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P.O. 185, WATERFORD, WI 53185
TELEPHONE 262-534-9001

Metal & Cable Corp., Inc.
Antenna Mount Calculations - R01

B & A Project 74035

Prepared for:
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P.O. Box 117
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July 24, 2010

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President
Beach & Associates, LLC

74035 Antenna Mount Calculations
74035R01
7/24/2010

Overview

The scope of Part 1 of the project required calculations based on AASHTO standards to determine loads at the base of a mounting system used to attach a dish/panel antenna array to the side of a water tower. The calculation set is shown on pages 0 thru 13 of the attached document and is loosely based on a proposed installation in Washington state. The general arrangement of that installation can be found in Appendix 1. Some of the geometric values used in the attached calculations such as the horizontal distances between components were scaled from this document.

Multiple exceptions and assumptions were employed in the execution of the calculation set. They are listed below in no specific order of priority.

1) The height above ground of the antenna array has been arbitrarily set to 200'.
2) The antenna array was assumed to have full exposure from a rear wind situation.
3) The exposure of the vertical pole was assumed to be negligible for front & rear wind situations.
4) The exposure of the various clamps, brackets, and hardware was assumed to inconsequential.
5) Loads per magnetic bracket in some cases were assumed to be evenly distributed even though the actual distribution is statically indeterminate.
6) Allowable loads per magnet and per magnetic bracket as well as the layout of the magnets on each bracket were supplied by the client.
7) The radius of curvature of the water tank was assumed to be negligible.
8) Ice loads, if applicable, are assumed to cover the entire component in question.

Constants used in the calculation set were taken from the AASHTO standard and are included in the appendix. All wind velocities were taken from the map on Appendix 2. It should be noted here that while the nominal wind velocities were used in generating the attached values, local building codes should be consulted in areas designated as special wind regions. The exposure factor, which is based on the height of the structure being analyzed relative to the local terrain, is taken from an AASHTO table and is shown in Appendix 3. A drawing of the magnet mounting plate is shown on Appendix 5. The magnets are attached to the 0.44 diameter thru holes. Other constants used in this report are the minimum gust factor of 1.14, a wind importance factor of 1.0, a drag co-efficient of 1.12, and an ice load of 3 lbs/ft^2.

The scope of Part 2 of this project involved the creation of an excel spreadsheet to be used in generating approximations of loadings where the installation is similar to the condition shown in Appendix 1. The results of this spreadsheet should be considered only as an approximation as each site should be carefully reviewed to apply the appropriate AASHTO values. A digital copy of this file has been supplied under separate cover under the file name of 74035genericR01.xls. A printed copy of a completed spreadsheet based on a specific example is shown on Appendix 4. A simplified general arrangement of

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the loading condition depicted by this spreadsheet is shown on page 15 of the calculation set. The tutorial on its use begins on page 14. The cells within the spreadsheet are NOT write protected. The overall accuracy can be verified using the example on pages 1 thru 13 and making allowances for round-off error.

Conclusion

Calculations for factors of safety for the conditions presented here-in are well within range of generally accepted safe working conditions.

ENGINEERING CALCULATIONS

Project# 74035 Client Metal-Cable Corp Date 07-08-10

Subject Antenna Mount Calculations - Abbreviations Page# 0 Next Page# 1

BB	Bottom bracket
FFBB	Front wind force @ bottom bracket
FFD	Wind load at front of dish antenna
FFP	Wind load at front of panel antenna
FFTB	Front wind force @ top bracket
FIB	Force @ magentic bracket from ice load
FID	Ice load on dish antenna
FIP	Ice load on panel antenna
FIT	Ice load on vertical tube
FMB	Force @ magentic bracket from component mass
FP	Force @ magentic pad
FRBB	Rear wind force @ bottom bracket
FRD	Wind load at rear of dish antenna
FRP	Wind load at rear of panel antenna
FRTB	Rear wind force @ top bracket
FSB	Shear load @ mounting bracket
FSD	Wind load at side of dish antenna
FSP	Wind load at side of panel antenna
FST	Wind load at side of vertical tube
FSV	Vertical shear force @ magnetic pad
MD	Mass of dish antenna
MP	Mass of panel antenna
MT	Mass of vertical tube
TB	Top bracket

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ENGINEERING CALCULATIONS

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Subject Antenna Mount Calculations - Wind Loads Page# 1 Next Page# 2

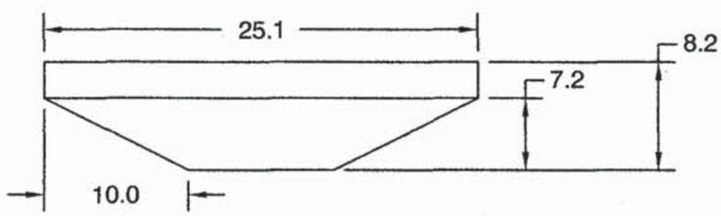
Wind Load Equation (AASHTO LTS-4)

$P_z(lbs/ft^2) = .00256\ K_z G\ V^2 I_r C_d$

- C_d → Drag Coefficient
- I_r → Wind Importance Factor
- V → Wind Velocity (mph)
- G → Gust Factor
- K_z → Exposure Factor *

Calculate Dish Antenna Area & Wind Load (Front or Rear Exposure)
- 25.1" Dia (given)
- Area = $\pi r^2 = (\pi)(12.55^2) = 494.8\ in^2$
- $494.8\ in^2 / 144 = 3.44\ ft^2$
- $P_z(lbs/ft^2) = (.00256(1.46)(1.14)(85^2)(1.0)(1.12) = 34.47 lbs/ft^2$
- FFD = FRD = (34.47)(3.44) = 118.58 lbs.

Calculate Dish Antenna Area & Wind load (Top or Side Exposure)
- Simplified profile shown below



- Area = $(25.1)(8.2)-(10)(7.2) = 133.82\ in^2$
- $133.82\ in^2 / 144 = .93\ ft^2$
- $P_z(lbs/ft^2) = (.00256(1.46)(1.14)(85^2)(1.0)(1.12) = 34.47 lbs/ft^2$
- FSD = (34.47)(.93) = 32.06 lbs.

* Arbitrarily set at 200'

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Calculate Panel Antenna Area & Wind Load (Front or Rear Exposure)
- 12.7 " x 42" profile (given)
- Area = (12.7)(42) = 533.4 in ^{2}
- 533.4 in ^{2} / 144 = 3.70 ft ^{2}
- P_z (lbs/ft ^{2}) = (.00256(1.46)(1.14)(85 ^{2})(1.0)(1.12) = 34.47lbs/ft ^{2}
- FFP = FRP = (34.47)(3.7) = 127.54 lbs.

Calculate Panel Antenna Area & Wind Load (Side Exposure)
- 2.7 " x 42" profile (given)
- Area = (2.7)(42) = 113.4 in ^{2}
- 113.4 in ^{2} / 144 = .79 ft ^{2}
- P_z (lbs/ft ^{2}) = (.00256(1.46)(1.14)(85 ^{2})(1.0)(1.12) = 34.47lbs/ft ^{2}
- FSP = (34.47)(.79) = 27.23 lbs.

Calculate Panel Antenna Area (Top Exposure)
- 12.7 " x 2" profile (given)
- Area = (12.7)(2) = 34.29 in ^{2}
- 34.29 in ^{2} / 144 = .24 ft ^{2}

Calculate Tube Projected Area (Front or Rear or Side Exposure)
- 4.5 " OD (given) x 140" long
- Area = (4.5)(140) = 630in ^{2}
- 630 ^{2}/ 144 = 4.4 ft ^{2}
- P_z (lbs/ft ^{2}) = (.00256(1.46)(1.14)(85 ^{2})(1.0)(1.12) = 34.47lbs/ft ^{2}
- FST = (34.47)(4.4) = 151.66 lbs.

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ENGINEERING CALCULATIONS

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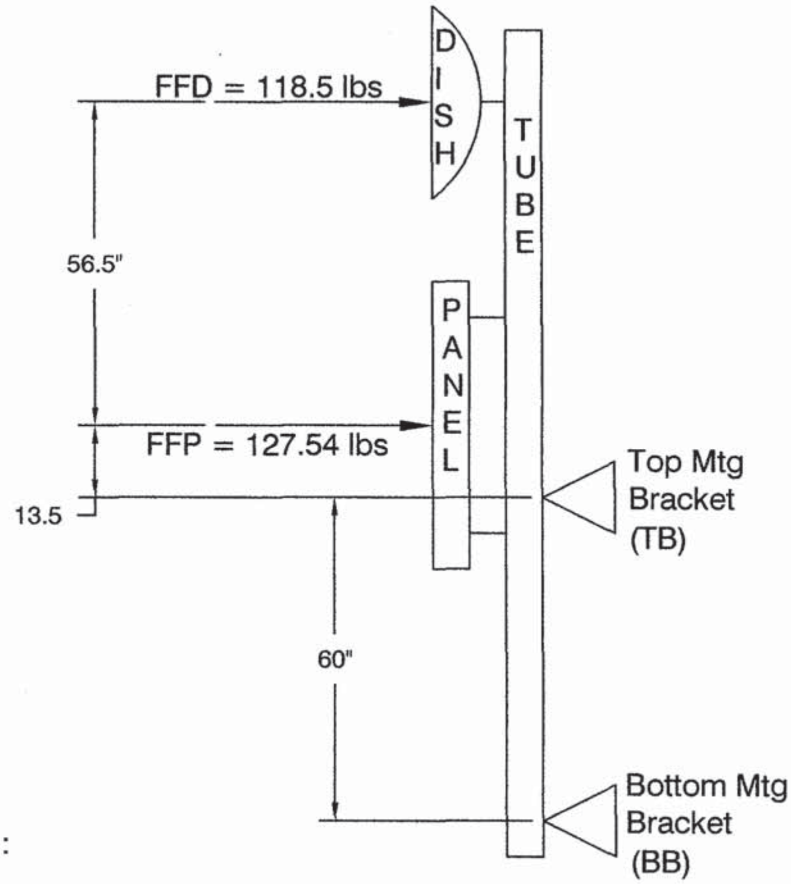
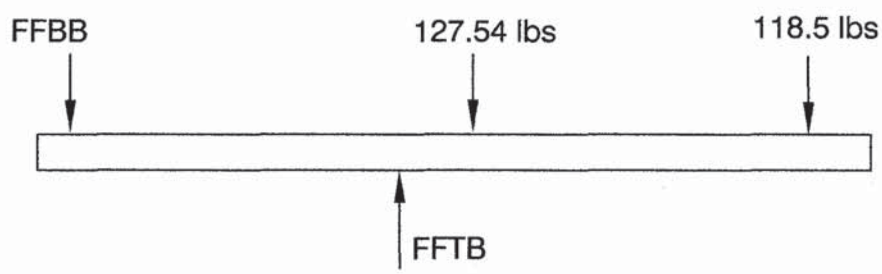
Subject Antenna Mount Calculations - Frontal Wind Loads Page# 3 Next Page# 4

Frontal Wind Loading

The top mounting bracket becomes the "pivot" for all horizontal forces in this configuration



Sum Moments about FFTB (cw= +):



ΣM @ TB = 0 = (13.5)(127.54)+(70)(118.5)-(60)(FFBB)
FFBB = ((13.5)(127.54)+(70)(118.5))/60 = 166.94 lbs

Solve for FFTB:

ΣF = 0 = 127.54+118.5 +166.94 - FFTB
FFTB = 412.98 lbs

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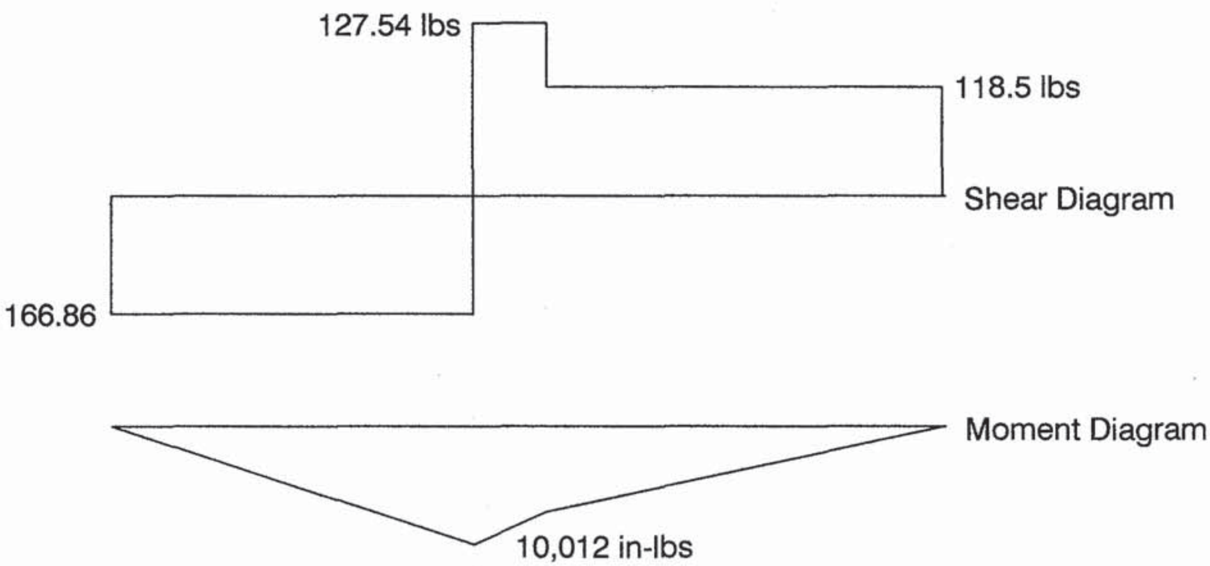

The frontal wind condition puts the top magnetic mounting bracket into compression and applies a tensile load to the lower mounting bracket. Per the equations on the previous page, that total tensile load (FFBB) is 166.82 lbs. Assuming equal distribution on all magnets, each individual magnet is subject to 166.86/24 or 6.95 lbs.

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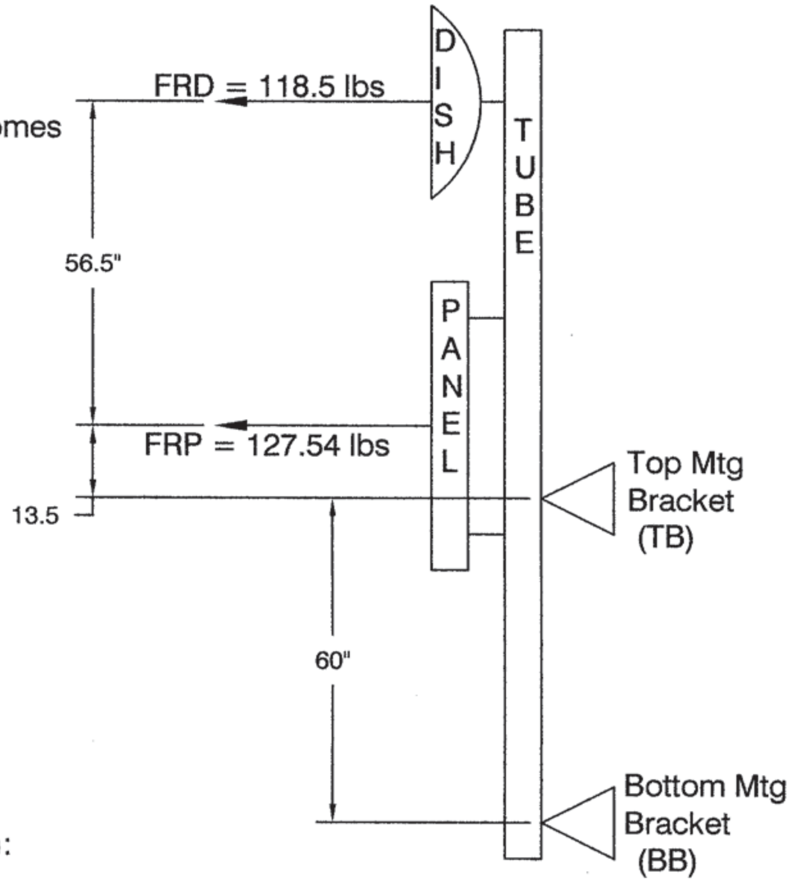
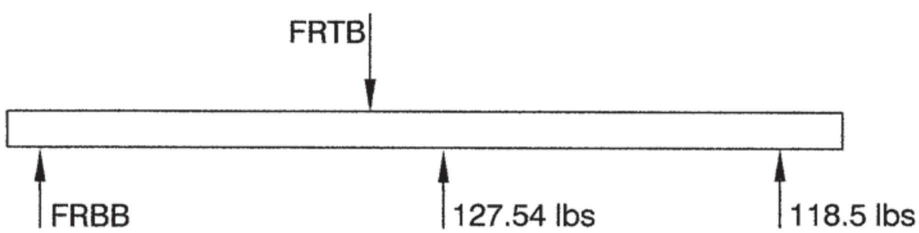
Rear Wind Loading

The "bottom" mounting bracket becomes the "pivot" for all horizontal forces in this configuration



Sum Moments about FRBB (cw= +):



ΣM @ BB = 0 = (60)(FRTB) - (73.5)(127.54) - (118.5)(130)

FRTB = ((73.5)(127.54)+(130)(118.5))/60 = 412.98 lbs

Solve for FRBB:

ΣF = 0 = 127.54+118.5 - 412.98 + FRBB

FRBB = 166.94 lbs

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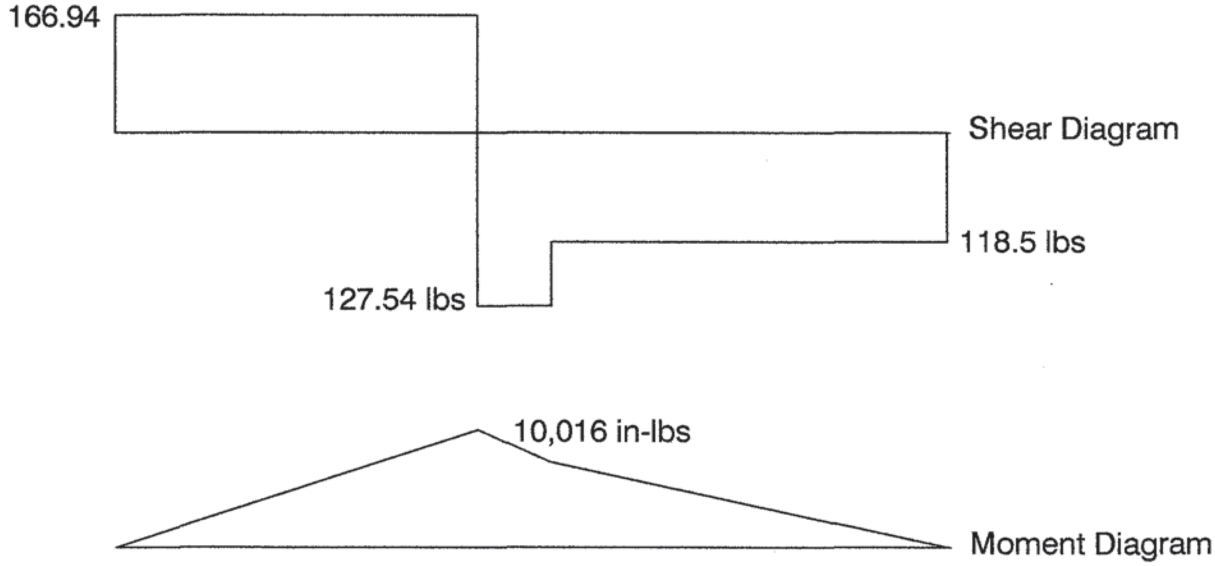

The rear wind condition puts the bottom magnetic mounting bracket into compression and applies a tensile load to the top mounting bracket. Per the equations on the previous page, that total tensile load (FRTB) is 412.98 lbs. Assuming equal distribution on all magnets, each individual magnet is subject to 412.98/24 or 17.20 lbs.

The analysis generated to this point indicates that the tensile loads created by the wind from the rear of the structure create higher "tensile" forces on the magnetic pads than do the winds from the front of the structure.

ff/calcgrid 990418

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Subject Antenna Mount Calculations - Side Wind Loads Page# 7 Next Page# 8

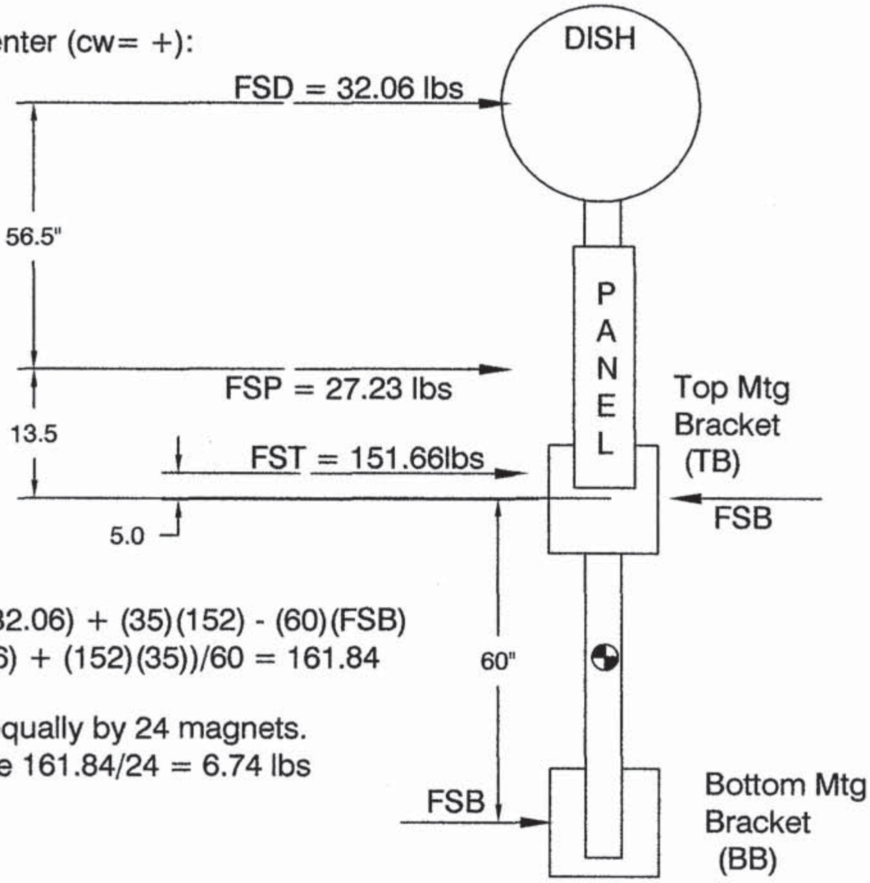
Side Wind Loading

Two types of loads are generated by winds blowing at the side profiles of the antennae. The first type of load is a shear loading which is discussed below. The second loading produces tensile and compressive loads on the magnets and is discussed on the following page.

Side Wind Loading - Shear

The shear loads generated by winds blowing at the side profiles of the antennae are resisted by a couple centered at the midpoint of the distance between the two magnetic mounting pads. By definition, both forces of a couple are equal to each other. Therefore, for subsequent shear calculations, FSBB and FSTB are renamed simply as FSB.

Sum Moments about couple center (cw= +):



$\Sigma M = 0 = (43.5)(27.23) + (100)(32.06) + (35)(152) - (60)(FSB)$

$FSB = ((43.5)(27.23)+(100)(32.06) + (152)(35))/60 = 161.84$

Each shear load will be resisted equally by 24 magnets.
the resulting individual load will be 161.84/24 = 6.74 lbs

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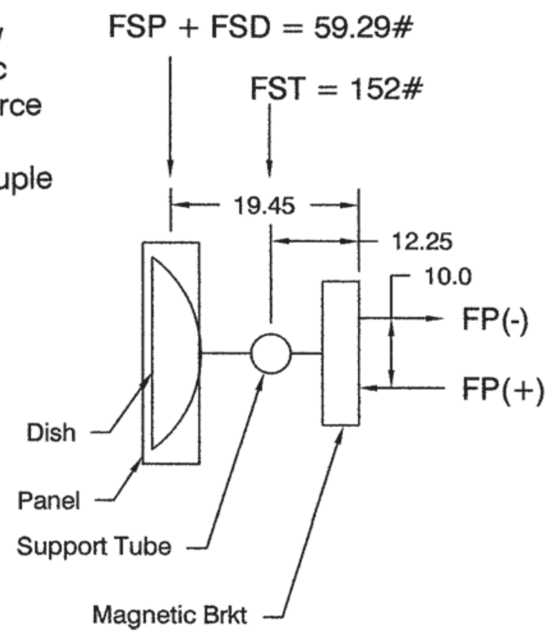
Side Wind Loading - Tension & Compression

The relative orientation of the antennae to each other and to the magnetic brackets is shown in the plan view to the right. The antennae are offset from the magnetic brackets by the distance shown. The indicated side force creates a moment about the pad. This moment is resisted by a "couple" at the pad. Each force of the couple is located halfway from the center of the bracket to the center of its outer magnet.



Sum Moments about couple center (cw= +):

$$\Sigma M = 0 = (10)FP - (12.25)(152) - (19.45)(59.29)$$
$$FP = ((19.45)(59.29) + (12.25)(152))/10 = 302 \text{ lbs}$$

Each component of the couple will be shared equally by 12 magnets/bracket.
The resulting individual load will be 302/24 = 12.56 lbs

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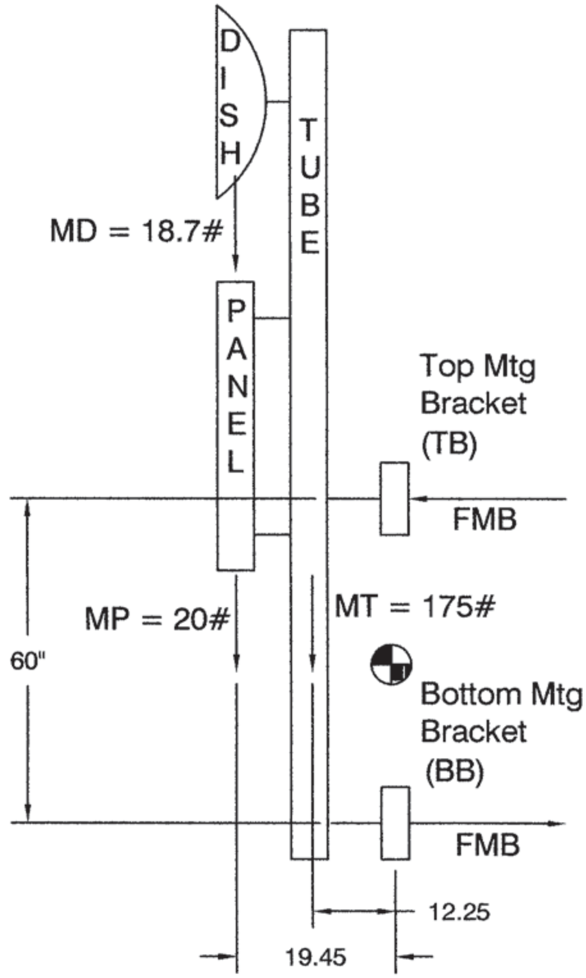
Subject Antenna Mount Calculations - Mass Loads Page# 9 Next Page# 10



Mass Loads

Mass loads from the individual components are resisted by a force couple with its center halfway between the upper and lower mounting brackets. This couple is similar to that created by wind side loads. This force couple is solved on this page. The mass loads are also resisted by a vertical shear and are also discussed on this page.

Shear Forces from Mass Loads

The total shear force will be shared equally among 48 magnets. The load per individual magnet will be (20 + 18.7 + 175)/48 = FSV

4.45 lbs = FSV

Tensile and Compressive Forces from Mass Loads

Sum Moments about couple center (cw= +):

$$\Sigma M = 0 = (60)(FMB) - (175)(12.25) - (18.7)(19.45) - (20)(19.45)$$

$$FMB = ((12.25)(175)+(18.7)(19.45) + (20)(19.45))/60 = 48.27 \text{ lbs}$$

The tensile load on the top bracket will be shared equally by 24 magnets. The load per individual magnet will be 48.27/24 = 2 lbs.

ff/calcgrid 990418

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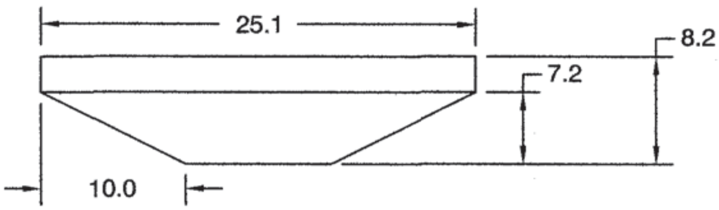
Ice Loads

Ice loads resulting from the coatings on individual components are calculated in exactly the same method as were the mass loads on the previous page. The mass of the ice is based on a constant of 3 lbs/ft of the surface being coated. Calculations of total areas and the corresponding ice masses are shown on this page.

Ice Surface Area - Dish Antenna
- Simplified profile shown below



- Area calculated via Solid Works = 8.18 ft ^{2}
- FID = (8.18)(3.0) = 24.55 lbs.

Ice Surface Area - Panel Antenna
- 12.7 " x 42" x 2.7" profile (given)
- Area = ((12.7)(42)(2) + (12.7)(2.7)(2) + (2)(2.7)(42))/144 = 9.45 ft ^{2}
- FIP = (9.45)(3.0) = 28.35 lbs.

Ice Surface Area - Support Tube
- 4.5 " OD (given) x 140" long
- Area = $((4.5)(140)(\pi) + (\pi)(2.25^2)(2))/144$ = 13.96 ft ^{2}
- FIT = (13.96)(3.0) = 41.9 lbs.

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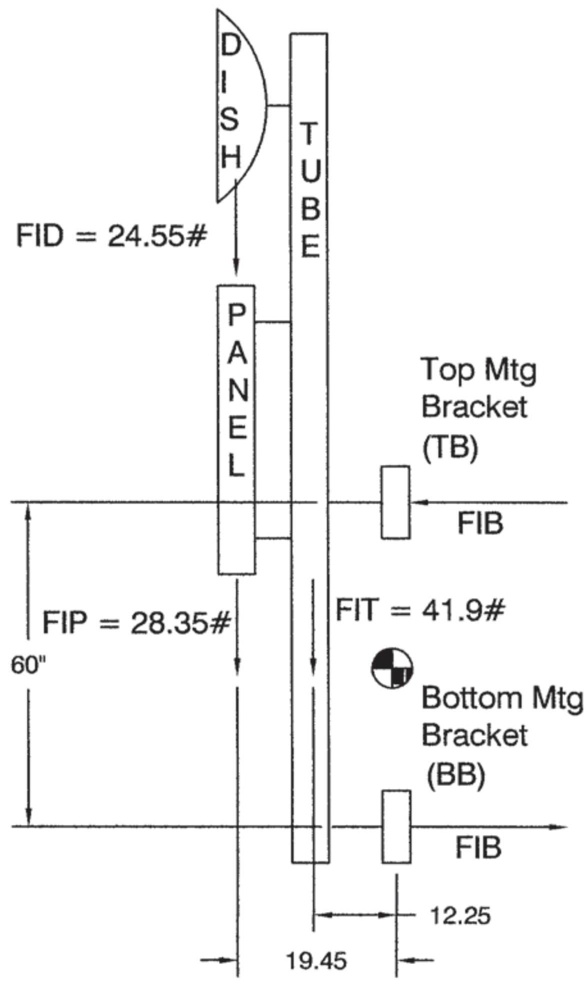
Shear Forces from Ice Loads

The total shear force will be shared equally among 48 magnets. The load per individual magnet will be (24.55 + 28.35 + 41.9)/48 = 1.98 lbs.



Tensile and Compressive Forces from Ice Loads

Sum Moments about couple center (cw= +):

$$\Sigma M = 0 = (60)(FIB) - (41.9)(12.25) - (24.55)(19.45) - (28.35)(19.45)$$

$$FIB = ((12.25)(41.9)+(24.55)(19.45) + (28.35)(19.45))/60 = 25.70 \text{ lbs}$$

The tensile load on the top bracket will be shared equally by 24 magnets. The load per individual magnet will be 48.27/24 = 1.07 lbs.

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Group I combined loads - Rear Wind Situation

This per magnet loading is a combination of the following components:
- Tensile from rear wind - 17.17 lbs
- Tensile from mass - 2.0 lbs
- Tensile from ice - 1.07 lbs
- Shear from mass - 4.45 lbs
- Shear from ice - 1.98 lbs

The shear forces resulting from ice and mass act in the same direction and can be added algebraically to form a single component.
That vector is 4.45(mass) + 1.98(ice) = 6.43 lbs
Factor of Safety = 35/6.43 = 5.44

Likewise, all tensile forces are acting in the same direction and can added algebraically to form a single component.
That vector is 17.17(wind) + 2.0(mass) + 1.07(ice) = 20.24 lbs
Factor of Safety = 100/20.24 = 4.94

Group II combined loads - Side Wind Situation

This per magnet loading is a combination of the following components:
- Tensile from side wind - 12.56 lbs
- Tensile from mass - 2.0 lbs
- Tensile from ice - 1.07 lbs
- Shear from side wind - 6.74 lbs
- Shear from mass - 4.45 lbs
- Shear from ice - 1.98 lbs

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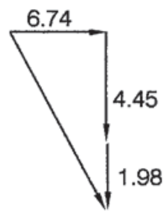
The shear forces resulting from ice and mass act in the same direction and can be added algebraically to form a single component. The shear vector from the wind load acts in in the same plane but at right angles to the ice & mass vector all three can be combined per the diagram below.

Combined Shear



(4.45 + 1.98 = 6.43)

Combined Shear = $((6.74^2) + (6.43^2))^{1/2}$ = 9.31 lbs

Factor of Safety = 35/9.31 = 3.76

All tensile forces are acting in the same direction and can be added algebraically to form a single component.

That vector is 12.56(wind) + 2.0(mass) + 1.07(ice) = 15.63 lbs

Factor of Safety = 100/15.63 = 6.4

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Note: The file 74035genericR01.xls is NOT write protected. Cells A7 thru A33 are user entered data and are relative to the geometry of specific components within the general arrangement being investigated. See page 0 of this calculation set to identify abbreviations for specific forces and reactions and see the next page to identify components and dimensions discussed below. Dimensions and mass values on the next page are marked with the appropriate cell where they should be entered (A19 thru A29). The user should not enter data into or alter any cells other than those discussed below. Note units where applicable.

Cell A7	Wind speed (mph) at location. See Appendix 02.
Cell A8	Exposure Factor based on elevation. See Appendix 03.
Cell A9	Ice Load Area? See Appendix 02. Enter 3 for yes and 0 for no.
Cell A11*	Antenna 1 exposure to rear winds (ft^2)
Cell A12*	Antenna 1 exposure to side winds (ft^2)
Cell A14*	Antenna 2 exposure to rear winds (ft^2)
Cell A15*	Antenna 2 exposure to side winds (ft^2)
Cell A17*	Vertical tube exposure area to side winds (ft^2)
Cell A19	Vertical distance between mounts. (in)
Cell A20	Vertical distance - Bottom mount to antenna #1 CG. (in)
Cell A21	Vertical distance - Bottom mount to antenna #2 CG. (in)
Cell A22	Vertical distance - Bottom mount to vertical tube CG. (in)
Cell A23	Horizontal distance - Magnet face to antenna #1 CG. (in)
Cell A24	Horizontal distance - Magnet face to antenna #2 CG. (in)
Cell A25	Horizontal distance - Magnet face to vertical tube CG. (in)
Cell A27	Mass (lbs) of antenna #1 (manufacturer supplied data)
Cell A28	Mass (lbs) of antenna #2 (manufacturer supplied data)
Cell A29*	Mass (lbs) of vertical tube.
Cell A31*	Ice surface area** (ft^2) of antenna #1
Cell A32*	Ice surface area** (ft^2) of antenna #2
Cell A33*	Ice surface area** (ft^2) of vertical tube

* Requires offline user calculation

** Ice surface area = Total outside surface

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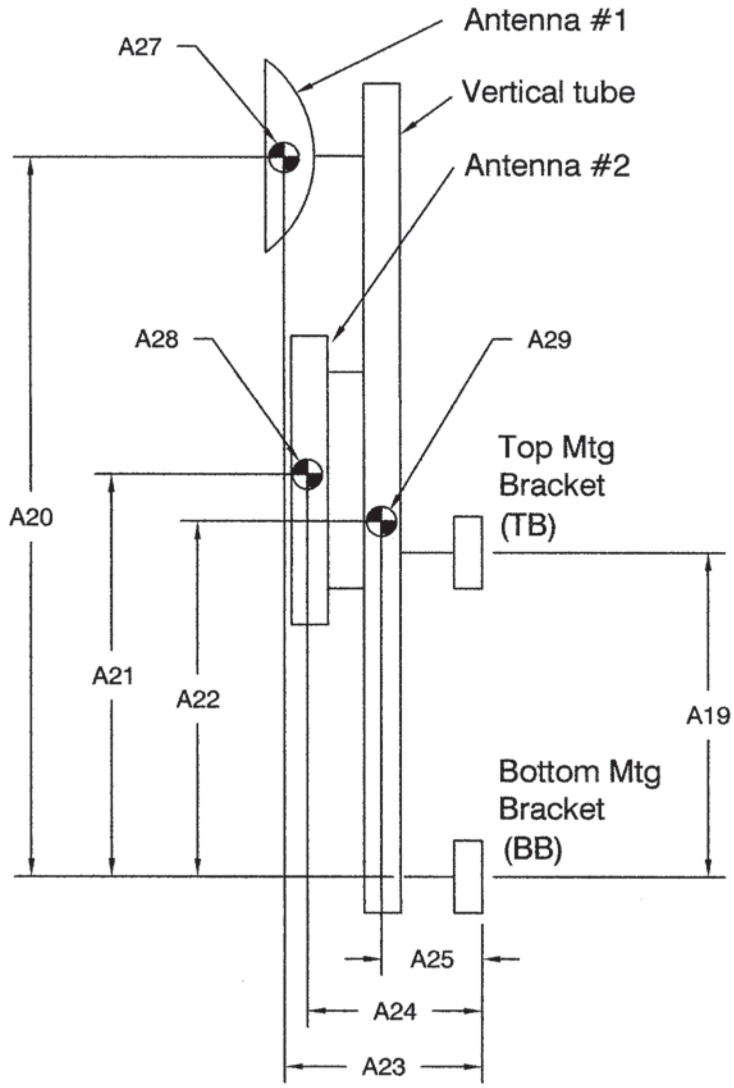
Subject Antenna Mount Calcs - Spreadsheet Example Page# 15 Next Page# -



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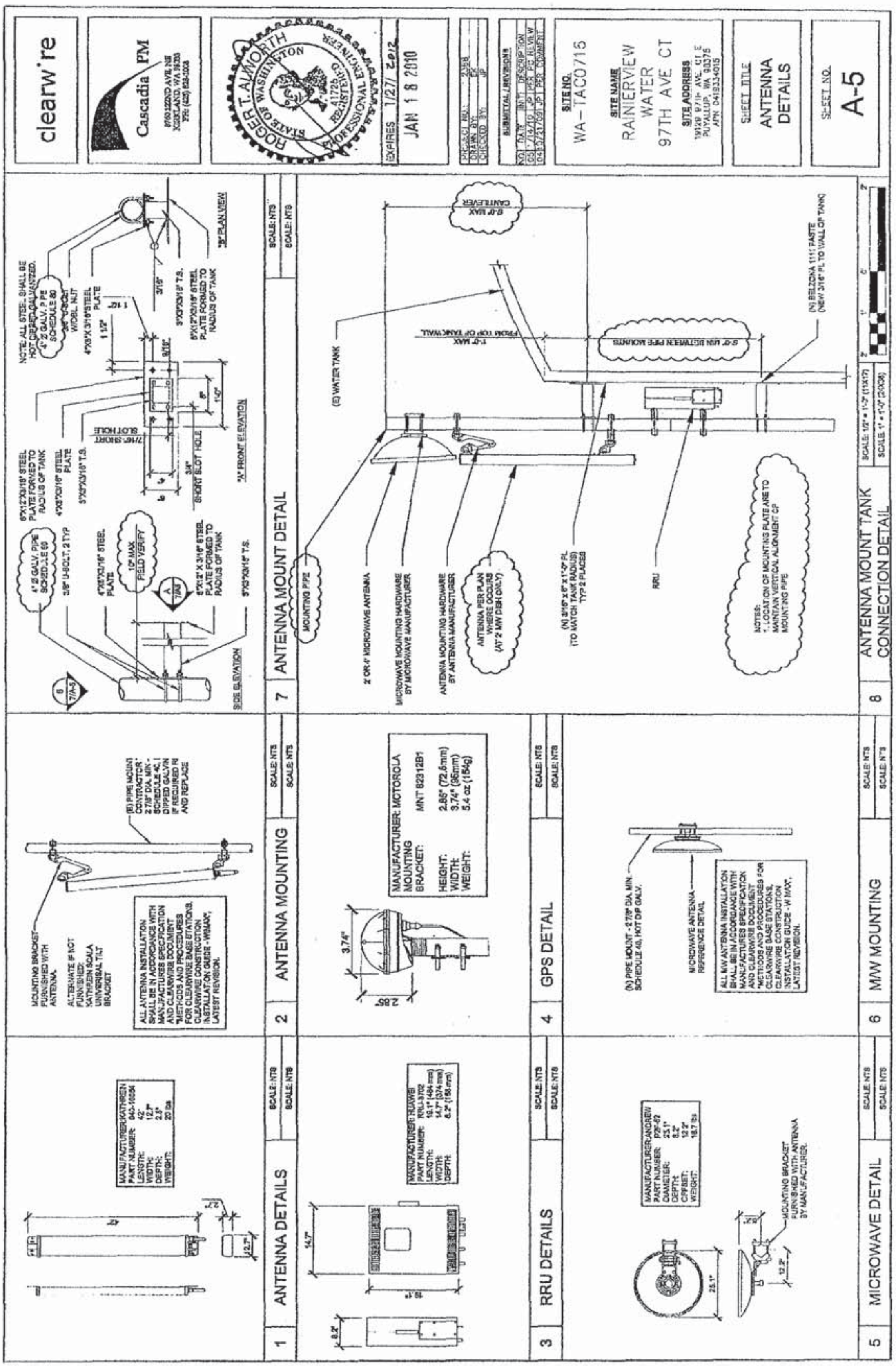

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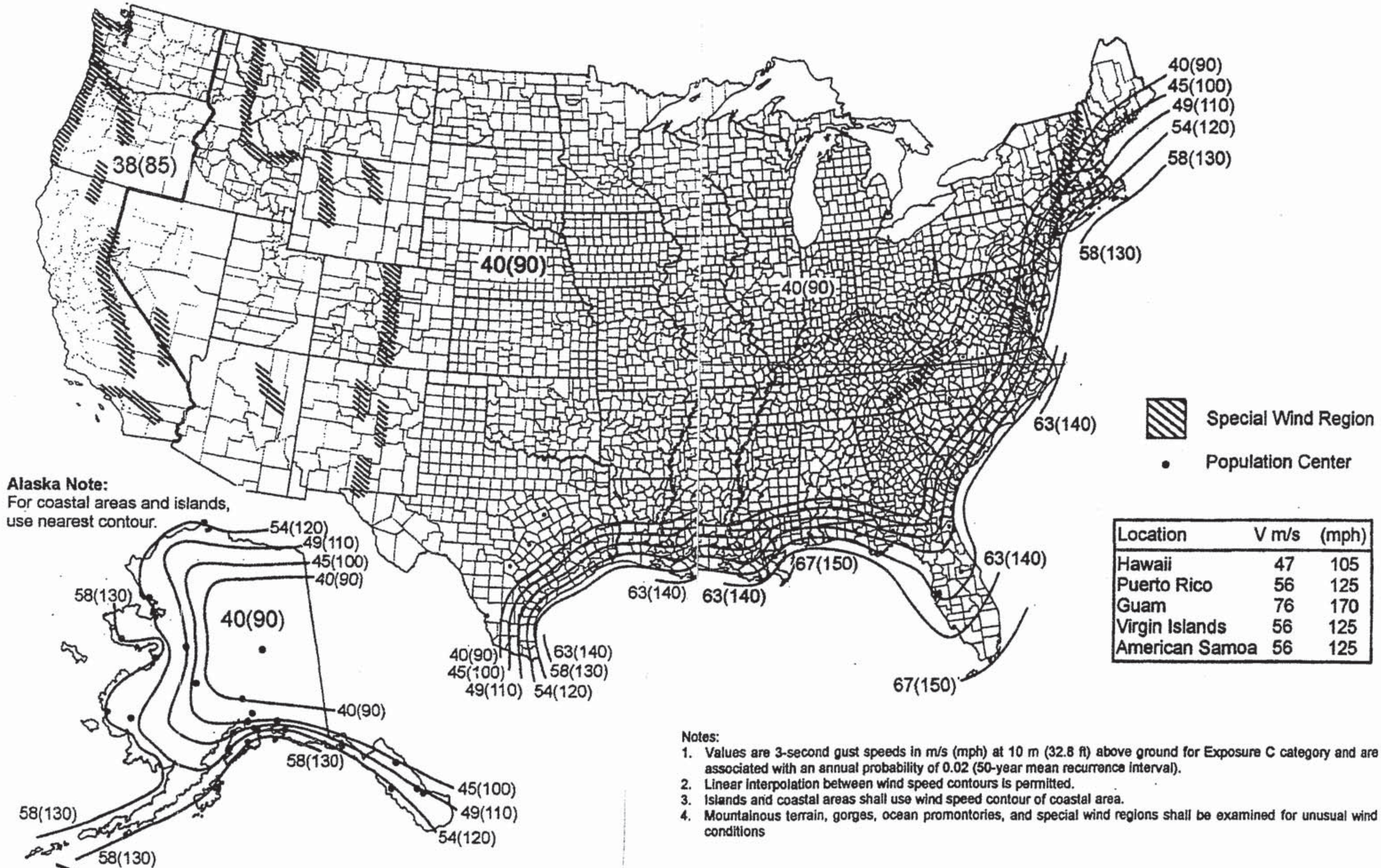
EXPIRES 1/27/2012
JAN 1 8 2010
SITE NO.
WA-TAC0715
SITE NAME
RAINIERVIEW WATER
97TH AVE CT
SHEET TITLE
ANTENNA DETAILS
SHEET NO.
A-5
1 ANTENNA DETAILS
2 ANTENNA MOUNTING
3 RRU DETAILS
4 GPS DETAIL
5 MICROWAVE DETAIL
6 M/W MOUNTING
7 ANTENNA MOUNT DETAIL
8 ANTENNA MOUNT TANK CONNECTION DETAIL
MANUFACTURER: MOTOROLA
MOUNTING BRACKET: MNT 82312B1
HEIGHT: 2.85" (72.5mm)
WIDTH: 3.74" (95mm)
WEIGHT: 5.4 oz (154g)
SIDE ELEVATION
"A" FRONT ELEVATION
"B" PLAN VIEW

Appendix 01



Location	V m/s	(mph)
Hawaii	47	105
Puerto Rico	56	125
Guam	76	170
Virgin Islands	56	125
American Samoa	56	125

Notes:

1. Values are 3-second gust speeds in m/s (mph) at 10 m (32.8 ft) above ground for Exposure C category and are associated with an annual probability of 0.02 (50-year mean recurrence interval).
2. Linear interpolation between wind speed contours is permitted.
3. Islands and coastal areas shall use wind speed contour of coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions

Appendix 02

Height and Exposure Factors, K_z	
Height, m(ft)	K_z
5.0(16.4) or less	0.87
7.5 (24.6)	0.94
10.0 (32.8)	1.00
12.5 (41.0)	1.05
15.0 (49.2)	1.09
17.5 (57.4)	1.13
20.0 (65.6)	1.16
22.5 (73.8)	1.19
25.0 (82.0)	1.21
27.5 (90.2)	1.24
30.0 (98.4)	1.26
35.0 (114.8)	1.30
40.0 (131.2)	1.34
45.0 (147.6)	1.37
50.0 (164.0)	1.40
55.0 (180.5)	1.43
60.0 (196.9)	1.46
70.0 (229.7)	1.51
80.0 (262.5)	1.55
90.0 (295.3)	1.59
100.0 (328.1)	1.63

Appendix 03

Generic Antenna Approximations
74035genericR01.xls
7/24/2010

User Entered Data

85.00 Wind Speed (mph)
1.46 Exposure Factor (per attached AASHTO table)
3.00 Ice (psf)

3.44 Antenna 1 Rear Exposure Area (square feet)
0.93 Antenna 1 Side Exposure Area (square feet)

3.70 Antenna 2 Rear Exposure Area (square feet)
0.79 Antenna 2 Side Exposure Area (square feet)

4.40 Vertical Tube Side Exposure Area (square feet)

60.00 Vertical Distance Between Mounts (in)
130.00 Vertical Distance - Bottom mount to antenna 1 CG (in)
73.50 Vertical Distance - Bottom mount to antenna 2 CG (in)
65.00 Vertical Distance - Bottom mount to vertical tube CG. (in)
19.45 Horizontal Distance - Magnet face to antenna 1 CG (in)
19.45 Horizontal Distance - Magnet face to antenna 2 CG (in)
12.25 Horizontal Distance - Magnet face to vertical tube CG (in)

18.70 Mass of Antenna #1 (lbs)
20.00 Mass of Antenna #2 (lbs)
175.00 Mass of Vertical Mount Tube (lbs)

8.18 Ice surface area antenna 1 (square feet)
9.45 Ice surface area antenna 2 (square feet)
13.96 Ice surface area vertical tube (square feet)

Calculated Constants

30.00 1/2 distance between magnetic mounts (in)

Calculated Component Wind Loads

118.61 FR1 (wind force (lbs) at rear of antenna 1)
32.07 FS1 (wind force (lbs) at side of antenna 1)

127.57 FR2 (wind force (lbs) at rear of antenna 2)
27.24 FS2 (wind force (lbs) at side of antenna 2)

151.71 FST (wind force (lbs) at side of mounting tube)

Calculated Component Ice Loads

24.54 Ice Load (lbs) Antenna 1
28.35 Ice Load (lbs) Antenna 2
41.88 Ice Load (lbs) Vertical Tube

Mounting Bracket Forces From Rear Winds

413.26 FRTB (top bracket force - rear wind)
167.08 FRBB (bottom bracket force - rear wind)
17.22 Top Mount Tension per magnet from rear wind

Mounting Bracket Forces from Side Winds

161.69 FSB horizontal "shear" load per bracket
6.74 Horizontal "shear" load per magnet from side wind

301.19 FP (mounting pad (lbs tension and compression) load from Side wind Loads
12.55 Tension load per magnet from side wind load

Mass Loads

106.85 FSVM Vertical "shear" load per bracket
4.45 Vertical "shear" load per magnet

48.27 FP (mounting pad (lbs tension and compression) load from Mass Loads
2.01 Tension load per magnet from Mass Load

Ice Loads

94.77 FSVI Vertical "shear" load per bracket
1.97 Vertical "shear" load per magnet

25.70 FP (mounting pad (lbs tension and compression) load from Mass Loads
1.07 Tension load per magnet from Mass Load

Combined Loads - Rear Wind Situation

6.43 Vertical "shear" (mass + ice)
5.45 Factor of Safety

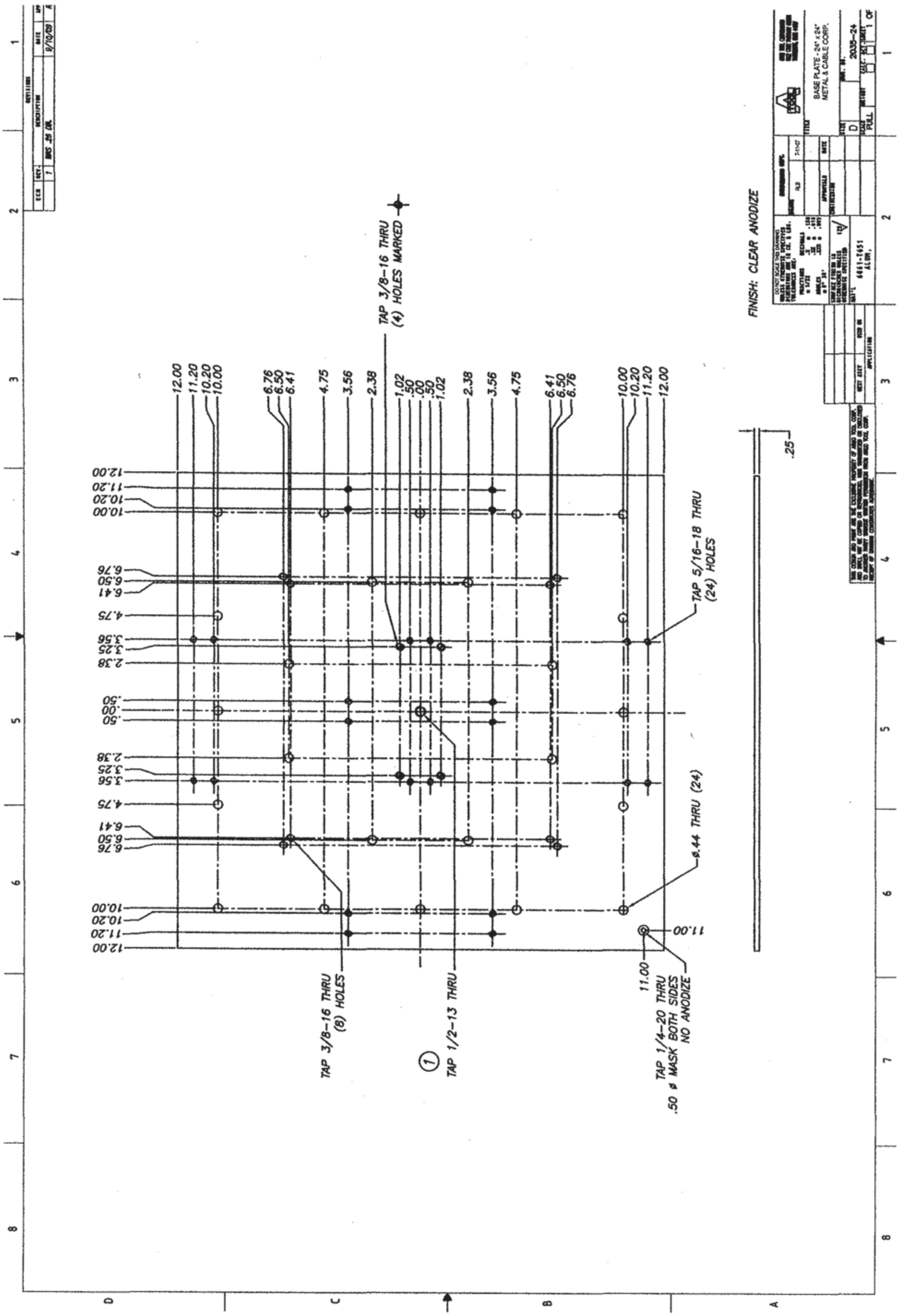
20.30 Tensile Load (wind + mass + ice)
4.93 Factor of Safety

Combined Loads - Side Wind Situation

9.31 Combined "shear" (wind + mass + ice)
3.76 Factor of Safety

15.63 Tensile Load (wind + mass + ice)
6.40 Factor of Safety

Appendix 04


FINISH: CLEAR ANODIZE
TAP 3/8-16 THRU
(4) HOLES MARKED
TAP 5/16-18 THRU
(24) HOLES
ø.44 THRU (24)
TAP 3/8-16 THRU
(8) HOLES
TAP 1/2-13 THRU
TAP 1/4-20 THRU
.50 ø MASK BOTH SIDES
NO ANODIZE
BASE PLATE - 24" x 24"
METAL & CABLE CORP.
2035-24
6061-T651
ALUM.

Appendix 05