................... 36

Figure 22: Partially Raised TallTower .............................................................................................................. 36
Figure 23: Tower Tilt Up Sequence ................................................................................................................... 38
Figure 24: Transferring Guys from Gin Pole to Anchor ................................................................................... 39
Figure 25: Straightening the TallTower ........................................................................................................... 40
Appendix A: Anchoring Guidelines ........................................................................................................... 42
  Table 3: Upwind Anchor Loads .................................................................................................................. 43
  Table 4: Specifications for Screw-In Anchors .............................................................................................. 45
  Table 5: Soil Classes ..................................................................................................................................... 45
  Table 6: Specifications for Arrowhead Anchors ............................................................................................ 46
  Table 7: Specifications for Rock Anchors .................................................................................................. 46
  Figure 26: Installing Screw-in Anchors ....................................................................................................... 47
  Figure 27: Installing Arrowhead Anchors .................................................................................................. 48
  Figure 28: Installing Rock Anchors ........................................................................................................... 50

Appendix B: Choosing the Correct Gin Pole & Winch .................................................................................. 50

Appendix C: Structural Analysis of NRG TallTowers .................................................................................. 51
  Table 8: NRG TALL TOWERS DESIGN LOADS ........................................................................................... 58
  Figure 29: Tower Load and Performance Chart: 30 m TallTower ................................................................ 59
  Figure 30: Tower Load and Performance Chart: 30 m HD TallTower ............................................................. 60
  Figure 31: Tower Load and Performance Chart: 30 m SHD TallTower ............................................................ 61
  Figure 32: Tower Load and Performance Chart: 40 m TallTower ................................................................ 62
  Figure 33: Tower Load and Performance Chart: 40 m HD TallTower ............................................................. 63
  Figure 34: Tower Load and Performance Chart: 50 m TallTower ................................................................ 64
  Figure 35: Tower Load and Performance Chart: 50 m HD TallTower ............................................................. 65
  Figure 36: Tower Load and Performance Chart: 60 m TallTower ................................................................ 66

Appendix D: Site Visit Procedures .................................................................................................................. 67

Appendix E: Glossary ......................................................................................................................................... 69

Appendix F: Technical Drawings .................................................................................................................. 75
  Figure 42: 30 m TallTower .......................................................................................................................... 75
  Figure 43: 30 m HD TallTower ................................................................................................................... 76
  Figure 44: 30 m SHD TallTower .................................................................................................................. 77
  Figure 45: 40 m TallTower .......................................................................................................................... 78
  Figure 46: 40 m HD TallTower ................................................................................................................... 79
  Figure 47: 50 m TallTower .......................................................................................................................... 80
  Figure 48: 50 m HD TallTower ................................................................................................................... 81
  Figure 49: 60 m TallTower .......................................................................................................................... 82

Index .............................................................................................................................................................. 83
WARNINGS

Read and Follow the Tower Installation Manual.

DO NOT  climb this tower.
DO NOT  erect tower within 1 ½ times the tower height of electric power lines.
DO NOT  erect tower within 1 ½ times the tower height of walkways, roads, or buildings.
DO NOT  permit unauthorized personnel onto the tower erection site while the tower is being installed.
DO NOT  raise or lower the tower on a day with high winds or gusty winds.
DO NOT  use mechanical tensioning devices to adjust guy wires.
DO NOT  stand in line with, directly in front of, or behind any tensioned cable.
DO NOT  oil tower joints. This can cause tower failure if the tubes “self flare.”
DO  determine the soil type at your site and install the correct anchors.
DO  place tower anchors according to anchor manufacturer’s recommendations.
DO  properly ground the tower electrically.
DO  stand to the side of any tensioned cables.
DO  thoroughly understand tower erection procedure before beginning installation. All crew members should read the manual before arriving at the installation site!
DO  review glossary so that you are familiar with all tower parts and terminology.
IF you are NOT familiar with erecting towers of this type, seek professional guidance. NRG will gladly help answer any questions.
IF you have never installed a TallTower before, DO NOT attempt to install your 40 m, 50 m, or 60 m TallTower without first installing the lower 20 m or 30 m of your tower to become familiar with all installation procedures and concepts.
IF you are not thoroughly familiar with all components of the tower, including all hardware and how all components function, DO NOT attempt to install this tower yourself. Tall guyed towers are dangerous, and you or members of your crew can be injured or killed.
IF installing the TallTower in an agricultural area, notify appropriate parties and install warning devices as needed. Towers can pose a threat to low-flying crop dusting aircraft.
Typical Wind Monitoring Site

1. Measure to height, then attach sensor mounting booms to TallTower using supplied hose clamps.

2. Bundle sensor wires, then wrap and tape around TallTower in a downward spiral, one wrap every 1.5 m (4.9 ft).

- Lightning spike
- Maximum #40 Anemometer
- 200P Wind Direction Vane
- Top Mount Boom (TMB) (combined Z-mast and stub mast)
- Maximum #40 Anemometer facing prevailing winds
- Side Mount Boom (SMB)
- Yagi Antenna (adjust position for maximum signal strength)
- Li-Cor Pyranometer facing sun
- "Drip loop" in sensor wire
- BP-20 Pressure Sensor
- NRG Logger and Shelter Box Mount above expected height of snow fall
- Logger ground wire to ground rod
- Grounding wire from lightning spike to ground rod
- Baseplate
- Ground Rod
- 0.5 meters (1.6 feet)

1) Measure to height, then attach sensor mounting booms to TallTower using supplied hose clamps.

2) Bundle sensor wires, then wrap and tape around TallTower in a downward spiral, one wrap every 1.5 m (4.9 ft).
Description

The NRG TallTower™ is of steel tube construction, guyed periodically in four directions. Sections slide together without the use of bolts or clamps. The tower is tilted up from the ground with a gin pole (except for the 10 meter tower) and small winch (not included). Lifting of the tower is done by one set of guy wires (lifting wires) attached to the gin pole. The tower is stabilized sideways with two side guy wire sets. The base plate is hinged so both the tower and gin pole can pivot to the erected position. TallTowers are supplied complete including all hardware. The standard anchors included are screw-in anchors suitable for many soil types. Other anchor types are available. (Refer to the anchoring guidelines in Appendix A of this manual for more information).

Previous experience installing other TallTowers is required for successful installation of 40 m, 40 m HD, 50 m, 50 m HD and 60 m TallTowers. If you have no prior experience with TallTower installation, install just the lower 20 to 30 meters of a 40 m, 50 m, or 60 m TallTower to become familiar with installation procedures and concepts.

Tools Required

- ¼ inch nut driver (for sensor installation)
- 5/16 inch nut driver (for hose clamps)
- 7/16 inch nut drivers (for wire rope clips) – one per crew member
- Large adjustable wrench or channel lock (for large bolts)
- 9/16 inch wrench, socket or open (for base plate assembly)
- Piece of rebar or similar (for turning anchors)
- Hand sledge (for ground rods)
- Small adjustable wrench (for opening/closing quick links, acorn clamps)
- Small pliers (for sensor cotter pins)
- Small Phillips head (+) screwdriver (for set screws)
- Flat (-) screwdriver (for antenna mounting assembly)
- Knives (to cut electrical tape) – one per crew member
- Level, preferably with a magnetic base (to straighten the tower)
- Compass (for aligning direction sensors)
- Permanent marker (for labeling lower ends of cables)
- Extra 12 V deep cycle marine battery (for winch)

Installation of Anchors and Base Plate

1. Refer to Figure 1, Tower Site Layout. Lay out locations for the tower base plate, guy anchors and the winch anchor. Lay out the site so that the tower is laid out downwind of the base-plate, so that the tower will be lifted into the wind. If the site is on a steep slope, lay out the site so that the tower is laid out uphill of the base-plate. Unless the slope is steep, it is more important to have the tower lifted into the wind.
2. Refer to Table 1: Tower and Anchor Layout Dimensions. Measure carefully to place the anchor points. Insure that the anchor radii (dimension “A”) and the diagonals (dimension “D”) are as tabulated for your tower.

**NOTE:** TallTowers can be installed on slopes up to 12°. When laying out a TallTower installation on a slope, measure the tabulated distances along the ground to place the anchors. It is not necessary to compensate for the slope. TallTower guys are cut long enough to allow for installation on slopes up to 12° while maintaining the ideal angle between the tower and the guys.

**NOTE:** The side guy anchors and the base plate should be on a straight line. If it is not possible to place them exactly in line, it is better to move an anchor in or out along this line, but no more than 1.5 m (5 feet) off the line. Some sites may require a compromise of this, as anchors may not be able to be located at the preferred spot.

**NOTE:** Extra care will have to be taken while raising the tower if:
- the anchor placement is not perpendicular to the tower.
- the anchors are not at the same elevation.
- the side anchors and base plate are not in a straight line.

Any of these conditions will affect the side guy wire tension as the tower is raised. Tension will have to be adjusted periodically as the tower is lifted.

3. Install the anchors. Leave the eye of screw-in anchors about 150 mm (6 inches) above ground. See Appendix A: Anchoring Guidelines at the end of this manual for more information on installing anchors.

4. Refer to Figures 3, 4, and 5 for base plate assemblies. Assemble the four (or 6) piece base plate with the supplied galvanized bolts. Place the base plate with its sides aligned toward the winch anchor, and the longer offset foot (4 piece base) toward the winch anchor. Sink the bent-down edges of the base plate into the soil. If possible (for additional resistance to movement), drive two rods (at an angle) into the ground through the holes in base plate. This is essential for the 60 m tower. If you have purchased an NRG Ground Kit for your tower, the ground rod can serve double duty as one of these rods. Some customers have found it helpful to drive additional rods on the winch side of the base plate to keep it from sliding horizontally.

5. If the soil surface is soft, it may be necessary to support the base plate to prevent it from settling under the load of the tower, or rotating down into the soil as the tower is lifted. The base plate can be set on planks or other suitable material to spread the load.
**Figure 1: Tower Site Layout**

<table>
<thead>
<tr>
<th>Tower</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>10 m</td>
<td>4.9 m (16 feet)</td>
</tr>
<tr>
<td>20 m</td>
<td>12.8 m (42 feet)</td>
</tr>
<tr>
<td>30 m, 30 m HD, 30 m SHD</td>
<td>18.3 m (60 feet)</td>
</tr>
<tr>
<td>40 m, 40 m HD (Inner Guy Point)*</td>
<td>21.3 m (70 feet)</td>
</tr>
<tr>
<td>40 m, 40 m HD (Outer Guy Point)*</td>
<td>22.9 m (75 feet)</td>
</tr>
<tr>
<td>50 m, 50 m HD (Inner Guy Point)*</td>
<td>30.5 m (100 feet)</td>
</tr>
<tr>
<td>50 m, 50 m HD (Outer Guy Point)*</td>
<td>33.5 m (110 feet)</td>
</tr>
<tr>
<td>60 m (Inner Guy Point)♦</td>
<td>38.1 m (125 feet)</td>
</tr>
<tr>
<td>*60 m (Middle Guy Point)♦</td>
<td>44.5 m (146 feet)</td>
</tr>
<tr>
<td>60 m (Outer Guy Point)♦</td>
<td>50.8 m (166.6 feet)</td>
</tr>
</tbody>
</table>

**Table 1: Tower and Anchor Layout Dimensions**

*40 meter and 50 meter towers have two anchors per side and two winch anchors.

♦ 60 meter tower has three anchors per side and two winch anchors.

**NOTE:** The winch anchor must be in line with the tower. It is very important that the distance from the base plate to the winch anchor (dimension W in Table 1) be exact. See Figure 2.
NOTE: The gin pole safety wire MUST be used to prevent gin pole separation.
Figure 3: TallTower Base Plate Assembly (for 3.5 inch dia. towers)
**Figure 4:** TallTower Base Plate Assembly (for 4.5 inch dia. towers)
6" & 8" BASE PLATE ASSEMBLY

1) Lay out 4 pieces upside down to form a square fasten mating ribs with 8 (3/8 x 1") bolts & nuts.

2) Flip base up in an edge and attach both vertical pieces to the top side using 4 (3/8 x 1") bolts, nuts & 3/8" washers.

3) Bolt stabilizer brackets (2) to the end of the baseplate that the ginpole will be in. Use 4 #8 bolts, nuts & washers.

NOTE: When using a 6" ginpole in the 8" base plate (40M & 50M H.D. towers), 1" spacers must be used between the ginpole tube and the baseplate vertical plates.

Figure 5: TallTower Base Plate Assembly (for 6 inch and 8 inch dia. towers)
Figure 6: 10 m TallTower Assembly

- Overall Erected Height: 10.26m (33'-8"
- Guy Level Erected Height: 8.25m (27'-7.5"
- Loop guy wire thru anchor eye & secure with 3 wire rope clips (typ).
- U-bolts to be on dead end of wire rope.
- 2m (7') tube SX
- Base plate - long foot towards winch anchor
- 4.9m (16') Guy Radius
Figure 7: 20 m TallTower Assembly

Guy wires fasten to anchor eye with wire rope clips. See instructions.

Base Plate Assembly
Note: Long Foot toward winch. See Instructions.

12.8m (42') Anchor Radius
Figure 8: 30 m TallTower Assembly
Figure 9: 30 m HD TallTower Assembly
Figure 10: 30 m SHD TallTower Assembly
Figure 11: 40 m TallTower Assembly
Figure 12: 40 m HD TallTower Assembly
Figure 13: 50 m TallTower Assembly
Figure 14: 50 m HD TallTower Assembly
Figure 15: 60 m TallTower Assembly
Tower Assembly

6. Identify the base tube. One box of tower tube is labeled “1B1T.” In this box are the base tube and one regular tube. The base tube has a hole drilled through the flared (wider) end, with the tower base bolt and nut installed. Remove the base bolt and nut from the base tube and use them to mount the base tube to the base plate through the lower holes in the center of the base plate sides. See Figures 3 –5 for TallTower Base Plate Assembly instructions.

7. Refer to the assembly drawing for your TallTower (Figures 6 through 15), and Table 2 for the correct sequence of tubes to lay out the tower. Table 2 specifies the number and length of the tubes to be assembled in bold type followed by the labeled height of the guy ring.

8. Each tube has a flared end, which slips over the tube below it. As you lay out each tube, slide them together, building to the first guy level. Make sure the tower is laid out at a right angle (perpendicular) to the line going through both side anchors and the base plate. Assemble the first section of tubes as specified under “Section 1” in Table 2. Note: **Do not use oil on tower joints.** This can cause tower failure if the tubes “self flare.”

9. Identify the lowest level guy set; it will be labeled with the guy level listed in italics in Table 2. Slide the guy ring over the top of the last tube. The corners of the guy ring where the guy wires attach are bent down. Make sure the guy ring is placed so these “ears” are bent towards the base plate.

10. Slide the guy ring all the way down the tube to the flared connection, carrying the spooled guy wires along. The ring will stop at the bottom of the tube against the flared connection.

11. Make sure the guy ring is positioned with the Lifter Guy on top of the tower. This guy wire will double as the lifting wire while the tower is erected. The lifting guy has a white “lifter” label on the side of the spool, and has red tag on the lifter eye specifying the guy level. Note: 10 m TallTowers are lifted directly by the upwind guy wire, so there is no special lifter.

12. For 10 m towers, assembly is complete. Proceed to step 14. For the taller towers, continue to add more tower tubes, building to the second guy level as specified in the second column of Table 2. Now slide on the second level guy ring. Remember to slide the guy ring over the seventh tube in order to rest at the joint between the sixth and seventh tube.

13. Continue until all sections and guys are assembled. Note: The top level guy ring is always placed over the top tube.
Table 2: Tower Assembly Sequence

<table>
<thead>
<tr>
<th>TOWER</th>
<th>Sequence of Tubes in each Section</th>
<th>Section 1</th>
<th>Section 2</th>
<th>Section 3</th>
<th>Section 4</th>
<th>Section 5</th>
<th>Section 6</th>
<th>Section 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 m</td>
<td>Base Tube + Four 2 m 8 m/26 feet</td>
<td>Three 2 m 12 m/40 feet</td>
<td>Three 2 m 18 m/60 feet</td>
<td>3 m + 1.5 m/75 feet</td>
<td>3 m + 1.5 m/75 feet</td>
<td>3 m + Two 1.5 m 30 m/100 feet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 m</td>
<td>Base Tube + Three 2 -m 6 m/20 feet</td>
<td>3 m + 1.5 m + 3 m 15 m/50 feet</td>
<td>3 m + 1.5 m + 3 m 15 m/50 feet</td>
<td>3 m + 2.5 m/75 feet</td>
<td>3 m + Two 1.5 m 30 m/100 feet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 m</td>
<td>Base Tube + 3 m + 1.5 m + 3 m 7.5 m/25 feet</td>
<td>3 m + 1.5 m + 3 m 15 m/50 feet</td>
<td>3 m + 1.5 m + 3 m 15 m/50 feet</td>
<td>3 m + 2.5 m/75 feet</td>
<td>3 m + Two 1.5 m 30 m/100 feet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 m HD</td>
<td>Base Tube + 3 m + 1.5 m + 3 m 7.5 m/25 feet</td>
<td>3 m + 1.5 m + 3 m 15 m/50 feet</td>
<td>3 m + 1.5 m + 3 m 15 m/50 feet</td>
<td>3 m + 2.5 m/75 feet</td>
<td>3 m + Two 1.5 m 30 m/100 feet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 m SHD</td>
<td>Base Tube + 3 m + 1.5 m + 3 m 7.5 m/25 feet</td>
<td>3 m + 1.5 m + 3 m 15 m/50 feet</td>
<td>3 m + 1.5 m + 3 m 15 m/50 feet</td>
<td>3 m + 2.5 m/75 feet</td>
<td>3 m + Two 1.5 m 30 m/100 feet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 m</td>
<td>Base Tube + 3 m + 1.5 m + 3 m 7.5 m/25 feet</td>
<td>3 m + 1.5 m + 3 m 15 m/50 feet</td>
<td>3 m + 1.5 m + 3 m 15 m/50 feet</td>
<td>3 m + 2.5 m/75 feet</td>
<td>Three 3 m 39 m/130 feet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 m HD</td>
<td>Base Tube + 3 m + 1.5 m + 3 m 7.5 m/25 feet</td>
<td>3 m + 1.5 m + 3 m 15 m/50 feet</td>
<td>3 m + 1.5 m + 3 m 15 m/50 feet</td>
<td>3 m + 2.5 m/75 feet</td>
<td>Three 3 m 39 m/130 feet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 m</td>
<td>Base Tube + Three 3 m 9 m/30 feet</td>
<td>Three 3 m 18 m/60 feet</td>
<td>Three 3 m 27 m/90 feet</td>
<td>Three 3 m 36 m/120 feet</td>
<td>3 m + 1.5 m + 3 m 43.5 m/145 feet</td>
<td>3 m + Two 1.5 m 51 m/170 feet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 m HD</td>
<td>Base Tube + Three 3 m 9 m/30 feet</td>
<td>Three 3 m 18 m/60 feet</td>
<td>Three 3 m 27 m/90 feet</td>
<td>Three 3 m 36 m/120 feet</td>
<td>3 m + 1.5 m + 3 m 43.5 m/145 feet</td>
<td>3 m + Two 1.5 m 51 m/170 feet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 m</td>
<td>Base Tube + Two 3 m + 1.5 m + 3 m 10.5 m/35 feet</td>
<td>Three 3 m + Transition + 3 m 22.5 m/75 feet</td>
<td>Three 3 m + Two 1.5 m 30 m/100 feet</td>
<td>Two 3 m + 1.5 m 37.5 m/125 feet</td>
<td>Two 3 m + 1.5 m 45 m/150 feet</td>
<td>Two 3 m + Transition + Two 3 m 52.5 m/175 feet</td>
<td>Two 3 m + 1.5 m 61.5 m/205 feet</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** All tubes for 10 m and 20 m TallTowers are 2 m (7 feet) long. 30 m, 30 m HD, 30 m SHD, 40 m, 40 m HD, 50 m, 50 m HD and 60 m TallTowers use a mix of 1.5 m (5 feet) and 3 m (10 feet) long tubes. Guy set level is theoretical and is based on nominal 5 feet (1.5 m) or 10 feet (3 m) tube lengths, neglecting tube engagement depths. The metric length is rounded to the nearest ½ meter. For actual erected heights, see Figures 6 thru 15.
Place Side Guys

14. Now roll out the side guys to the side anchors. Guys must be rolled out to the anchors, not let out from the side of the spool. Wire rope let out from the side of the spool will become severely twisted and kinked. Twisted and or kinked wire rope is very difficult to handle and may fail under load.

15. Slide three wire rope clips (supplied in hardware box) onto each guy wire end. Now run the guy wire end through the anchor eye, double the guy back and slide the end through the first wire rope clip. Place the wire rope clip on the wire so the saddle (the forged, grooved part) cradles the wire coming from the tower and the “U” bolt part clamps down on the dead end of the guy. Leave a little slack in the guy wire, snug up the wire rope clip nuts. Don’t tighten the wire rope clip too tightly; you will need to adjust the guy length as the tower is erected. Let the other two clips remain loose until the tower has been erected. If you have a 10 m TallTower, you may proceed to the section entitled ‘Guy Wire Tensioning While Raising TallTower’.
Assemble the Gin Pole

(All but 10 m towers)

16. As with the tower tubes, the gin pole includes one box marked “1B1T,” which includes the base tube. The base tube has a galvanized bolt and nut pre-assembled through the flared end. The gin pole top is packed with all the gin pole hardware, including the gin pole safety wire. The top tube has a bolt and nut pre-assembled through the non-flared end of the tube.

17. For the 50 foot (8 inches dia. tube) gin pole (used for 60 m tower), see Figures 17 - 19 for the “booster” gin pole set up. The 50 foot gin pole must first be raised with the help of the “booster” gin pole.

18. Refer to Figure 16. Slide the safety wire through the gin pole base tube. Lay out the gin pole base tube on top of the tower. Bolt the base tube to the base plate through the holes in the base plate sides closest to the winch point. Make sure that the bolt goes through the eye in the safety wire.
Figure 17A: Booster Gin Pole Set Up (for raising 8 inch dia. x 50 foot gin pole used for 60 m tower)
2) While holding ginpole partially up, place winch cable into pulley grooves.

1) Insert UPPER bolt through baseplate, spacers & ginpole tube. Attach nut.

**Figure 17B: 60 m ‘Booster’ Gin Pole**
3) Push ginpole into vertical position and insert bottom bolt through baseplate, spacers, & ginpole tube. Thread nut onto bolt.

Figure 18: 60 m Tower Installation
OBSERVE WHEN CABLES ARE FREE FROM THE PULLEYS

MAIN GINPOLE LIFT

NOTE:
WHEN CABLES ARE NO LONGER SUPPORTED BY HELPER GINPOLE, IT IS SAFE TO REMOVE THE HELPER GINPOLE.

MAIN GINPOLE PARTIALLY LIFTED

REMOVE BOLTS AND REMOVE GINPOLE

Figure 19: 60 m ‘Booster’ Gin Pole
19. Assemble the middle tube(s) of the gin pole onto the base tube, threading the safety wire through each tube as it is assembled.

20. Slide the top gin pole section onto the middle tube(s). Make sure the bracket bolt hole in the gin pole top is parallel to the bolt in the base tube.

21. Bolt the rocker brackets to the top section, making sure that the bolt goes through the eye in the safety wire.

22. Attach the snap links (or quick links) to the rocker brackets with the supplied shackle. Each snap link has a rubber tube (quick links have a threaded closure) used to hold the snap link closed during the lift. It is essential that the rubber tube is positioned over the closure point to prevent the snap link from opening. If using quick links, it is essential that the threaded closure is closed completely (until it no longer turns) to prevent the quick link from opening and breaking during the tower lift. Be sure to orient the snap links as shown in Figure 16, so they open down and away from the base plate. This will allow you to clip and unclip the lifting guys in the correct order.

23. Now roll out each level of the lifting guy wires and clip the swaged-on lifting eyes into the two snap links on the top of the gin pole. Clip the lowest level half of the lifters into one snap link. On this lower group, clip in the lowest level first and work up one level at a time. Make sure the wires are not twisted. Now clip the higher level half of the lifters into the other snap link. On this upper half, clip in the highest level first and work down. For towers with an odd number of lifters, let there be one more lifter in the lower level group. Now slide the rubber tube on each snap link down over the opening to prevent the snap link from opening. The end of each guy wire will be attached to the anchor after the tower is erected. Keep these wires organized so this is easy to do.

24. Tie the two (three for 60 m tower) gin pole guy ropes (yellow polypropylene) to the top on the gin pole. These are used to guy the gin pole while erecting. Run these out to the side anchors and tie them off. The 60 m gin pole uses a 3rd rope, which is tied to the guy anchor on the winch side. If the gin pole guys are not used, the gin pole could fall over to either side when it is vertical.

**Attach the Winch**

25. Attach the winch cable to the upper end of the rocker brackets with the supplied shackle. For the 60 m tower and gin pole, route the winch cable over one of the cable guide pulleys in the top of the 3 ½ inches dia. x 7 feet “booster” gin pole, then up and through the pulley on the main gin pole, and finally back over the 2nd pulley in the booster gin pole and attach to the 2nd anchor by the winch (Figures 17 - 19).

**Figure 20: Using the X1 Winch Kit**
Guy Wire Tensioning While Raising TallTower

As a tower is raised, unless the anchors are placed in precisely their correct positions, and unless the site is perfectly level, some guy wires will tighten and some will go slack as the tower is raised. The same is true as a tower is lowered on the same site. Because of this, guy wire tension must be checked and adjusted as needed to maintain uniform tension, until the tower erection procedure is complete.

A wire that becomes too tight can put very high forces on both the anchor and the tower. This force can rapidly grow if the tower lifting or lowering procedure continues. These high forces can suddenly buckle the tower, causing it to fall, endangering the tower crew, and possibly damaging
any vehicles or equipment nearby. Do not let the tower be bowed to the side more than 0.3 m (1 foot) to 0.5 m (1 ½ feet) away from a straight line. If the tower is bowed more than this, the side guys should be adjusted to straighten out the tower.

It is critically important that proper tension be maintained on side guy wires at all times during the lifting procedure to provide side support for the tower. Too little tension can allow the tower to buckle to the side.

Too much tension may cause failure of the tower, anchors, or wire. There must always be visible slack in the guy wires. If no slack is visible, the tension is too great.

Once the tower is vertical, two people of average size pulling by hand can properly tension the guy wires.

MECHANICAL TENSIONING DEVICES SHOULD NEVER BE USED TO ADJUST GUY WIRES!!

Take care that guy wires do not get caught on tree branches, roots, rocks, or other obstructions.

This sequence of observing, communicating observations, issuing commands to guy wire tenders, adjusting the side guys and re-tightening wire rope clips must be well understood before lifting a tower. The sequence will be repeated many times before a tower erection is completed on all but the most flat and level sites.

Tower Lift Crew

We suggest the following organization to form an efficient and safe crew to erect NRG TallTowers:

Four Member Crew:

- Crew Leader to operate the winch and coordinate the other members. It is especially important to maintain clear communication among the members of the crew.
- Two people, one to attend to each side guy anchor and adjust side guy wires. These people must be familiar with taking in and letting out guy wires.
- One person free to assist with holding or pulling in guys, tending the opposite guys at the end of the lift, and otherwise observing guy wires. For 40 m, 50 m and 60 m towers, two people are needed to tend the opposite guys.

Two or three people can safely install 10 m TallTowers.
26. For 10 m towers only: The tower can now be lifted by hand about 1 m (2 to 3 feet) off the ground. Then skip to step 30 and mount sensors, etc.

27. Refer to Figure 23. Lift the gin pole up by hand while taking in slack with the winch until gin pole is almost vertical and all lifting wires are tight. For the 60 m, 8 inch x 50 foot ginpoles, be sure to remove the booster gin pole once the main gin pole is near vertical. If using NRG winch kits, guide the cable onto the drum with your free (gloved) hand so it winds tightly and evenly across the drum. You can also help the cable to wind evenly by using the winch control handle to move the winch motor from side to side.

28. Lift the tower about 1 m (2 to 3 feet) off the ground while checking side guy tension. The lifters are set up to allow a slight bow in the tower, with the top slightly 0.3 m to 0.6 m (1 to 2 feet) higher than the middle. This is normal. Check the side guy wire tension to prevent the tower from either falling off to one side or bowing which could damage the tower.

29. Watch the winch anchor for movement. The maximum lifting force will be experienced when the tower is first lifted a few feet off the ground. If the winch will not hold, either the anchor was not installed correctly or another type of anchor is needed. See Appendix A: Anchoring Guidelines for more information.

30. Set the tower back down on blocks placed about every 6m (20 feet) along the tower. Now install sensors, sensor wire, instruments, etc. Do not work near or under a tower that is lifted off the ground unless it is permanently guyed or resting on blocks. Do not stand directly in front of or behind (in line with) any wires under tension. Spiral wrap sensor cables firmly around outside of tower (approx. 1 wrap every tube), taping or tying every 1.5 to 2.5 m (5 to 8 feet). Protect cables as they pass over guy rings. Do not install cables inside the tower - sharp inside edges may cut sensor cables.

31. Next roll out the guy wires that will be attached to the anchor opposite the winch point. For 10 m towers, attach these guys now and skip to step 32.

32. Start lifting the tower, 10 to 20 degrees at a time. Stop the winch each time and check the side guy wire tension. Only adjust side guy tension when the winch is stopped. As explained above, the proper tension must be maintained on side guy wires at all times to provide side support for the tower.
33. Readjust with wire rope clips, letting cable out or pulling loose cable in. Work slowly and smoothly. Fast uneven movements tend to make the tower shake or swing. Be sure that communication between all members of the lifting team is clear and concise. Continue lifting and adjusting until tower is about half way to vertical (45°).

34. Now attach the set of guy wires opposite the winch to their anchor. Measure the correct length by walking each guy to one of the side anchors. Note the length required to reach the side anchor at proper tension. Now fasten each of these “opposite” guys to its anchor at that point. For 10 m towers, go to step 36.

35. It is essential that tension is maintained on all of the guy wires opposite the winch during this last part of the lift. To do this, a crew member pulls outward on the guy wire, pulling against the tower and the anchor to take out the slack. The safest way to do this is to tie ropes around the guy wires. This allows the crew members to maintain tension by hand without being under the tower.

36. On 10 m to 30 m towers, maintain tension on a minimum of one mid level and one top level guy. For 40 m, 40 m HD, 50 m, 50 m HD, and 60 m towers, use two crew members to tend two top level and two mid level guys. These crew members should maintain tension in the opposite guys and allow the winch to pull against them as they let out slack during this last part of the lift. NOTE: The tower will lift easily at this point; very little winch force is required to lift into final position.

37. As mentioned before, it is normal to have a slight bow in the tower. Stop lifting when the top of the tower is directly over the base. The tower will still be bowed slightly away from the winch. Re-check that the tension in the guys opposite the winch and in the side guy wires is set up correctly to about 23 kgf (50 pounds) of tension, allowing some slack in each guy wire. Check that wire rope clips are secure. If installing a 10 m TallTower, you may now skip to step 39.
Figure 23: Tower Tilt Up Sequence
38. Refer to Figure 24. Transfer the lifting guys one at a time from the snap links on the gin pole to their anchor. Secure each with wire rope clips. Remember that you will be holding the tower! Maintain tension while transferring the wires. Start with the top guy level. Adjust the guy tension on the lifting guy and the one opposite to pull the tower straight and vertical.

39. Working downward, transfer the lower level guys one at a time to their anchor. Remember that on the 40 m, 40 m HD, 50 m, 50 m HD, and 60 m towers, some of these guys will be attached to the inner anchor point. Again, check the tension on the lifting guy and its opposite guy as each is transferred. If you are installing a 10 m tower, you may proceed to step 41.

40. Finally, transfer the lowest level guys from the gin pole to the anchor. On 40 m, 40 m HD, 50 m, and 50 m HD towers, these guys go to the inner anchor points. On 60 m towers, there is a third anchor point. To keep the tower straight, it may be necessary to winch out slightly and or adjust the opposite guys as the lifters are transferred. As you remove the last lifter, lower the gin pole to the ground.
41. Make final adjustments to the guys. Using a carpenter’s level on the base tube, adjust the lowest level guy wires as needed so the base tube is vertical.

42. Working upward, adjust all four guys at each level while sighting up the tower from the base to straighten the tower (see Figure 25).

![Figure 25: Straightening the TallTower](image)

43. Re-check guy tension in all guys as described above. Remember that there should be visible slack in all guy wires. This is normal. Place the other two wire rope clips on each guy now, with about 100 mm to 200 mm (4 inches to 8 inches) between clips. Re-check that all wire-rope clips are tight. Final torque on wire rope clips should be 6 Nm (4.5 ft-lb) for 1/8 inch wire rope clips and 10 Nm (7.5 ft-lb) for 3/16 inch wire rope clips.

44. The gin pole may be left in place, or it may be removed and disassembled if desired.

45. Check the guy wires in 2 or 3 weeks. Some settling of the tower or anchors may occur, and guy wires can stretch. Tighten loose guys and straighten the tower if needed. It is especially important to do this before any icing events occur.

**Tower Lowering**

Lowering the tower is the reverse of raising the tower, though there are a few additional precautions to be taken.
46. Just as side guy tension may vary during the lifting process, the same is true as the tower is lowered. Side guy wires will have to be tended in order to maintain proper guy tension.

47. If the gin pole was removed, set up the gin pole as described in steps 16 to 24, above. If the tower will be lowered onto blocking, place the blocking now while it is still safe to work under the tower.

48. Lift the gin pole and transfer the lowest level lifting guy wire from the anchor to the gin pole. Remember you will be holding the tower - maintain tension while transferring the wires. Winch in or out as needed to maintain the correct amount of tension in the guy wire when it is transferred.

49. Working upward, transfer the lower half of the lifter guy wires from the anchor to the gin pole, in order from lowest to highest. The tension in the opposite guys may need to be adjusted when the guys are transferred. Then transfer the upper half of the guys from their anchor to the gin pole. The last guy to be transferred will be the top level.

50. Tension must be applied to the guys opposite the lifting guys to pull the tower away from the winch as you begin lowering. To do this, leave the guy attached to the anchor and pull outward on the guy wire to take out the slack. The safest way to do this is to tie a rope around the guy wire. This allows the crew members to maintain tension by hand without being under the tower.

51. Maintain tension on a minimum of one mid level and one top level guy during lowering. For 40 m, 40 m HD, 50 m, 50 m HD, and 60 m towers, use two crew members to tend two top level and two mid level guys. These crew members should maintain tension in the opposite guys and take up the slack in the guy as the tower lowers toward them.

52. As the tower is lowered and reaches an angle of between 60 degrees and 45 degrees, it will no longer be necessary to maintain tension on the guy wires opposite the winch. Stop the winch each 20 degrees or so to re-check side guy tension. The force on the winch is greatest as the tower nears the ground. Be sure to stand to either side of the winch cable rather than directly in line with it.
Appendix A: Anchoring Guidelines

Before the tower is ordered, the soil type should be determined and the correct anchors ordered. The purpose of this section is to give you the information needed to provide suitable anchoring for your TallTower. Because anchor requirements are site specific, it remains the responsibility of the customer to determine anchor requirements. If you are not sure what is required, seek professional guidance. Local utility companies can often provide useful information regarding anchoring used in the site area.

The choice of anchors must take into consideration soil type, maximum winds to be experienced, icing or other weather that may affect the tower, and a safety factor suitable for the location and to meet any legal requirements.

Considerations include but are not limited to: tornadoes, hurricanes or typhoons, locations where very high winds are expected, periodic soaking of the soil which may shift or become undermined, and icing events.

Table 3 lists the maximum anchor loads for each tower at the maximum rated wind speed. Anchors must be placed at the correct angle to provide specified holding power and to prevent shifting of the anchors under load.
Table 3: Upwind Anchor Loads

<table>
<thead>
<tr>
<th>Tower size</th>
<th>Tube diameter (a)</th>
<th>EIA-222-F wind velocity (a)</th>
<th>Guy anchor reaction (b)</th>
<th>Winch anchor reaction (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 m</td>
<td>114 mm (4.5 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>6200 N (1400 pounds) at 45°</td>
<td>5300 N (1200 pounds) at 45°</td>
</tr>
<tr>
<td>30 m HD</td>
<td>152 mm (6 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>7100 N (1600 pounds) at 45°</td>
<td>7100 N (1600 pounds) at 45°</td>
</tr>
<tr>
<td>30 m SHD</td>
<td>203 mm (8 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>8900 N (2000 pounds) at 45°</td>
<td>9800 N (2200 pounds) at 45°</td>
</tr>
<tr>
<td>40 m</td>
<td>152 mm (6 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>8500 N (1900 pounds) at 51°</td>
<td>12500 N (2800 pounds) at 45°</td>
</tr>
<tr>
<td>40 m HD</td>
<td>203 mm (8 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>9800 N (2200 pounds) at 51°</td>
<td>16500 N (3700 pounds) at 45°</td>
</tr>
<tr>
<td>50 m</td>
<td>152 mm (6 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>10200 N (2300 pounds) at 49°</td>
<td>14200 N (3200 pounds) at 45°</td>
</tr>
<tr>
<td>50 m HD</td>
<td>203 mm (8 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>10700 N (2400 pounds) at 49°</td>
<td>18700 N (4200 pounds) at 45°</td>
</tr>
<tr>
<td>60 m</td>
<td>114, 152, 203 mm (4.5, 6, 8 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>8900 N (2000 pounds) at 45°</td>
<td>20500 N (4600 pounds) at 45°</td>
</tr>
</tbody>
</table>

NOTES:
(a) Fastest mile wind velocity per EIA-222-F at 10 meters (33 ft) above ground level
(b) Maximum guy anchor reaction vector opposing the guy wires. Angle below horizontal.
(c) Maximum force on the winch anchor during erection
Screw-In Anchors

Screw-in anchors are the most commonly used anchors for normal clay soils without rocks. They are installed by hand, using a cross bar to screw them into the earth like a corkscrew. Screw-in anchors can also be used to provide the anchoring rod and eye for site-built anchors, such as concrete. Refer to the information on concrete anchors below.

150 mm (6.0 inches) screw-in anchors are the standard anchors supplied with NRG TallTowers.

### Table 4: Specifications for Screw-In Anchors

<table>
<thead>
<tr>
<th>150 mm (6 inches) Anchor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helix diameter: 152 mm (6.0 inches)</td>
</tr>
<tr>
<td>Length Overall: 1.65 m (66 inches)</td>
</tr>
<tr>
<td>Rod diameter: 19 mm (0.75 inches)</td>
</tr>
<tr>
<td>Material: Galvanized steel</td>
</tr>
</tbody>
</table>

**Holding Power:** (These anchors are not suitable for soils denser than class 5.)

<table>
<thead>
<tr>
<th>Soil Class</th>
<th>Holding Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 5 soils *</td>
<td>3,000 kg (6,500 pounds)</td>
</tr>
<tr>
<td>Class 6 soils *</td>
<td>2,300 kg (5,000 pounds)</td>
</tr>
<tr>
<td>Class 7 soils *</td>
<td>1,100 kg (2,500 pounds)</td>
</tr>
</tbody>
</table>

* Consult the Soil Classes chart, Table 5.

** In class 7 soils, it is advisable to place anchors deep enough to penetrate to underlying class 5 or 6 soil.

### Table 5: Soil Classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Common Soil Types</th>
<th>Geological Soil Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Dense clays, sands and gravel; hard silts and clays</td>
<td>Glacial till; weathered shales, schist, gneiss and siltstone</td>
</tr>
<tr>
<td>4</td>
<td>Medium dense sandy gravel; very stiff to hard silts and clays</td>
<td>Glacial till; hardpan; marls</td>
</tr>
<tr>
<td>5</td>
<td>Medium dense coarse sand and sandy gravels; stiff to very stiff silts and clays</td>
<td>Saprolites, residual soils</td>
</tr>
<tr>
<td>6</td>
<td>Loose to medium dense fine to coarse sand; firm to stiff clays and silts</td>
<td>Dense hydraulic fill; compacted fill; residual soils</td>
</tr>
<tr>
<td>7**</td>
<td>Loose fine sand; Alluvium; loess; soil-firm clays; varied clays; fill</td>
<td>Flood plain soils; lake clays; adobe; gumbo; fill</td>
</tr>
</tbody>
</table>

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**Arrowhead Anchors**

Arrowhead anchors can penetrate stiff and rocky soils because the unique triangular design tends to thread its way between obstacles such as rocks, which can prevent successful installation of screw-in anchors. Arrowhead anchors are driven into the ground with a hardened steel drive rod. Once in the ground, upward force on the attached cable rotates the anchor perpendicular to the cable for maximum holding power.

**Table 6: Specifications for Arrowhead Anchors**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length Overall</td>
<td>1.22 m (48.0 inches)</td>
</tr>
<tr>
<td>Arrowhead Length</td>
<td>203 mm (8.0 inches)</td>
</tr>
<tr>
<td>Materials</td>
<td>6.35 mm (0.25 inches) galvanized (7x19) steel cable; breaking strength - 1905 kg (4200 pounds); with malleable iron head.</td>
</tr>
</tbody>
</table>

**Holding Power:**

<table>
<thead>
<tr>
<th>Soil Class</th>
<th>Holding Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 3</td>
<td>1905 kg (4200 pounds)</td>
</tr>
<tr>
<td>Class 4</td>
<td>1361 kg (3000 pounds)</td>
</tr>
<tr>
<td>Class 5</td>
<td>907 kg (2000 pounds)</td>
</tr>
<tr>
<td>Class 6</td>
<td>544 kg (1200 pounds)</td>
</tr>
<tr>
<td>Class 7</td>
<td>272 kg (600 pounds)</td>
</tr>
</tbody>
</table>

* See Table 5 for soil class descriptions

**Rock Anchors**

Rock anchors are placed into solid rock, when anchoring to either bare rock, or thin soils with solid rock near the surface. They are constructed of a threaded rod with integral eye, and two opposing wedge halves. The anchor is placed in a hole pre-drilled in the rock. Twisting the eye of the anchor forces the wedges against the sides of the hole, locking the anchor in place. Load actually increases the wedging force, developing holding power equal to the full tensile strength of the rod.

**Table 7: Specifications for Rock Anchors**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holding Power</td>
<td>9072 kgf (20,000 pounds)</td>
</tr>
<tr>
<td>Rod Length Overall</td>
<td>0.38 m (15 inches), 0.76 m (30 inches) or 1.35 m (53 inches), other lengths available</td>
</tr>
<tr>
<td>Anchor Diameter</td>
<td>44 mm (1.75 inches) as supplied, 60 mm (2.375 inches) max. expanded</td>
</tr>
<tr>
<td>Rod Diameter</td>
<td>19 mm (.75 inches)</td>
</tr>
<tr>
<td>Materials</td>
<td>Malleable iron, dipped in rust-resisting black paint</td>
</tr>
<tr>
<td>Required Hole Size</td>
<td>50 mm (2 inches) diameter (nominal)</td>
</tr>
<tr>
<td>Use Rock Drill Size</td>
<td>50 mm (2 inches) diameter</td>
</tr>
</tbody>
</table>
Concrete Anchors

The most common alternative anchoring system is to place site-built concrete anchors. A hole is excavated at the anchor position. Reinforcing steel is placed in the hole. A screw-in anchor is often tied into the reinforcing steel to provide a rod and eye above ground to attach the guys. Concrete is poured in place to form the anchoring mass, and the hole is then back-filled.

Guidelines for concrete anchors:

- The anchors must be placed carefully to provide anchor points at the proper locations for the tower.
- The holding power of concrete anchors is essentially due to their weight. The weight of concrete placed must exceed the required anchor holding force. Refer to Table 3 for the anchor loads for your tower, and the angle of the guy wires from the ground.
- Concrete anchors still depend on the soil to prevent the concrete mass from shifting toward the tower under load.

As with all anchoring systems, it is your responsibility to ensure that the anchors will perform as required. If in doubt, seek professional advice for anchor design.

Installing Screw-In Anchors

Note: Unlike a tent stake, screw-in anchors are installed in line with the pull of the guy wires from the tower. It is important to install the anchor at an angle, so the eye of the anchor is toward the tower and the helix screws in away from the tower. If the anchor is incorrectly installed straight into the ground, the load will bend the rod and pull it through the ground, allowing the guys to go slack. Refer to Table 3 to find the angle of the tower guys from the ground.

Screw the anchor into the ground by placing a stout bar through the eye of the anchor, and rotating clockwise. It is sometimes helpful to start the anchor into the ground straight down for the first turn, then push it down to the correct angle and complete the installation.
screwing the anchor into the ground until about 150 mm (6 inches) of the anchor rod remain above the ground.

If the anchor cannot be installed due to rocks in the soil, or other obstacles, try placing the anchor as much as 1 m (3 feet) from its ideal position to avoid the obstacle, or replace the screw-in anchor with the correct anchor for the soil. Arrowhead anchors are often suitable for rocky soils.

If necessary, a hole can be dug for the screw-in anchor to the proper installed depth, the anchor placed in the hole, and the hole back-filled. The earth must be tamped onto the anchor hard while back filling. The holding power of an anchor placed this way will not be as great as an anchor screwed into undisturbed soil. If in doubt, consult professional advice on whether this option will work for your site.

**Installing Arrowhead Anchors**

Arrowhead anchors are designed for all soils but are especially effective in rocky soils.

The arrowhead anchor is driven into the soil with a special drive rod. The rod is removed leaving the anchor in the ground. Then the anchor must be pre-tensioned which will cause the anchor to rotate in the ground developing its full holding potential.

Like screw-in anchors, the arrowhead anchor must be placed so the force from the guy wires pulls directly on the anchor. Drive the arrowhead anchor away from the tower at an angle into the ground. Refer to Table 3 to find the angle of the tower guys from the ground.

Note: It is important to drive the anchor at an angle. If the anchor is incorrectly installed straight into the ground, the load will result in the anchor cable cutting through the ground until the angle is correct, resulting in significant slack in the tower guys, and possible tower failure.

![Figure 27: Installing Arrowhead Anchors](image)

To install the anchor, place the drive rod over the anchor's shank. Drive the anchor into the soil using a sledgehammer, fence post driver, or power jackhammer, until the cable eye attached to the anchor is 50 mm (2 inches) to 100 mm (4 inches) above the surface of the ground.

After the anchor is driven, remove the drive rod, leaving the anchor in the ground. The anchor must now be pre-tensioned by applying strain to the cable. This can be done using a lever, come-along, jack, or winch. Pre-tensioning causes the anchor to rotate in the ground developing its full holding power. The pull distance will be approximately the length of the anchor head, 203 mm (8 inches). The tension should become significantly higher as the pre-tensioning is complete.
Note: The anchor must be properly pre-tensioned before attaching the tower guys. If it is not, the tower guy tension will turn the anchor later, resulting in significant slack in the tower guys, and possible tower failure.

**Installing Rock Anchors**

Rock anchors are used when anchoring to either bare rock or thin soils with solid rock near the surface.

Like any anchor, rock anchors must be placed so the force from the guy wires pulls directly on the anchor. Drill the hole for the anchor away from the tower at an angle into the ground.

*Note: It is important to install the anchor at an angle. If the anchor is incorrectly installed straight into the ground, the load will bend the rod until the angle is correct, resulting in significant slack in the tower guys and possible tower failure. Refer to the anchoring information for your tower to find the angle of the tower guys from the ground.*

To install the anchor, a hole must be pre-drilled in the rock by hand or power tool. The hole must be 50 mm (2 inches) in diameter, and the walls of the hole should be smooth in the area that the anchor will wedge.

Place the anchor in the hole. Using a bar through the eye of the anchor, turn clockwise to tighten. The anchor will expand and wedge into the hole.

After placing the anchor, fill the hole around the rod with expanding cement grout. One brand is “Rocktite” made by Hartline Products Co, Cleveland, OH, USA (telephone: +216 291 2303). Always grout rock anchors to prevent water from collecting and freezing in the drilled hole. Grouting also increases the anchor’s holding strength.
**Appendix B: Choosing the Correct Gin Pole & Winch**

<table>
<thead>
<tr>
<th>TOWER</th>
<th>REQUIRED GIN POLE</th>
<th>RECOMMENDED WINCH</th>
<th>RECOMMENDED TOOL KIT</th>
<th>INSTALLATION KIT (includes winch, gin pole, tool kit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 m TallTower</td>
<td>No gin pole required.</td>
<td>No winch required.</td>
<td>Item #2162</td>
<td>No winch or gin pole required.</td>
</tr>
<tr>
<td>20 m TallTower</td>
<td>Item #2021</td>
<td>Item #1998</td>
<td>Item #2162</td>
<td>Item #2025</td>
</tr>
<tr>
<td>30 m TallTower</td>
<td>Item #2022</td>
<td>Item #1998</td>
<td>Item #1840</td>
<td>Item #2026</td>
</tr>
<tr>
<td>30 m HD TallTower</td>
<td>Item #2023</td>
<td>Item #1999</td>
<td>Item #1840</td>
<td>Item #2027</td>
</tr>
<tr>
<td>30 m SHD TallTower</td>
<td>Item #2878</td>
<td>Item #1999</td>
<td>Item #1840</td>
<td>Not available.</td>
</tr>
<tr>
<td>40 m TallTower</td>
<td>Item #2023</td>
<td>Item #1999</td>
<td>Item #1840</td>
<td>Item #2027</td>
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<tr>
<td>40 m HD TallTower</td>
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<td>Item #1999</td>
<td>Item #1840</td>
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<tr>
<td>50 m TallTower</td>
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<td>Item #1840</td>
<td>Item #2775</td>
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<tr>
<td>50 m HD TallTower</td>
<td>Item #3239</td>
<td>Item #1999</td>
<td>Item #1840</td>
<td>Item #3239</td>
</tr>
<tr>
<td>60 m TallTower</td>
<td>Item #3179</td>
<td>Item #1999</td>
<td>Item #1840</td>
<td>Item #3294</td>
</tr>
</tbody>
</table>
Appendix C: Structural Analysis of NRG TallTowers

OBJECTIVE:
The objective of the analysis is to estimate the anchor reactions, member stresses and structural code compliance for the NRG TallTowers, when subjected to high wind speeds.

IMPORTANT NOTE:
It is important to remember that the purpose of this analysis is to provide insight, not exact numbers. All modeling and analysis include assumptions and approximations to the actual hardware. The computed results have been checked and are believed to be reasonably correct for the conditions stated.
A qualified professional should evaluate whether this analysis is applicable to your particular site and conditions.

STRUCTURAL CODE COMPLIANCE
The performance of NRG TallTowers is assessed using the provisions of EIA-222-F (1996) and AISC ASD (1989). These standards are accepted in the BOCA 1996 and ICBO 2000 building codes for use on guyed structures. For a complete copy of the TIA/EIA 222-F Standard, contact:

Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112-5704
In the U.S.A. or Canada, call: 1-800-854-7179
International callers: 303-397-7956.

Each municipality or region will have specific code compliance requirements. Local ordinances must be reviewed to determine if the NRG analysis is acceptable.

Wind speeds are based on location, exposure, and probability of occurrence. EIA-222-F lists minimum Basic Wind Speeds for different areas of the country. Basic Wind Speed is the fastest-mile wind speed at 33 ft (10 m) above ground corresponding to an annual probability of 0.02 (50-year recurrence interval). A 50-year recurrence interval is typically used for weather loading. Note that the basic wind speed differs from the 3-second wind speed reported by the National Weather Service (NWS).

Wind speed and corresponding force are functions of the elevation above the ground, the diameter of the tower member or guy wire, and the three dimensional angle of the member or guy wire to the wind direction.

The EIA-222-F Standards defines equations for use on the guy wires, and specifies a slightly different form for use on the main tower tube. A detailed description of each of the variables listed below is contained in the text of EIA-222-F.

The EIA-222-F equations for wind speed, lift and drag force on vertical tubes and guy wires due to wind are listed below.
Drag and lift force on inclined guy wires

\[ F_D = q_Z G_H C_D d L_C \] (lb) [N]
\[ F_L = q_Z G_H C_L d L_C \] (lb) [N]

\( q_Z \) = See below

\( G_H = 1.69 \)

\( d \) = Diameter of guy strand (ft) [m]

\( L_C \) = Chord length of guy (ft) [m]

\( \theta \) = Clockwise angle of guy to wind direction (\( \theta \leq 180^\circ \))

\[ C_D = 1.2 \sin^3 \theta \]
\[ C_L = 1.2 \sin^2 \theta \cos \theta \]

Vertical force on tube element

\[ F = q_Z G_H C_F A \] (lb) [N]

\( G_H = 1.69 \) for tubular pole structures

\( C_F = 1.0 \) for round tubular structures

\( A \) = Projected area of tube normal to the wind

For round tubes this is element length * tube diameter

Velocity pressure of wind at a given height is determined by

\[ q_Z = 0.00256 K_Z V^2 \] for V in miles per hour

\[ q_Z = 0.613 K_Z V^2 \] for V in m/s

Exposure coefficient

\[ K_Z = \left[ \frac{z}{33} \right]^{2/7} \] for z in ft

\[ K_Z = \left[ \frac{z}{10} \right]^{2/7} \] for z in meters

\( V \) = Basic fastest mile wind speed (mph) [m/s]

\( z \) = Height above ground (ft) [m]

The horizontal and vertical forces on a given element at a specified elevation are calculated using the above equations and are used in the finite element analysis described next.

METHODOLOGY

The tower is modeled using the ANSYS Finite Element Analysis (FEA) method. FEA is a widely accepted method for analyzing stress, reactions and deformation in complex structures. ANSYS is one of the most widely accepted FEA programs in the world. The tower and guy wires are broken down into small sections called elements with the corresponding wind and or ice forces applied to each element. Elements are mathematical models of a physical structure that deform in the same fashion as the actual tower. The elements are combined mathematically using the finite element method to account for the effect each element has on the entire structure. Tower models are solved using the non-linear large deflection model.
Tower elements are modeled as ANSYS PIPE 16 elements and the guy wires as flexible LINK 10 elements. Typical guy wire elements are 0.3m (12 inches) long and tower sections vary from 0.05 - 0.3m (2 inches - 12 inches) long. A typical 50-meter tower analysis will have over 4000 elements and up to 8000 loads. A given tower may be tested using 4 - 6 different loading conditions and design alternatives. This includes wind, ice, erection, and several different wind velocities in combination with ice.

Wind forces are calculated for each element using a proprietary program at the center of the element height using the equations given in the specific building or structural code. Variables in the wind force equation include basic 10 m wind speed, gust response factor, diameter (including ice diameter), element length, guy angle, coefficient of drag, height above ground, basic wind speed, and alpha. The load is then applied to each element.

The applied force due to wind, ice and weight of the structure is then combined in a load factor equation to determine what load to apply to the structure. For example, EIA-222-F has determined that the full 50-year wind speed is unlikely to occur at the same time as the maximum amount of ice, so it allows one to decrease the wind load by 25% when the wind with ice combination is analyzed.

After a tower has been analyzed the results are processed to assess the stress and structural stability of the tower. The ASD and EIA codes have allowable stress or strength limits depending on the specific code and type of member. Elastic deformation of the long slender tube elements is often the limiting factor in determining maximum allowable loads. Tube buckling is assessed using Euler’s equation for elastic column buckling and the corresponding combined axial stress and bending stress equation in the ASD code. Appropriate factors of safety are built into each equation.

A tower is a flexible structure composed of tube elements and guy elements. The equations governing these elements are quite different and have different factors of safety that may change with geometry. For this reason there is no single factor of safety specified for a tower.

Using the stresses determined from the FEA analyses and taking into account such factors as axial stress, bending stress, unsupported length of the tower, maximum allowable stress, and the end conditions of the tube sections, our engineers have calculated if the structure is considered stable according to the specific code.

The applied loads are compared to a MathCAD spreadsheet of the various equations to validate the accuracy. The MathCAD model includes several different methods of applying loads. These are used to verify that the applied loads are realistic. NRG also applies over 20 years of field experience in deciding if a given analysis is realistic.

An analysis is only as good as the assumed conditions of loading, assembly and structural behavior. The field installation team must ensure that the structure and any foundations are assembled properly. Tubes must be dent free and straight. Dented or bent tubes will significantly reduce the load carrying capacity of the entire structure. Guy wires must have the correct number of wire clips and not be over tensioned, and the foundations must be adequately designed for the site conditions.

Notice of NRG EIA-222-F Compliance

Please note: TIA/EIA Engineering Standards and Publications are designed to serve the public interest by eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for the particular need. Since EIA-222-F Standards apply to steel antenna towers and antenna supporting structures for all classes of
communications services, NRG Systems has identified the specific standards that apply to NRG TallTowers and outlined them below.

Paragraph numbers are per EIA-222-F nomenclature.

1 Material
1.1.1.2 Tube materials are as follows
4.5” – AISI 1010
6” – AISI 1015 (ASTM A-787 type 2)
8” – AISI 1020

2 Loading
2.1.2.2
Ice density for design is 56 lb/ft³ (8.8 kN/m³).

2.1.3.1
Basic wind speed is fastest mile wind speed at 10 m (33 ft) above ground corresponding to an annual probability of 0.02 (50-year recurrence interval). The appropriate basic wind speed for a given site must be determined on a site-by-site basis by the installer.

2.3.1.2
Ice thickness varies and depends on specific geographic location and other site parameters. NRG does not specify or recommend a design ice thickness.

2.3.2, 2.3.3
Horizontal wind force is calculated using the following equations
\[ F = q_z G_H C_F A \] (lb) [N]
\[ q_z = 0.00256 K_x V^2 \text{ for } V \text{ in mi/h} \]
\[ q_z = 0.613 K_x V^2 \text{ for } V \text{ in m/s} \]
\[ K_x = \left(\frac{z}{33}\right)^{27} \text{ for } z \text{ in ft} \]
\[ K_x = \left(\frac{z}{10}\right)^{27} \text{ for } z \text{ in meters} \]
\[ G_H = 1.69 \text{ for tubular pole structures} \]
\[ C_F = 1.0 \text{ for round tubular structures} \]
\[ V = \text{Basic fastest mile wind speed (mi/h)[m/s]} \]
\[ z = \text{Height above ground (ft) [m/s]} \]

2.3.14
Guy loads are calculated using the following equations
\[ F_D = q_Z C_D dL_C \]
\[ F_L = q_Z C_L dL_C \]
\[ q_Z = \alpha \]  (Per above equation (sec 2.3.3))
\[ G_H = 1.07 \]  (Gust response factor 2.3.4.2)
\[ d = \text{Diameter of guy strand (ft) [m]} \]
\[ L_C = \text{Chord length of guy (ft)[m]} \]
\[ \theta = \text{Clockwise angle of guy to wind direction (} \theta \leq 180^\circ \text{)} \]
\[ C_D = 1.2 \sin^3 \theta \]
\[ C_L = 1.2 \sin^2 \theta \cos \theta \]

2.3.16

Two load combinations are tested

\[ F = D + W \]
\[ F = D + 0.75W + I \]

The force due to the wind (W) is calculated per EIA-222-F Section 2.3.2, 2.3.14 above. The wind force for ice loading is calculated using the ice radius added to the guy or tower element radius. Dead load (D) is the gravity force due to the mass of the structure. Ice force (I) is the gravity force due to the weight of a uniform coating of ice on the structure. The wind force (W) is the vertical (F_L) and horizontal (F_D) force applied to the structure using the equations presented in section 2.3.14.

3  Stresses

3.1.1

NRG uses American Iron and Steel Construction (AISC) Allowable Stress Design (ASD), 1989 to determine the allowable load due to wind or ice.

3.1.11-15

Element stability is considered using ASD equations for combined axial and bending loading. NRG tower elements are considered to be slender elements per ASD (1989) and slenderness ratios range from less than 100 to greater than 170.

3.1.16

NRG does not specify or recommend specific reinforced concrete foundation and guy anchor design details for a specific site.

4  Manufacturing

4.1.1

Manufacturing and workmanship are in accordance with commonly accepted standards of the structural steel fabricating industry.
4.1.2
Welding procedures are in accordance with the requirements of appropriate AISC or AISI specification.

5 Factory finish
5.1.1.1
Structural materials shall be galvanized in accordance with ASTM A123 (hot dip).

5.1.1.2
Hardware shall be galvanized in accordance with ASTM A153 (hot-dip) or ASTM B693 Class 50 (mechanical).

5.1.1.3
Guy Strand – Zinc coated guy strand shall be galvanized in accordance with ASTM A475 or ASTM A586.

7 Foundations and Anchors
NRG does not recommend specific anchor or foundation details due to the variability of specific site conditions. It is the responsibility of the installer to determine the appropriate anchor or foundation design.

8 Safety Factors of Guys
8.1.1
Guy connections are swaged at the top and use u-bolt clips at the bottom end of the guy cable. Allowable guy strength is calculated using a connection efficiency of 90 percent.

8.1.2
The safety factor of guys is calculated by dividing the published breaking strength of the guy or guy connection strength; whichever is lower, by the maximum calculated tension design load.

8.2.1
The minimum allowable guy safety factor is 2.0.

9 Prestressing and proof loading of guys
9.2.1
NRG does not prestress or proof-load guy wires.
10 Initial guy tension

10.2 Reactions and member forces

NRG towers are designed with low initial guy tensions as the towers are intended to be flexible. Galloping issues and slack taut problems have not been an issue in 20 years of field experience. Excessive initial guy tensions may reduce the loading capacity of the tower significantly. High initial guy tensions will not stop the leeward wires from going slack as the tower is designed to accommodate minor deflections.

11 Operational requirements

Section 11 does not apply, as NRG towers are not intended for directional antenna mounting applications.

12 Protective grounding

Electrical grounding per the appropriate electrical or building code is the responsibility of the installer. NRG does not specify or recommend protective grounding design details. NRG does supply a ground system to protect the instrumentation installed on the tower.

13 Climbing and working

NRG towers are not designed for climbing and must not be climbed when erect. NRG towers must be lowered for safe maintenance or service.

14 Maintenance and inspection

14.1.1

NRG strongly recommends that maintenance and inspection be performed on a regular basis. Towers must be inspected after severe wind, ice storms, or other extreme loading events.
## Table 8: NRG TALL TOWERS DESIGN LOADS

<table>
<thead>
<tr>
<th>Tower size</th>
<th>Tube diameter</th>
<th>EIA-222-F wind velocity</th>
<th>Vertical base reaction (a)</th>
<th>Guy anchor reaction (b)</th>
<th>Winch anchor reaction (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 m</td>
<td>114 mm (4.5 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>12500 N (2800 pounds)</td>
<td>6200 N (1400 pounds) @ 45</td>
<td>5300 N (1200 pounds) @ 45</td>
</tr>
<tr>
<td>30 m HD</td>
<td>152 mm (6 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>13300 N (3000 pounds)</td>
<td>7100 N (1600 pounds) @ 45</td>
<td>7100 N (1600 pounds) @ 45</td>
</tr>
<tr>
<td>30 m SHD</td>
<td>203 mm (8 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>14700 N (3300 pounds)</td>
<td>8900 N (2000 pounds) @ 45</td>
<td>9800 N (2200 pounds) @ 45</td>
</tr>
<tr>
<td>40 m</td>
<td>152 mm (6 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>19100 N (4300 pounds)</td>
<td>8500 N (1900 pounds) @ 51</td>
<td>12500 N (2800 pounds) @ 45</td>
</tr>
<tr>
<td>40 m HD</td>
<td>203 mm (8 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>20500 N (4600 pounds)</td>
<td>9800 N (2200 pounds) @ 51</td>
<td>16500 N (3700 pounds) @ 45</td>
</tr>
<tr>
<td>50 m</td>
<td>152 mm (6 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>26700 N (6000 pounds)</td>
<td>10200 N (2300 pounds) @ 49</td>
<td>14200 N (3200 pounds) @ 45</td>
</tr>
<tr>
<td>50 m HD</td>
<td>203 mm (8 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>28000 N (6300 pounds)</td>
<td>10700 N (2400 pounds) @ 49</td>
<td>18700 N (4200 pounds) @ 45</td>
</tr>
<tr>
<td>60 m</td>
<td>114, 152, 203 mm (4.5, 6, 8 inches)</td>
<td>31.3 m/s (70 mph)</td>
<td>32500 N (7300 pounds)</td>
<td>8900 N (2000 pounds) @ 45</td>
<td>20500 N (4600 pounds) @ 45</td>
</tr>
</tbody>
</table>

**Notes:**
Fastest mile wind velocity per EIA-222-F at 10 meters (33 feet) above ground level.

a) Vertical base reaction. The maximum horizontal reaction is equal to horizontal component of winch anchor reaction.

b) Maximum guy anchor reaction vector opposing the guy wires. Angle below horizontal.

c) Maximum force on the winch anchor during tower erection.
Figure 29: Tower Load and Performance Chart: 30 m TallTower
Figure 30: Tower Load and Performance Chart: 30 m HD TallTower
Figure 31: Tower Load and Performance Chart: 30 m SHD TallTower
Figure 32: Tower Load and Performance Chart: 40 m TallTower
Figure 33: Tower Load and Performance Chart: 40 m HD TallTower
Figure 34: Tower Load and Performance Chart: 50 m TallTower
Figure 35: Tower Load and Performance Chart: 50 m HD TallTower
Figure 36: Tower Load and Performance Chart: 60 m TallTower
Appendix D: Site Visit Procedures

When making a site visit, check the following:

- Make sure the tower is straight. Standing at the base of the tower, look up to identify any bowed sections or curves in the tower that may have developed since the tower installation. Carefully adjust guy wires as necessary to straighten the tower.

- Check guy wires for excessive slack and adjust as necessary. It is normal for guy wires to stretch over time, and it is especially important to adjust them before they are subjected to icing or high winds.

- Check each anchor for movement or loosening. A loose anchor can also cause excessive slack in guy wires.

- Check that mounting booms, cellular antennas, temperature sensors, etc. are securely attached.

- Confirm that all grounding connections on the tower and on the logger are secure and haven’t corroded.

- Check instantaneous sensor readings on each channel of your data logger. Any sensor providing erroneous readings should be disconnected from the logger and tested independently and/or replaced. It is a good idea to always have spare sensors, memory cards, batteries, and a spare data logger!

- Change the data logger’s batteries. Remember that batteries are cheap – it’s better to change them prematurely rather than risk losing data!
Appendix E: Glossary

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
<th>Photo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchor eye</td>
<td>Loop at top of anchor through which guy wires are attached</td>
<td></td>
</tr>
<tr>
<td>Arrowhead anchor</td>
<td>A type of anchor that is driven into the ground and then secured by rotating its position in the earth by pulling on the attached cable.</td>
<td></td>
</tr>
<tr>
<td>Base bolt/nut</td>
<td>The base bolt and nut secure the base tube to the base plate.</td>
<td></td>
</tr>
<tr>
<td>Base tube</td>
<td>The base tube has a hole drilled at one end. Both the tower and its gin pole have their own base tubes.</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Drive rod for arrowhead anchor</td>
<td>Used to drive arrowhead anchors into the ground.</td>
<td></td>
</tr>
<tr>
<td>Gin pole</td>
<td>An assembly of tubes attached to the base of the tower used as a lever to raise a tower from horizontal to vertical position.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><img src="" alt="Image" /></td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------------------------------------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td><strong>Gin pole guy ropes</strong></td>
<td>Gin pole guy ropes are used to prevent lateral movement of the gin pole.</td>
<td><img src="" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td>The gin pole safety wire prevents the gin pole tubes from separating during the tower lifting process.</td>
<td><img src="" alt="Image" /></td>
</tr>
<tr>
<td><strong>Guy ring</strong></td>
<td>Guy wires are swaged to the guy ring.</td>
<td><img src="" alt="Image" /></td>
</tr>
<tr>
<td><strong>Lifting wires</strong></td>
<td>The lifter wires are connected to the top of the gin pole when the tower is being raised or lowered. After the tower is raised, all of the lifter wires are disconnected from the snap links at the end of the gin pole and secured to the anchor(s).</td>
<td></td>
</tr>
<tr>
<td><strong>Rock anchor</strong></td>
<td>A type of anchor that is inserted into a pre-drilled hole and secured by rotating the anchor eye, which causes the anchor to expand.</td>
<td></td>
</tr>
<tr>
<td><strong>Rocker brackets</strong></td>
<td>Part of the gin pole assembly.</td>
<td></td>
</tr>
<tr>
<td><strong>Screw-in anchor</strong></td>
<td>A type of anchor that screws into the earth at an angle.</td>
<td></td>
</tr>
<tr>
<td><strong>Shackle</strong></td>
<td>Part of the gin pole assembly that secures the pulley to the top of the gin pole.</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Snap link (left)</strong>&lt;br&gt;<strong>Quick link (right)</strong></td>
<td>Parts of the gin pole that connect to eyes of lifter guy wires. Snap links are used on gin poles for 10 m, 20 m, and 30 m towers. Quick links are used on gin poles for 40 m, 40 m HD, 50 m, 50 m HD, and 60 m towers.</td>
<td></td>
</tr>
<tr>
<td><strong>Winch control handle</strong></td>
<td>Used to control how the cable is spooled onto the winch’s cable drum.</td>
<td></td>
</tr>
<tr>
<td><strong>Wire rope clip</strong></td>
<td>Used to secure guy wires.</td>
<td></td>
</tr>
</tbody>
</table>
Appendix F: Technical Drawings

![Figure 42: 30 m TallTower](image)

**Notes**

A. Wind forces and allowable member loads are calculated using ANSI/IEEE-822-2F, (1996), "Structural Standards for Steel Antenna Towers and Antenna Supporting Structures".

B. Wind speeds are based on wind velocity per EIA-222-F. EIA-222-F wind loading coefficients: GH, 0.85, CH = 1.5, a = 0.77.

C. Vertical loads (Wt) have been converted to maximum tower tube stress using the equation:

\[ V(\text{winds}) = 1.25 \times \text{winds} \]

D. Guy line loads determined using a safety factor of 2.0.

E. The ANSYS large deflection FEA model was used to calculate the maximum tower tube stress.

F. The ANSYS large deflection FEA model was used to calculate the maximum tower tube stress.

G. The tower design meets the structural requirements of EIA-222-F, sections 7.2, 2.5, 2.6 for the given loading condition.

H. Foundation design must be considered separately and is not a part of this analysis. Specific foundation details must be approved by the specific location. Foundation details are subject to change without notice or by a qualified professional.

I. A locally qualified professional must determine the applicability of this analysis for the specific site conditions. Due to the lack of involvement in the engineering or construction of this product at the specific location, liability is solely limited to issues arising from negligence or willful misconduct by NRG or the professional engineer completing this analysis. No warranty, expressed or implied, is made concerning the suitability of this product for a given application or location.

**Tables and Figures**

<table>
<thead>
<tr>
<th>Materials</th>
<th>Outer Diameter (in)</th>
<th>Wall Thickness (in)</th>
<th>Description</th>
<th>Test Strength (ksi)</th>
<th>Breaking Strength</th>
<th>Corrosion Protection</th>
<th>Supplier(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>1.5</td>
<td>M1090</td>
<td>320.0</td>
<td>345.0</td>
<td>HDG</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>35-35.6</td>
<td>2.0</td>
<td>M1090</td>
<td>320.0</td>
<td>345.0</td>
<td>HDG</td>
<td>B</td>
</tr>
<tr>
<td>3</td>
<td>40-40.6</td>
<td>2.5</td>
<td>M1090</td>
<td>320.0</td>
<td>345.0</td>
<td>HDG</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>45-45.6</td>
<td>3.0</td>
<td>M1090</td>
<td>320.0</td>
<td>345.0</td>
<td>HDG</td>
<td>D</td>
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<tr>
<td>5</td>
<td>50-50.6</td>
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<td>345.0</td>
<td>HDG</td>
<td>E</td>
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<tr>
<td>6</td>
<td>55-55.6</td>
<td>4.0</td>
<td>M1090</td>
<td>320.0</td>
<td>345.0</td>
<td>HDG</td>
<td>F</td>
</tr>
</tbody>
</table>

**Figure 42: 30 m TallTower**

**REV | DESCRIPTION | DATE | APPROVED**

A. Units, notes update 17Jul03 APB
B. Changed reaction format 17Aug03 APB
C. Revised SI forces 13Dec06 APB
Figure 43: 30 m HD TallTower
Figure 44: 30 m SHD TallTower
Figure 45: 40 m TallTower
Figure 46: 40 m HD TallTower

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Wall Thickness</th>
<th>Description</th>
<th>Yield Strength</th>
<th>Breaking Strength</th>
<th>Corrosion Protection</th>
<th>ASTM OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>40.6 in</td>
<td>0.1 in</td>
<td>40 m HD TallTower</td>
<td>36.5 ksi</td>
<td>40.0 ksi</td>
<td>N/A</td>
<td>N/A</td>
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### Notes

A) Wind forces and allowable member loads are calculated using ANSI/TIA/EIA-222-F (1996), "Structural Standards for Steel Antenna Towers and Antenna Supporting Structures".

B) Wind speeds are based on mile wind velocity per EIA-222-F, EIA-222-F wind loading coefficients: G=1.69, C=1.0, q=0.27.

C) For wind speed in the horizontal plane the wind speed is 1.15 times that of the free stream air speed for a given elevation and site conditions. The tower is designed for a maximum of 100 mph wind speed.

D) Guy joint efficiency = 0.9 and the guy safety factor = 2.0.

E) An ANSYS finite element analysis was performed using the ANSYS Element Set for the given loading condition. This analysis does not apply to EIA-222-F sections 7.3, 7.12, 12.12.


G) Tower design meets the structural requirements of EIA-222-F, sections 13.2, 13.6, 13.6, 13.8 for the given loading condition. This analysis does not apply to EIA-222-F sections 7.3, 7.12, 12.12.

H) Foundation design must be performed separately and is not a part of this analysis. Specific foundation details must be approved by the site engineer and site to a qualified professional.

I) A lead or qualified professional must determine the applicability of this analysis for the expected site conditions. Due to the lack of involvement in the sitting or construction phase of this product at a specific location, liability is strictly limited to issues arising from negligence or wilful misconduct by NRG or the professional engineer completing this analysis. No warranty, expressed or implied, is made concerning the suitability of this product for a given application or location.

---

NRG SYSTEMS INC
110 RIGGS ROAD, HINESBURG, VT, 05461

40 Meter Heavy Duty TallTower
203 mm (8.0 inch) diameter tube

Approvals

A Booth 25apr03 B C

Figure 46: 40 m HD TallTower
### Figure 47: 50 m TallTower

#### Table: Revisions

<table>
<thead>
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<th>REV</th>
<th>DESCRIPTION</th>
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<tr>
<td>A</td>
<td>Units, notes update</td>
<td>02Aug03</td>
<td>APB</td>
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<tr>
<td>B</td>
<td>Changed reaction format</td>
<td>17Aug03</td>
<td>APB</td>
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<tr>
<td>C</td>
<td>Revised SI forces</td>
<td>13Dec06</td>
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#### Table: Materials

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<th>Wall Thickness</th>
<th>Description</th>
<th>Yield Strength</th>
<th>Breaking Strength</th>
<th>Corrosion Protection</th>
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<tr>
<td>1 3-3/8</td>
<td>0.129 in</td>
<td>5T00</td>
<td>50.6 ksi</td>
<td>91.6 ksi</td>
<td>ASTM 653</td>
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<tr>
<td>2 4-5/16</td>
<td>0.199 in</td>
<td>5T00</td>
<td>50.6 ksi</td>
<td>91.6 ksi</td>
<td>ASTM 653</td>
</tr>
<tr>
<td>3 6-5/8</td>
<td>0.199 in</td>
<td>5T00</td>
<td>50.6 ksi</td>
<td>91.6 ksi</td>
<td>ASTM 653</td>
</tr>
<tr>
<td>4 6-5/8</td>
<td>0.199 in</td>
<td>5T00</td>
<td>50.6 ksi</td>
<td>91.6 ksi</td>
<td>ASTM 653</td>
</tr>
<tr>
<td>5 8-5/8</td>
<td>0.199 in</td>
<td>5T00</td>
<td>50.6 ksi</td>
<td>91.6 ksi</td>
<td>ASTM 653</td>
</tr>
<tr>
<td>6 10-5/8</td>
<td>0.199 in</td>
<td>5T00</td>
<td>50.6 ksi</td>
<td>91.6 ksi</td>
<td>ASTM 653</td>
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#### Table: Reactions and Member Forces

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<tr>
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<th>SI</th>
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<tbody>
<tr>
<td>100 mph</td>
<td>160.9 m/s</td>
</tr>
<tr>
<td>88 mph</td>
<td>141.6 m/s</td>
</tr>
<tr>
<td>0.0 in</td>
<td>0 mm</td>
</tr>
<tr>
<td>53 lb</td>
<td>23.6 N</td>
</tr>
<tr>
<td>30°</td>
<td></td>
</tr>
<tr>
<td>10.2 kN</td>
<td></td>
</tr>
<tr>
<td>32.6 kN</td>
<td></td>
</tr>
<tr>
<td>45°</td>
<td></td>
</tr>
<tr>
<td>3.6 kN</td>
<td></td>
</tr>
<tr>
<td>14.1 kN</td>
<td></td>
</tr>
<tr>
<td>127 mm</td>
<td></td>
</tr>
<tr>
<td>0.9 kN</td>
<td></td>
</tr>
</tbody>
</table>

**Notes**


B) Wind speeds are fastest mile wind velocity per EIA-222-F, EIA-222-F wind loading coefficients: G43.60, C1.0, α=0.27.

C) Fastest mile (fm) wind speed can be approximately converted to three second (3sec) wind speed using the equation:

\[
\text{V}_{3\text{sec}} = \frac{V_{\text{fm}}}{2.2} \quad \text{(for Vfm} \leq 100 \text{ mph)}
\]

D) Guy joint efficiency = 0.8 and the guy safety factor is greater than or equal to 2.0.

E) An ANSYS large deflection FEA model using beam (Timoshenko) and tension (Link10) elements with distributed wind load was used to calculate member forces and reactions.


G) This tower design meets the structural requirements of EIA-222-F, sections 1.3.1.3.6.9 for the given loading condition. This analysis does not apply to EIA-222-F sections 7.11.12.13.

H) Foundation design must be considered separately and is not a part of this analysis. Specific foundation details must be approved for the specific application and site by a qualified professional.

I) A locally qualified professional must determine the applicability of this analysis for the expected site conditions. Due to the lack of involvement in the siting or construction phase of this product at a specific location, this guidance is strictly limited to issues arising from negligence or willful misconduct by NHR or the professional engineer completing this analysis. No warranty, expressed or implied, is made concerning the suitability of this product for a given application or location.

**Units:**

- mm = Millimeters
- m = Meters
- m/s = Meters per second
- KN = Kilonewtons
- kN = 1,000,000 Pascals
- kL = 1,000 US pounds
- klb = 1,000 US pounds per inch^2
- mph = Miles per hour
- ID = Diameter

**Material:**

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**Approvals:**

- NTS
- TT1991

**50 Meter TallTower 152 mm (6.0 inch) dia tube**

---

[Figure and text continued]
Figure 48: 50 m HD TallTower
Figure 49: 60 m TallTower

Notes:
A) Wind forces and allowable member loads are calculated using ANSI TIA/EIA-222-F, (1992), "Structural Standards for Steel Antenna Towers and Antenna Supporting Structures."
B) Wind speeds are fastest mile wind velocity or EIA-222-F, EIA-222-F wind loading coefficients, G=1.68, C=1.0, 0=20°.
C) Fastest mile wind speed can be approximately converted to three second (basic) wind speed using the equation:

\[
V_{3sec} = 0.65 V_{fastest mile}
\]

D) Guy joint efficiency is 0.9 and the guy safety factor is greater than or equal to 2.0.
E) An ANSI/EIA large deflection FEA model using beam (PLANE183) and tension (LINK10) elements with distributed wind load was used to calculate member forces and reactions.
F) Tower allowable stress design per American Institute of Steel Construction (AISC) " Allowable Stress Design", 9th Ed. 1989, Chapter 1, equations 1-41, H-1, H-2
G) This tower design meets the structural requirements of EIA-222-F, sections 11.2.3.8, for the given loading condition. This analysis does not apply to EIA-222-G, sections 7.11.2, 7.2.
H) Foundation design must be considered separately and is not part of this analysis. Specific foundation details must be approved by the specific professional.
I) A highly qualified professional must determine the applicability of this analysis for the specific site conditions. Due to the lack of involvement in the siting or construction phase of this product at a specific location, liability is strictly limited to issues arising from negligence or willful misconduct by NRG or the professional engineer completing this analysis. No warranty, expressed or implied, is made concerning the suitability of this product for a given application or location.
Index

10 m ...........................................................................9, 15, 25, 26, 27, 28, 36, 37, 39, 50, 51, 53, 54, 75
20 m ...........................................................................5, 9, 16, 26, 50, 75
30 m ...........................................................................5, 9, 17, 26, 37, 43, 50, 59, 60, 75, 77
30 m HD .................................................................9, 18, 26, 61, 78
30 m SHD .................................................................9, 19, 26, 62, 79
40 m 5, 7, 9, 20, 26, 35, 37, 39, 41, 43, 45, 50, 59, 63, 75, 80
40 m HD ........................................................................7, 9, 21, 26, 37, 39, 41, 64, 75, 81
50 m 5, 7, 9, 22, 23, 26, 35, 37, 39, 41, 43, 50, 59, 65, 75, 82
50 m HD7, 9, 23, 26, 37, 39, 41, 43, 50, 59, 66, 75, 83
60 m ...........................................................................5, 7, 8, 9, 24, 26, 28, 29, 30, 31, 32, 33, 35, 36, 37, 39, 41, 43, 50, 59, 63, 65, 75, 78, 80
alternative anchoring ..................................................47
anchor .................................................................8, 48
anchor loads ..............................................................43
anchor placement .......................................................8, 48
anchor radii ................................................................8
anchor requirements ..................................................42
anchoring ...............................................................5, 7, 8, 9, 27, 33, 34, 35, 36, 37, 39, 41, 42, 43, 46, 47, 48, 49, 51, 56, 59, 69, 71, 72, 73, 74
anchoring in solid rock ................................................46
anchors .................................................................5, 7, 8, 9, 25, 27, 33, 34, 35, 37, 40, 42, 45, 46, 47, 48, 72
arrowhead anchors .....................................................46, 48
arrowhead anchors, installing ....................................48
arrowhead anchors, pre-tensioning ............................48
base bolt, nut .........................................................71
base plate ...............................................................7, 8, 9, 25, 28, 33, 71
base plate assembly ..................................................11, 12, 13, 25
base tube ....................................................................25
batteries ....................................................................69
booster gin pole .......................................................28
booster gin pole assembly .......................................29, 30, 32
bow in the tower ......................................................37
building codes .........................................................51
cement anchors .......................................................45, 47
design loads ............................................................9, 59
drawings, engineering .............................................77
drive rod .................................................................46
EIA-222-F ..................................................................43, 51, 53, 54, 55, 59
gin pole .................................................................28, 29, 50
gin pole assembly ....................................................28
gin pole guy ropes ....................................................33
gin pole safety wire ..................................................10, 28, 33, 73
gin pole safety wire, assembly ..................................28
ginpoles.................................................................50
Glossary ..................................................................71
ground rod .............................................................8
guy anchor reaction ..................................................43, 59
guy ring .................................................................25, 26, 73
guy ropes ...............................................................33, 73
guy wire tensioning ..................................................34
guys .........................................................................8, 25, 27, 33, 35, 36, 37, 39, 40, 41, 47, 48, 49, 57
holding power ..........................................................42
ice loading ..............................................................42
icing .......................................................................40, 42, 69
installation crew .......................................................35
installation kit ..........................................................50
installing arrowhead anchors ...................................48
installing rock anchors ..........................................49
lifting force ............................................................36
lifting guy ...............................................................25
lifting wires ............................................................73
loads .......................................................................47, 53, 55
lowering the TallTower .............................................41
maximum anchor loads ...........................................42
mechanical tensioning devices .................................35
pre-tensioning arrowhead anchors .........................48
quick links ............................................................33, 75
rock anchors ..........................................................46, 74
rocker brackets .......................................................33, 74
S9000 winch kit ......................................................34
safety wire, gin pole ...............................................28, 33, 73
screw-in anchors .....................................................74
screw-in anchors, installing .....................................47
sensor cables ........................................................36
settling .................................................................8, 40
shackle ..................................................................33, 74
site visit procedures ..............................................69
site-built anchors ....................................................45
slack in guy wires .....................................................27, 34, 35, 36, 37, 40, 41, 47, 48, 49, 57
snap links .............................................................33, 75
soil ........................................................................5, 7, 8, 42, 45, 46, 47, 48
soil classes ............................................................45
spools, guy wire .....................................................27
straightening the TallTower ......................................40
stretch, guy wires ....................................................40
structural analysis ...................................................51
TallTower installation on a slope ...............................8
technical drawings ..................................................77
tension, guy wire .....................................................8, 34, 35, 36, 37, 39, 40, 41, 48, 49, 57
tools ........................................................................7, 50
top level guy ring ....................................................25
tower and anchor layout dimensions .......................9
tower assembly sequence .......................................26
tower joints ............................................................5
tower lift crew .........................................................35
tower load and performance charts ..........................60, 61, 62, 63, 64, 65, 66, 67
tower site layout .....................................................9
transferring the lifting guys .....................................39
vertical base reaction ..............................................59
WARNINGS ..............................................................5
winch ....................................................................10, 33, 41, 43, 50, 59, 75
winch anchor ..............................................................7, 36
winch anchor placement .........................................10

TallTowerManual-7.11.doc

83

15 February 2007
winch anchor reaction ..........................................43, 59
winch control handle .............................................75
wind force ............................................................53, 54, 55
wire rope clips .......................................................27, 75
X1 winch kit .............................................................33
yellow ropes ............................................................33