Mastering Masts – Part 2
Of Wind, and Ice, and Other Things

By Tom Cox, KT9OM

Let's Review

When we talked last, I was recovering from the loss of two antennas at the top of my 120-foot tower, as a result of an ice-storm-induced mast failure. Attentive readers will recall, probably flawlessly, that this mast failure was my fault, although I did have a lot of help from Ole' Mom Nature, in the form of a half-inch of radial ice, followed by snow and wind.

I Blame Myself, Since No One Else Is Handy

My fatal mistake, I have since learned, was in picking the wrong material to use for a mast. I chose galvanized iron pipe with an approximate outside diameter (OD) of two inches, which looked very substantial. It turns out that "pipe," while fine for "piping" liquids and gases, is much less than fine as a structural support. In fact, pipe is not made for withstanding external stresses, but internal ones.

The stuff you need for holding up antennas -- which you had to talk your indulgent spouse into letting you buy with brilliant arguments and exorbitant promises -- is ***tubing***; not pipe.

And not just any tubing, but tubing made to resist bending under high lateral stress from wind loading and high vertical stress from the weight of antennas and, in applicable environments, from the additional weight and cross-section of a coating of ice. The amount of vertical and horizontal stress your mast is likely to experience over its long, useful life is somewhat predictable. Use that predictability to improve the odds of keeping those antennas in the air.

Reading the Wind

There are several, different "standard" methods of calculating the effect of wind on a structure, and none of them is flawless. Engineers have been trying to predict the effect of wind on structures for centuries. Imagine an architect who needs a safe design for a bridge across a windy chasm, or a skyscraper rising hundreds of feet into the air… all such designs rely on the ability to build something strong enough to withstand the force of the wind, without being so heavily built that they fall of their own weight, or so expensive that no one can afford to build them.

Only recently has the computer power become available to model the effect of wind on a structure with anything like the accuracy and reproducibility we take for granted in antenna modeling. If you don't want to rely on models, a wind tunnel big enough to hold a skyscraper or a bridge would, itself, be a big wind catcher, and you'd have to wind tunnel test that…. Scale models only work so well, since the behavior of wind at full scale, out in the real world, is not linear, predictable and neat.

For example, there's "gusting." A gust is a sudden increase in local wind, and wind models take it into account with a "gust factor," which sounds to me like a way for the engineers to add a margin to the calculations to allow wind to gust (as if they could stop it) beyond the "standard" wind speed for a given area (as if there really were such a thing), and still beef up the construction enough so the structure they design won't blow over until after they are dead, and their heirs have squandered their estates.

I didn't find anyone on the Web willing to explain why gusts take place, or when, so I think it's safe to say that wind, like RF propagation, is somewhat predictable in a general sense, over a long time interval -- but much less predictable at a given location in a definite time frame. In fact, the only meaningful wind measurements are frequently calculated averages, recorded over a long, LONG time.

Since the only way to know the worst-case wind speed for a given location is to measure it from the beginning of time until the Sun goes out, or goes supernova, we just about have to stop measuring and calculating at some point, gather our best data, make some highly-qualified calculations, and put up an antenna. And hope for the best!

Should you feel compelled to consult standards for wind loading, there is no shortage of them. Standards in wide use have been produced by the Electronic Industry Association (EIA222c, EIA222f) and The International Code Council (The Uniform Building Code("UBC '97")) -- and probably every major government entity and bureaucracy around the world. A quick comparison of the EIA and UBC standards can be found in the reference pages of K7NV, including a page copied on the Array Solutions Website, at http://www.arraysolutions.com/Products/windloads.htm.

How Windy Is It?

OK, we have established that there are standard means of describing the representative wind conditions, and the demands made by those conditions, on your antenna support structure. An important first step is to determine a standard wind speed for the area where your structure is, or (preferably, you are still in the planning stage) will be. Then you have a benchmark for determining how stout your support needs to be. One of the most convenient sources if this information is a look-up table on Champion Radio's Website, which can be found at http://www.championradio.com/windspeed.php

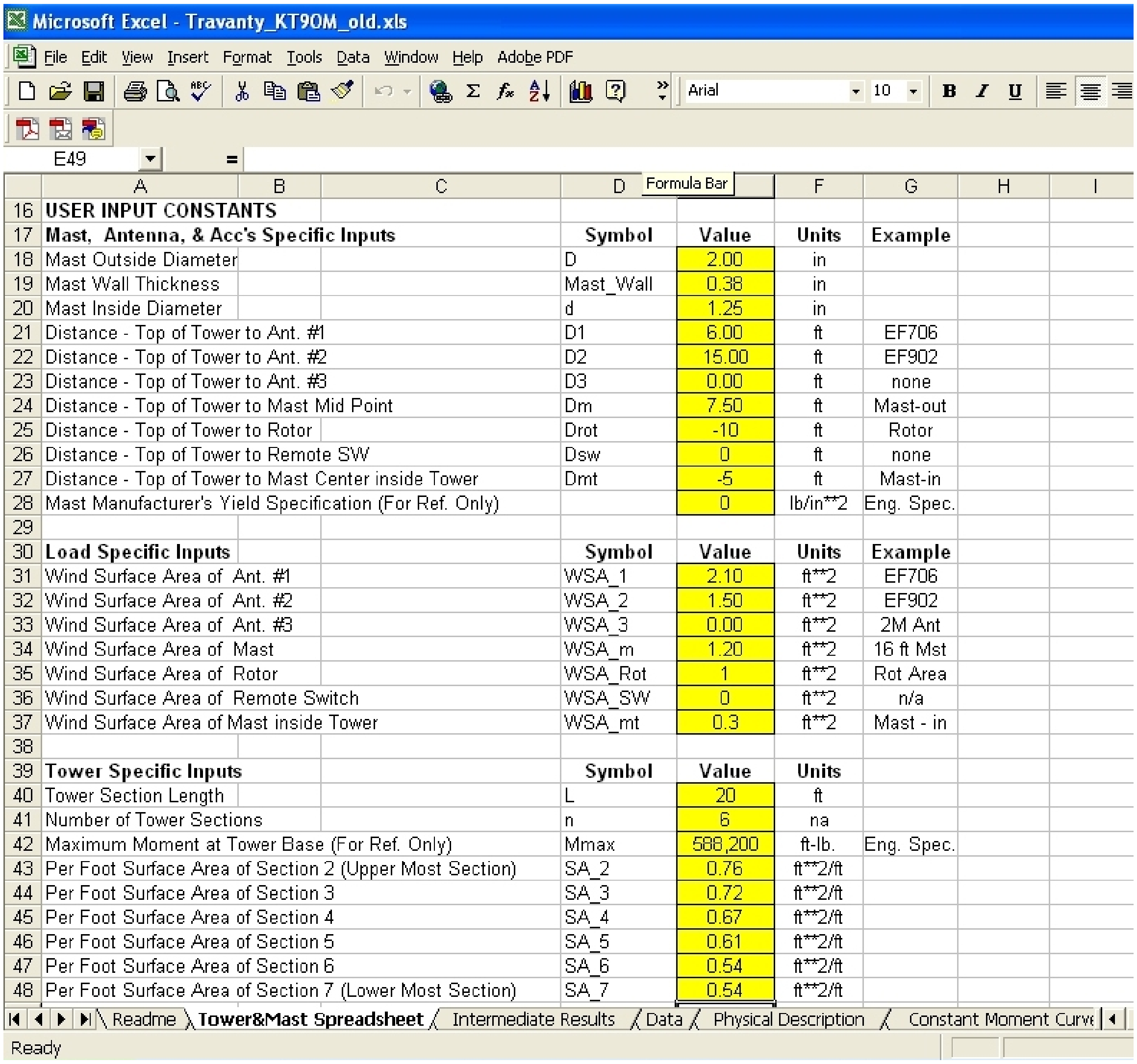
This site only covers US counties, so *antenneX*'s many foreign users are left to their own devices. Corresponding sites for international locations are almost certainly available, however, and can likely be found by firing up your favorite search engine.

I found that Delaware County, Indiana has a "Listing of Minimum Wind Speed" of 70 MPH. Fortunately, that doesn't mean our local wind speed never drops *below* 70 MPH, because that would probably result in a local population of very short, stocky people with short haircuts, living in concrete bunkers and driving tanks. No, it means any antenna support structure (or, for that matter, any structure subject to the wind) should be built to withstand at least a 70 MPH wind, according to "The County Listings of Minimum Wind Speeds" from EIA/TIA-222-E "Structural Standards for Steel Antenna Towers and Antenna Supporting Structure," from which the builders of the Champion Radio page derived these values.

This Time, Do the Math!

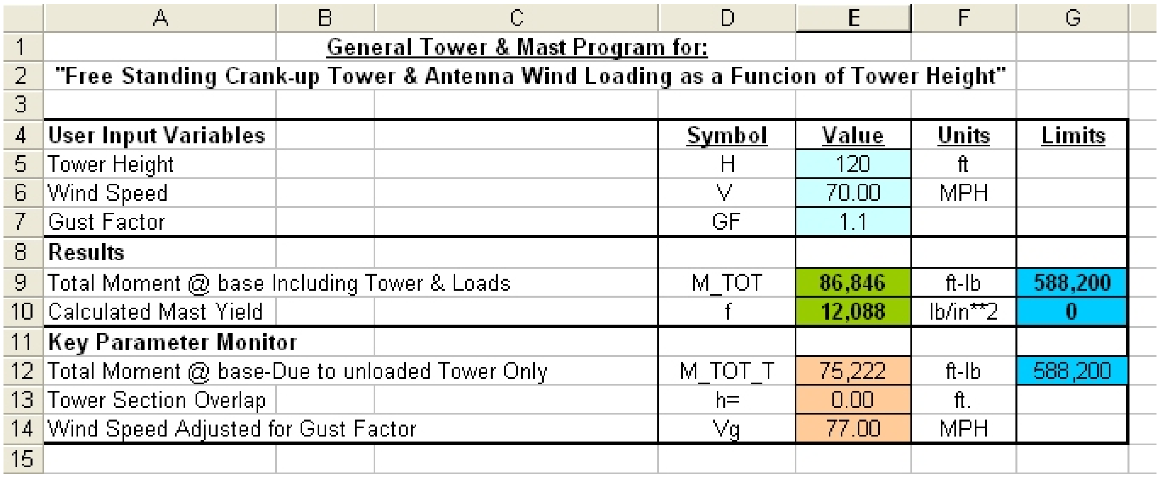
So, I have the wind speed for which I need to design. Now, what? I found a couple of very useful tools for getting me past the point of looking at a piece of galvanized pipe and thinking, "Well, that looks strong enough. Maybe."

There is a very helpful article reprinted from the ARRL publication *QEX* in the members' area of the ARRL Website, which is also reproduced elsewhere on the Web, that offers a great deal of design help. "Tower and Antenna Wind Loading as a Function of Height," by Frank Travanty, W9JCC, is a thorough and readable discussion of the effect of antenna and mast wind loading, as well as the load imposed by the tower itself, on an antenna system. A Microsoft Excel spreadsheet accompanies the article, which calculates wind loads based on user input. The spreadsheet is a powerful tool for planning and troubleshooting an antenna system, and I've included some screen captures from it here, applied to my situation.



	A	D	Formula Bar	F	G
16	**USER INPUT CONSTANTS**				
17	**Mast, Antenna, & Acc's Specific Inputs**	**Symbol**	**Value**	**Units**	**Example**
18	Mast Outside Diameter	D	2.00	in	
19	Mast Wall Thickness	Mast_Wall	0.38	in	
20	Mast Inside Diameter	d	1.25	in	
21	Distance - Top of Tower to Ant. #1	D1	6.00	ft	EF706
22	Distance - Top of Tower to Ant. #2	D2	15.00	ft	EF902
23	Distance - Top of Tower to Ant. #3	D3	0.00	ft	none
24	Distance - Top of Tower to Mast Mid Point	Dm	7.50	ft	Mast-out
25	Distance - Top of Tower to Rotor	Drot	-10	ft	Rotor
26	Distance - Top of Tower to Remote SW	Dsw	0	ft	none
27	Distance - Top of Tower to Mast Center inside Tower	Dmt	-5	ft	Mast-in
28	Mast Manufacturer's Yield Specification (For Ref. Only)		0	lb/in**2	Eng. Spec.
29					
30	**Load Specific Inputs**	**Symbol**	**Value**	**Units**	**Example**
31	Wind Surface Area of Ant. #1	WSA_1	2.10	ft**2	EF706
32	Wind Surface Area of Ant. #2	WSA_2	1.50	ft**2	EF902
33	Wind Surface Area of Ant. #3	WSA_3	0.00	ft**2	2M Ant
34	Wind Surface Area of Mast	WSA_m	1.20	ft**2	16 ft Mst
35	Wind Surface Area of Rotor	WSA_Rot	1	ft**2	Rot Area
36	Wind Surface Area of Remote Switch	WSA_SW	0	ft**2	n/a
37	Wind Surface Area of Mast inside Tower	WSA_mt	0.3	ft**2	Mast - in
38					
39	**Tower Specific Inputs**	**Symbol**	**Value**	**Units**	
40	Tower Section Length	L	20	ft	
41	Number of Tower Sections	n	6	na	
42	Maximum Moment at Tower Base (For Ref. Only)	Mmax	588,200	ft-lb.	Eng. Spec.
43	Per Foot Surface Area of Section 2 (Upper Most Section)	SA_2	0.76	ft**2/ft	
44	Per Foot Surface Area of Section 3	SA_3	0.72	ft**2/ft	
45	Per Foot Surface Area of Section 4	SA_4	0.67	ft**2/ft	
46	Per Foot Surface Area of Section 5	SA_5	0.61	ft**2/ft	
47	Per Foot Surface Area of Section 6	SA_6	0.54	ft**2/ft	
48	Per Foot Surface Area of Section 7 (Lower Most Section)	SA_7	0.54	ft**2/ft	

Fig. 1. The data in the yellow cells is my input, which reflects the status of my antenna system with the mast and antennas on it before the ice storm. Where W9JCC had data that didn't apply to my situation, I put zeroes in those cells, so they don't affect the calculations.



	A	B	C	D	E	F	G
1		**General Tower & Mast Program for:**					
2	**"Free Standing Crank-up Tower & Antenna Wind Loading as a Funcion of Tower Height"**						
3							
4	**User Input Variables**			**Symbol**	**Value**	**Units**	**Limits**
5	Tower Height			H	120	ft	
6	Wind Speed			V	70.00	MPH	
7	Gust Factor			GF	1.1		
8	**Results**						
9	Total Moment @ base Including Tower & Loads			M_TOT	**86,846**	ft-lb	**588,200**
10	Calculated Mast Yield			f	**12,088**	lb/in**2	**0**
11	**Key Parameter Monitor**						
12	Total Moment @ base-Due to unloaded Tower Only			M_TOT_T	75,222	ft-lb	588,200
13	Tower Section Overlap			h=	0.00	ft.	
14	Wind Speed Adjusted for Gust Factor			Vg	77.00	MPH	
15							

Fig. 2. The next screen capture shows the most significant results of the calculations done by the operations Frank built into his spreadsheet. As you can see, I was in no danger of tipping over my tower with the load on the mast.

Another useful tool is MARC, a DOS-based program that is available for a US $10 fee from Champion Radio Products (www.championradio.com). While it is written in "old fashioned" DOS, it runs fine in a DOS Window on my XP machines. It's simple to use, and although not very snazzy -- it's DOS text, after all; no fancy animation or cute noises -- the calculations seem consistent with others I've seen for my installation, and it's fast. It's refreshingly "minimalist," in fact – I think it occupies less memory and disk space than any program on any computer I have owned in this century.

```
   Please enter the wind speed  70   MPH (70 MPH or higher)

   Please enter the total height of the mast above the tower  15      FT

                     Ant 1      Ant 2

                      2.10       1.50  Area in SQ FT

                      6.00      15.00  Height in FT

                     20.00      16.00  Weight in LB

                     10.30       6.80  Turn Rad in FT

   The total bending moment is   11450  IN-LB

   The recommended mast is  Yield Strength 39000 PSI, 0.120 IN thickness.

   The recommended rotor has   315 Ft-Lb torque.  These rotors will work:
       Hy-Gain HDR 300A, T2X TailTwister, Ham IV/V and CD45 II
       Yaesu G-2800SDX, G-1000SDX, G-800S/SDX and G450XL

 F1 for more information.  F2 for new numbers.  Use the Esc key to end program.
```

Fig. 3. After entering data from my failed system into highlighted fields in vintage DOS style, I got the results shown in the screen capture. As you can see, the bending moment I should have allowed for, according to MARC, was 11,450 inch-pounds. A 2-inch mast with a 1/8-inch wall thickness, and yield strength of 39,000 PSI would have met the requirements.

As I have made painfully apparent, the galvanized iron pipe I chose to use, even though it had a thicker wall, was not of the right alloy to produce that yield strength. For a discussion of alloys and their effect on yield strength, and, for that matter, what is meant by "yield strength," review the first installment of my writing on this topic, in the August, 2005, issue of *antenneX*.

That information alone, had I had sense enough to get it and use it, would have probably saved me from picking up pieces of antenna out of my back yard, last winter.

Unfortunately, one feature my climate has to offer, in addition to "minimum wind speeds" of 70 MPH, is an occasional ice storm. Although it was inadequate by design, my mast and antennas had survived about a year and a half of winter and summer storms, gusty fall and spring breezes, and all that this climate has to offer. Except for a lot of ice.

Ice Is Not Nice

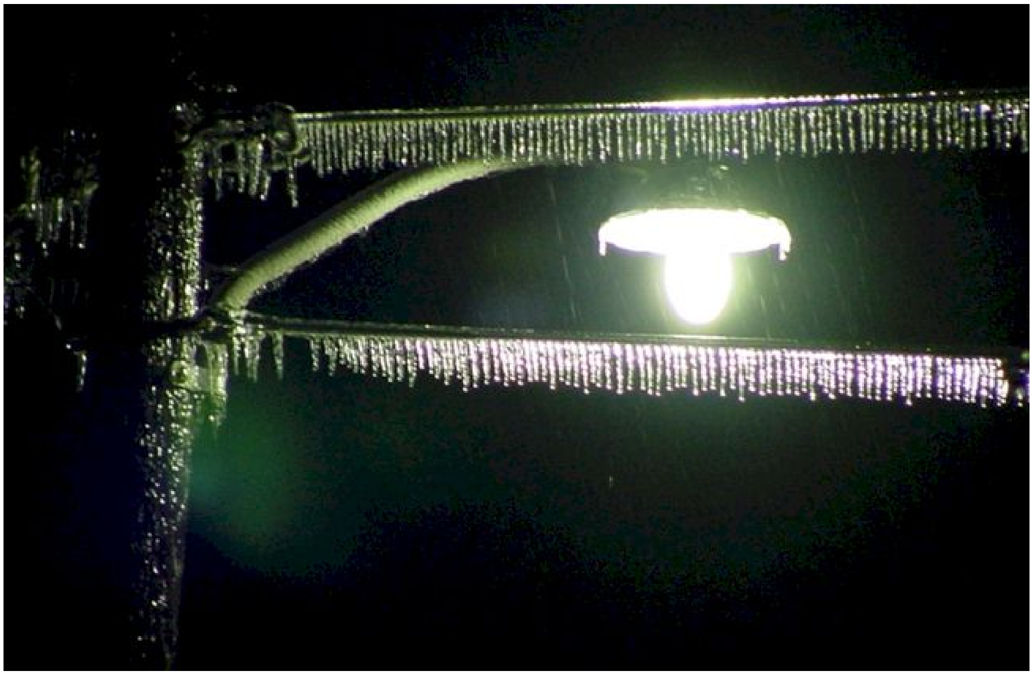


Fig. 4. A good example of ice loading.

Once the ice was added to the original antenna and mast dimensions, things got ugly. The half-inch of radial ice added about an inch of diameter (not counting the fringe of icicles on horizontal runs). You can see in my nighttime shot of the streetlight and adjacent power lines in **Fig. 4** that a fringe of icicles adds significant weight and wind load, although it would be difficult to calculate either, given the complex shapes involved. Every piece of metal on the mast, and the mast, itself, had one degree or another of coating, significantly increasing the cross-sectional area intercepting the wind, and a lot of weight. Is it safe to say that the wind load doubled, or tripled? I don't know, because I don't know which wind loading formula Force 12 uses to calculate the wind load of the two antennas on the mast. I would bet, however, that the extra inch of frozen water "flab" moved these two, relatively petite VHF antennas into the league with much larger HF arrays, in terms of both weight and wind load. I can't prove it, but that's my story.

I do have a fair idea of how much weight all that ice added, and why that matters as much as wind loading. I recall many occasions before this storm, watching with some unease as the "pipe" mast bent quite a bit under high wind conditions, but I consoled myself with the thought that the bending was temporary. In other words, the mast always returned to the straight and narrow when the wind quit. I tried not to think about the cumulative fatigue of that repeated bending, because I knew there was a limit to how much of it the pipe would tolerate before it cracked and failed. I just didn't know how close to that limit I might be.

Without ice, the two antennas, together, weighed about 35 pounds, which was normally applied as compression against the mast along the vertical axis. This compression, applied by gravity, was probably not even slightly significant, even for puny old "pipe." On a windy day, with maximum flexion, when gravity was pulling straight down on the antennas, and the mast was bent by the wind, the additional bending moment of the 35 pounds of antenna didn't amount to much.

Then Mother Nature added ice, *Lots* of ice. I know that many places around the world get a lot more than a half-inch of ice, but not here. Local weather observers described the January ice storm as a 100-year event, like a 100-year flood. I hope they're right. Anyway, it's time to think about how much ice that amounts to, when you apply it to an antenna, or anything else, for that matter.

(Author's note: With apologies to those who think in metric units, I have kept to English, because math is hard enough for me without using unfamiliar units. After re-reading this section, I can't think of a better example of why metric units make a lot more sense. Gallons, cubic inches, pounds… if I hadn't been born to it, I'd have nothing to do with it. – KT9OM)

Water weighs about 8.34 pounds per gallon, and a US gallon (liquid) has a volume of about 231 cubic inches. That means a cubic inch of water weighs about 0.036 pounds. (Yes, the density of water changes a little around the freezing point, but the change is only visible so many decimal places to the right, that it doesn't matter for this application. Unless you forget you left a bottle of beer in the freezer to get it cold quickly, or have to replace your plumbing because it froze, you probably don't care about that change in density, either.)

0.036 pounds doesn't seem like a lot, but it's surprising how much ice accumulates on an antenna, when you start adding it up. A table with just that information follows, and I expect you to be suitably surprised. I used the following formulas to arrive at these figures:

Volume of a "right" cylinder = Area of one end X cylinder's length.
Volume of ice = volume of resulting cylinder minus volume of original element

I used

$$\pi \bullet \left(r1 + r2\right) \bullet (r1 - r2) \bullet L$$

to get the annular section, or cross-sectional area of ice "sleeve," where *r*1 is the larger radius (element plus ice coating) and *r*2 is the smaller one (the element alone); and then multiplied it by *L*, the length of the element. Of course, the ice coating wasn't uniform in radius, but the variations tended to average out, from what I could see of the ice cover on various objects on the ground and on the tower. **Fig. 5** shows a clear case of ice coating. See last month's article for a photo of my ice-covered tower.

Fig. 5. A sample of ice coating

. **Weight of 1/2-in. Uniform Ice Load on Tubing from 0.5 to 3.0 in.**						
Elem Diam "	**Elem Rad**	**El+IceRad**	**New Diam**	**CSA_Ice**	**Vol/LinFt**	**Lbs/LinFt**
0.50	0.250	0.750	1.50	1.57	18.85	0.68
0.63	0.315	0.815	1.63	1.77	21.30	0.77
0.75	0.375	0.875	1.75	1.96	23.56	0.85
0.88	0.440	0.940	1.88	2.17	26.01	0.94
1.00	0.500	1.000	2.00	2.36	28.27	1.02
1.25	0.625	1.125	2.25	2.75	32.98	1.19
1.50	0.750	1.250	2.50	3.14	37.69	1.36
1.75	0.875	1.375	2.75	3.53	42.40	1.53
2.00	1.000	1.500	3.00	3.93	47.12	1.70
2.25	1.125	1.625	3.25	4.32	51.83	1.87
2.50	1.250	1.750	3.50	4.71	56.54	2.04
2.75	1.375	1.875	3.75	5.10	61.25	2.20
3.00	1.500	2.000	4.00	5.50	65.96	2.37

As you can see from this table, which I cannot blame on anyone else, because I generated it with Microsoft Excel, 0.036 pounds here, and 0.036 pounds there, and all of a sudden you have some real weight. The first column lists some common antenna element and boom diameters, and each succeeding column is another painful step in figuring out how much weight a half-inch of ice adds per foot to a given size tubing.

You will discover that a half-inch aluminum element, as seen in the first row, winds up with 18.85 cubic inches of ice *on each foot* of element, and 0.68 pounds of additional weight. Slip down to the 3-inch row, and notice that a foot of 3-inch tubing (not an uncommon boom size on HF Yagis) picks up 2.37 pounds PER FOOT, with just a half-inch coating of ice.

The 2-inch OD boom on my EF706 6 meter yagi is 18 feet long. The boom, alone, picks up 30.6 pounds of ice with a 0.5-inch coating. The “dry” weight of the whole antenna is specified at 20 pounds, so we have increased its weight by a factor of 2.5, just in ice on the boom, without even considering the roughly 35 feet of elements. Even if the elements were all ½-inch tubing, add another 28 pounds, bringing the total weight up to about 80 pounds. Since the elements actually taper from ¾ inch down to ½ inch, and we haven’t even considered the coating on hardware, element mounting brackets and the coax, the 20-pound antenna probably wound up weighing about 100 pounds – *not counting* icicles.

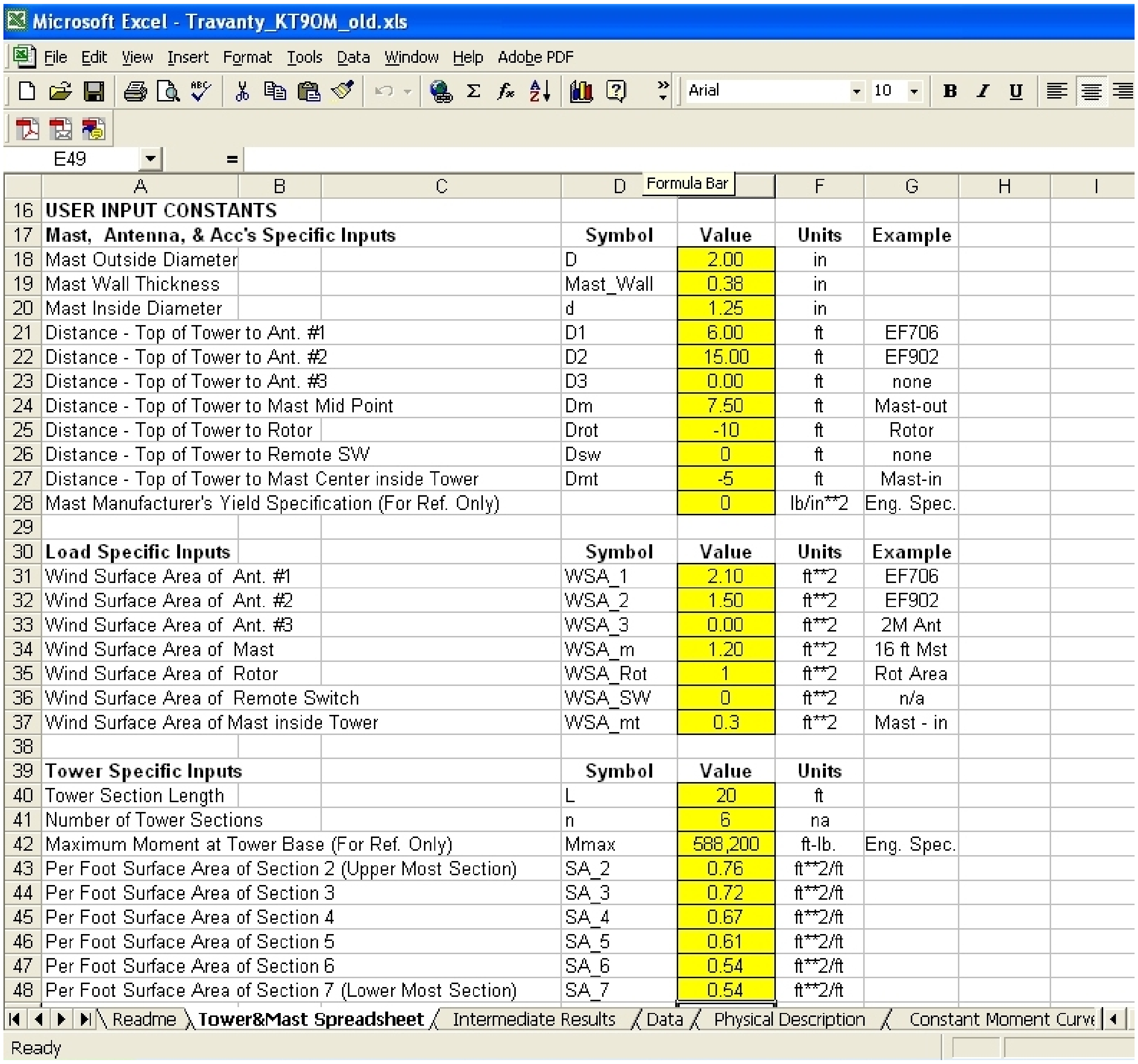
Remember the streetlight picture? Both antennas were used for SSB, so their elements were in a horizontal plane, loaded with icicles. The two-meter antenna was smaller, of course, having only nine elements, but its weight probably increased by about the same rate, bringing it up to a portly 80 pounds. Then add the ice on the mast, itself, and on the feed lines taped to the mast… and bend that all over with a 40-MPH wind. Now, instead of 35 pounds of antenna pulling down on the bending mast, it’s more like 180 pounds. Add the icicles, and we are probably well above two hundred pounds. Apply that punishment to plain old “pipe,” and it’s not hard to see why it failed. Not from the comfort and safety of retrospect, anyway.

Bending the Odds in My Favor

Ah, hindsight. It is, as they say, 20-20. I can’t change history, but I can do my best to avoid repeating it. Using both of the tools I introduced earlier, I have examined the combination of mast and antennas that will replace the casualties of last winter’s misadventures. Actually, I plan to put the 2-meter yagi back up there, after I straighten the reflector’s mounting bracket and – probably – replace the reflector element. It will go at the top, but a new antenna will replace the 6-meter yagi. I hope to put up a SteppIR three-element beam with the optional, passive 6-meter element.

If this antenna works as advertised, it will give me the performance of a three-element yagi at all frequencies between 20M and 10M, and it approaches the claimed performance of the antenna it replaces on 6M… all with a wind load of 6.1 square feet. When I load the numbers for these antennas and the replacement mast into the Travanty spreadsheet, it looks like **Fig. 6.**

The results appear in **Fig. 7**. As you can see from the results section of the spreadsheet, I am now well within the safety margin of the tower’s and mast’s ability to keep things in the air, as opposed to raining all over my back yard, and hanging forlornly alongside the tower.



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17	**Mast, Antenna, & Acc's Specific Inputs**	**Symbol**	**Value**	**Units**	**Example**
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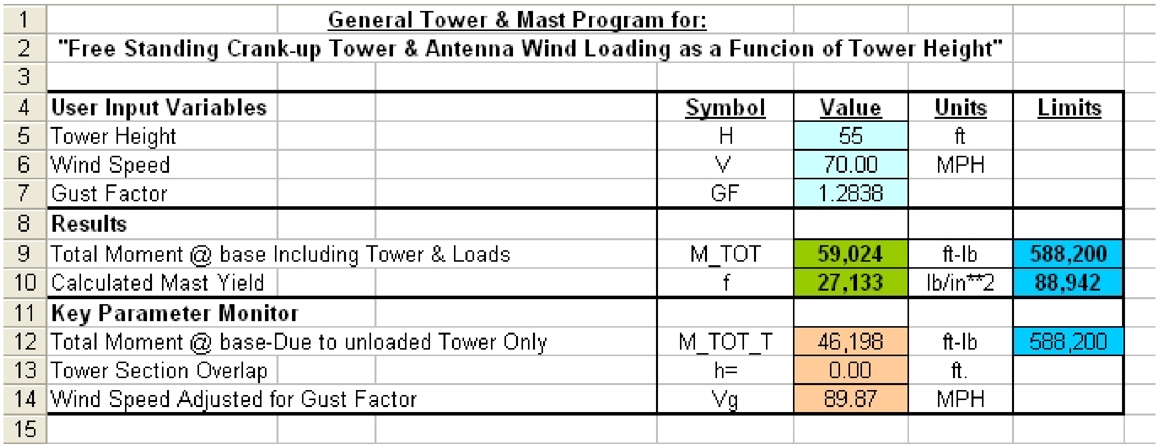
19	Mast Wall Thickness	Mast_Wall	0.38	in	
20	Mast Inside Diameter	d	1.25	in	
21	Distance - Top of Tower to Ant. #1	D1	6.00	ft	EF706
22	Distance - Top of Tower to Ant. #2	D2	15.00	ft	EF902
23	Distance - Top of Tower to Ant. #3	D3	0.00	ft	none
24	Distance - Top of Tower to Mast Mid Point	Dm	7.50	ft	Mast-out
25	Distance - Top of Tower to Rotor	Drot	-10	ft	Rotor
26	Distance - Top of Tower to Remote SW	Dsw	0	ft	none
27	Distance - Top of Tower to Mast Center inside Tower	Dmt	-5	ft	Mast-in
28	Mast Manufacturer's Yield Specification (For Ref. Only)		0	lb/in**2	Eng. Spec.
29					
30	**Load Specific Inputs**	**Symbol**	**Value**	**Units**	**Example**
31	Wind Surface Area of Ant. #1	WSA_1	2.10	ft**2	EF706
32	Wind Surface Area of Ant. #2	WSA_2	1.50	ft**2	EF902
33	Wind Surface Area of Ant. #3	WSA_3	0.00	ft**2	2M Ant
34	Wind Surface Area of Mast	WSA_m	1.20	ft**2	16 ft Mst
35	Wind Surface Area of Rotor	WSA_Rot	1	ft**2	Rot Area
36	Wind Surface Area of Remote Switch	WSA_SW	0	ft**2	n/a
37	Wind Surface Area of Mast inside Tower	WSA_mt	0.3	ft**2	Mast - in
38					
39	**Tower Specific Inputs**	**Symbol**	**Value**	**Units**	
40	Tower Section Length	L	20	ft	
41	Number of Tower Sections	n	6	na	
42	Maximum Moment at Tower Base (For Ref. Only)	Mmax	588,200	ft-lb.	Eng. Spec.
43	Per Foot Surface Area of Section 2 (Upper Most Section)	SA_2	0.76	ft**2/ft	
44	Per Foot Surface Area of Section 3	SA_3	0.72	ft**2/ft	
45	Per Foot Surface Area of Section 4	SA_4	0.67	ft**2/ft	
46	Per Foot Surface Area of Section 5	SA_5	0.61	ft**2/ft	
47	Per Foot Surface Area of Section 6	SA_6	0.54	ft**2/ft	
48	Per Foot Surface Area of Section 7 (Lower Most Section)	SA_7	0.54	ft**2/ft	

Fig. 6. The new worksheet



1	**General Tower & Mast Program for:**				
2	**"Free Standing Crank-up Tower & Antenna Wind Loading as a Funcion of Tower Height"**				
3					
4	**User Input Variables**	**Symbol**	**Value**	**Units**	**Limits**
5	Tower Height	H	55	ft	
6	Wind Speed	V	70.00	MPH	
7	Gust Factor	GF	1.2838		
8	**Results**				
9	Total Moment @ base Including Tower & Loads	M_TOT	**59,024**	ft-lb	**588,200**
10	Calculated Mast Yield	f	**27,133**	lb/in**2	**88,942**
11	**Key Parameter Monitor**				
12	Total Moment @ base-Due to unloaded Tower Only	M_TOT_T	46,198	ft-lb	588,200
13	Tower Section Overlap	h=	0.00	ft.	
14	Wind Speed Adjusted for Gust Factor	Vg	89.87	MPH	
15					

Fig. 6. The new results page

The MARC program also sees the wisdom of the new arrangement, as we can see in the screen capture from the run with new parameters. With the above-the-thrust-bearing portion of the mast topping out at nine feet, and with the SteppIR at five feet and the EF902 at the top, MARC recommends a mast with a yield strength of 42,000 PSI, and a wall thickness of 0.120 inches, or about an eighth of an inch. My eventual purchase of DOM tubing with twice that wall thickness, and a yield moment of 88,942 PSI, puts me comfortably above that margin.

Here are some photos of the mast sections as they were when I got them home, and some detail shots of the ends and finish, showing the wall thickness. Since they cost me an arm and a leg, I'll inflict some photos on you, as if I had you cornered with a stack of pictures of my grandchildren.

The New Arrivals – a Photo Album

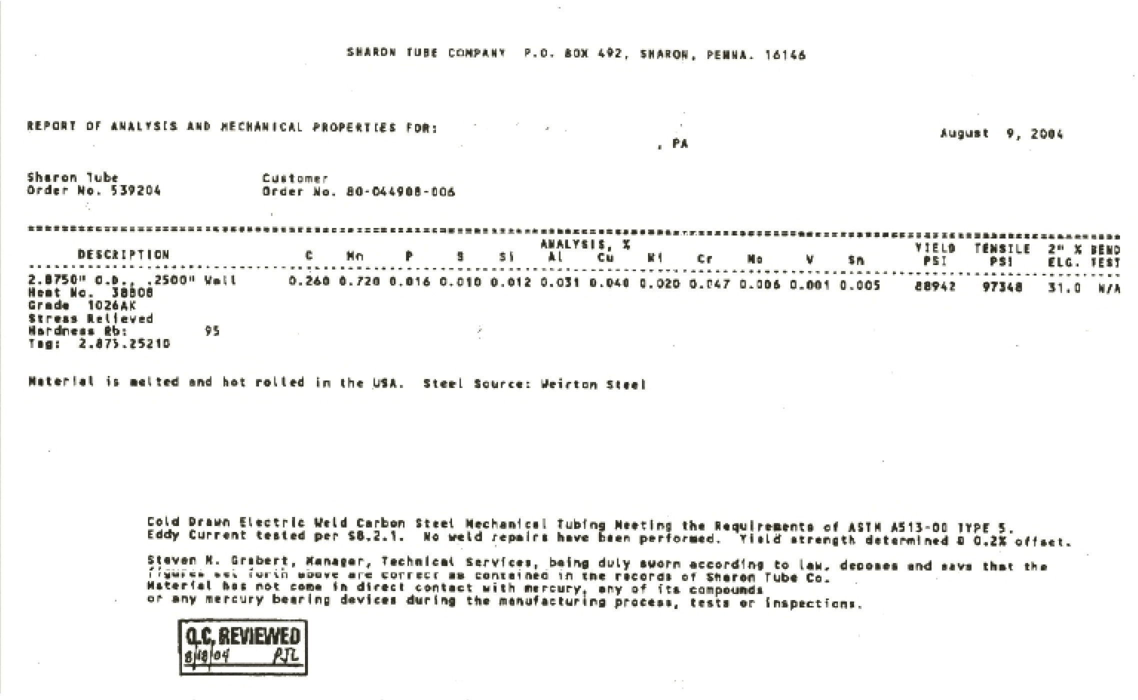
Still mostly wrapped in the cardboard tubing in which they were shipped, as I was inspecting them for damage.

Aw, aren't they cute? Well, no, but they are quite substantial. And straight! Also, notice the galvanizing, which will slow down the rust, quite a bit.

This shows the wall thickness of 0.25 in., and the OD of 2 in. Beefy!

Here’s an oblique view of the ends, with a US dime sitting on the left tube for scale. Note the galvanizing “pimple” on the one on the left. Not too esthetically pleasing, but it won’t affect the function.

I stuck a “MiniMaglight” flashlight in the far end of one tube, to see the irregularities in the interior. I assume the DOM process left the tube “bores” smooth, and the galvanizing added the irregularities, which are exaggerated by the shadows from the flashlight.



SHARON TUBE COMPANY P.O. BOX 492, SHARON, PENNA. 16146

REPORT OF ANALYSIS AND MECHANICAL PROPERTIES FOR: , PA August 9, 2004

Sharon Tube
Order No. 539204

Customer
Order No. 80-044908-006

	ANALYSIS, %															
DESCRIPTION	C	Mn	P	S	Si	Al	Cu	Ni	Cr	Mo	V	Sn	YIELD PSI	TENSILE PSI	2" % ELG.	BEND TEST
2.8750" O.D., .2500" Wall Heat No. 38808 Grade 1026AK Stress Relieved Hardness Rb: 95 Tag: 2.875.25210	0.260	0.720	0.016	0.010	0.012	0.031	0.040	0.020	0.047	0.006	0.001	0.005	88942	97348	31.0	N/A

Material is melted and hot rolled in the USA. Steel Source: Weirton Steel

Cold Drawn Electric Weld Carbon Steel Mechanical Tubing Meeting the Requirements of ASTM A513-00 TYPE 5.
Eddy Current tested per S8.2.1. No weld repairs have been performed. Yield strength determined @ 0.2% offset.

Steven M. Grabert, Manager, Technical Services, being duly sworn according to law, deposes and says that the figures set forth above are correct as contained in the records of Sharon Tube Co.
Material has not come in direct contact with mercury, any of its compounds or any mercury bearing devices during the manufacturing process, tests or inspections.

Q.C. REVIEWED
8/18/04 PJL

Here is a scan of the “birth certificate” for the tubing, showing, among other things, the content of significant metals other than iron, and describing the origin of the steel and the treatment it received to become tubing, as well as the important engineering characteristics of the finished product. Also, note that the raw material, the flat sheet steel used to make the tubing was “melted and hot rolled in the USA.” The second paragraph from the bottom tells the most important detail: “Cold Drawn Electric Weld Carbon Steel Mechanical Tubing Meeting the Requirements of ASTM A513-0D Type 5. Eddy current tested… No Weld Repairs Have Been Performed…” Also, up in the table note the Yield PSI: 88942. That’s what I’m after!

Now, Go Out There and Do It Right!

Well, that about wraps up this little piece on the wrong way AND the right way to choose a mast for your antennas that will last through what Mother Nature has to offer, and keep your antennas aloft and worthy of your hard-earned money and time.

Start with understanding the stresses your antennas and their environment will put on your mast. Then, use the right material for the job. Remember: PIPE IS NOT TUBING! Don't scrimp on the research and expense. Money and time spent at the early stages may save you the from the unhappy experience of picking up bent and broken pieces of your antennas scattered around the base of your tower, not to mention losing weeks or months off the air, and spending even more money and time to replace those lost antennas. I wish I'd have done it right, the first time. Here's hoping you benefit from my mistakes. Why make old mistakes, when you can make new ones? **–30-**

BRIEF BIOGRAPHY OF THE AUTHOR

Tom Cox, KT9OM

Tom Cox, **KT9OM**, is assistant director of the information technology department of a 10,000-student, 7,000-computer public school corporation. His most recent project is replacing the corporation's leased digital telephone lines with high-speed wireless connections. On his own time, Tom plays with antennas, reads fiction and non-fiction, and gardens or removes snow and splits firewood, depending on the season, and rides about 250 miles a summer on a bicycle.

He was born to generous and patient parents, Jim and Jeannette Cox (both deceased), in 1949, and has been a Ham since 1982. He shares his Muncie, Indiana home with his lovely and indulgent wife, Sherry, and three dogs. He shares his neighborhood with his brother, KA9PBO, with whom he plays radio and attends hamfests. Tom is an active member of the GARDS.

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Send mail to webmaster@antennex.com with questions or comments.