

**ATS-Sales, LLC**  
14522-K Lee Rd, Chantilly VA 20151-1639

703.631.6661(O)  
703.631.6694(F)

November 2, 2021

Re: Mast Arm Poles  
MP-3 Standard Loads – 90 MPH Wind  
Virginia  
ATS# 16362-3

This is to certify that the traffic poles for the above referenced intersection were designed in accordance with:

- o **The project plans and specifications**
- o **VDOT 2020 Road and Bridge Specifications**
- o **The 2013 AASHTO Specification (LTS-6), Using:**
  - **90 mph wind velocity with Appendix C**
  - **25 Year Recurrence**
  - **Fatigue Category II (No fatigue loads for mast arms smaller than 50')**
    - **Natural Wind Gusts (11.2 MPH)**
    - **No Galloping Loads**
    - **No truck-induced Gust**
  - **Maximum Standard Loading (MP-3)**

The following identifies this submittal's documents:

ATS Drawings: 16362-3(A) Rev. C, 16362-3(B) Rev. C, 16362-3(C) Rev. C &  
16362-3(D) Rev. C, 16362-3(E) Rev. C, 16362-3(F) Rev. C  
Calculations Dated: November 2, 2021, Consisting of 374 pages

In accordance with the Virginia Department of Transportation Road and Bridge Specification, I am a registered Professional Engineer holding a valid license in the Commonwealth of Virginia.

Sincerely,

Armand A. Damiano, P.E.

VIRGINIA DEPARTMENT OF TRANSPORTATION C.O. STRUCTURE AND BRIDGE REVIEW OF WORKING DRAWINGS	
Working drawings have been reviewed in accordance with Section 105.10 of the Specifications with the following comments.	
<input checked="" type="checkbox"/> Reviewed	<input type="checkbox"/> Revise and Resubmit
<input type="checkbox"/> Reviewed as Noted	
Reviewed by: Karl Larson 11/30/2021	



**Submittal Revisions**

<u>Description</u>	<u>Pages</u>	<u>Signed Date</u>
Original Design	1 - 367	April 05, 2019
Revision per VDOT Review Comments	1 - 370	September 11, 2019
Revision per VDOT Review Comments	1 - 370	October 2, 2019
Revision per VDOT Review Comments, conformance to updated VDOT Std., Flange Connection Data Table Added, corrections to minor errors & typos.	1 - 374	November 2, 2021



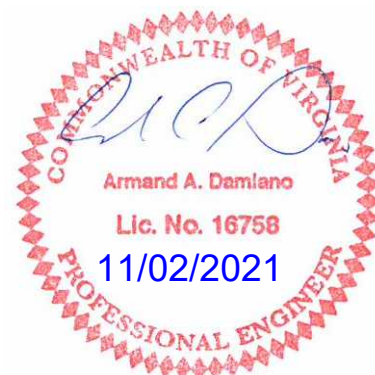
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**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-1 - VA - 90 MPH - MP-3 Std. Loads - Type A - 49' Arm

11/02/21

**General**

Wind Vel. - mph	90	Roadway - mph	55	<b>Fatigue Importance Factors</b>	
Natural Wind	11.2	Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65	Wind Import. Ir	0.870	Galloping	0.00 No
Fatigue Cat.	0	Vel. Conver. Cv	0.930	Vortex Shedding	0.00 No
Recurrence (yr)	25	Gust Effect G	1.300	Natural Wind Gust	0.00 No
Hurricane Region	0 No	Elev. Pole Bot.(ft)	1	Truck Gust	0.00 No
# Traffic Arms	1	<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	Yes
# Lum. Arms	0	State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.2500	0.14	17.00	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.2190	0.14	14.00	49.00	18.00	-	2.57	0	55	29000	180
Traffic Arm #2								0	55	29000	90
Lum Arm #1								0	36	29000	180
Lum Arm #2								0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	6	Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00 in	Double Top Nuts	Yes	
A.B. Bolt Circle	24.00 in	Foundation Diameter	48	in
Baseplate Dia.	30.00 in	Concrete Cover	4	in
Baseplate Thk.	2.00 in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	12.50 in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.	Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50 in	in
Flange Plate Length (V)	24.00 in	in
Flange Plate Width (H)	24.00 in	in
Spac. Between Bolt (V)	19.50 in	in
Spac. Between Bolt (H)	19.50 in	in
Flange Plate Thk.	2.00 in	in
Flange Plate Yield (Fy)	50 ksi	ksi
Gusset Thk.	0.375 in	in
Plate Center Hole	6.00 in	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.25	0.34	0.41								15.06	0.00
GP II CSR	0.92	0.87	0.97									
GP III CSR	0.56	0.59	0.70								24.83	

Arm #1 Flange Bolt (Max.) CSR	0.36
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.69
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.00
Handhole at Toe (Fatigue) CSR	0.00
Minimum Qty of Vertical Reinf. Bars	6

Fatigue Allowable - Shaft to Baseplate	
Fatigue Allowable - Arm#1 to Flange	
Fatigue Allowable - Arm#2 to Flange	
Anchor Bolt Max. CSR	0.63
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.56
Anchorage Capacity S.F.	1.49
Concrete Pull Out Capacity S.F.	1.70

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
4091	6069	128706	117926

Rev. 06/26/2018



16362-3-1 - VA - 90 MPH - MP-3 Std. Loads - Type A - 49' Arm

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft.)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd	
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.2	
	#2	Ped Head	10.5	2.4	1			1	6	30	1.2	
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.2	
	#4											
Lum #1	#1											
Lum #2	#1											
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20	
	#2	12'x2.5' Sign	7.5			12	2.5	1	30	66	1.20	
	#3	5 Section Head w/BP	16	13.75	4			2	42	105	1.20	
	#4	2.5'x3' Sign	23			2.5	3	1	7.5	22.5	1.13	
	#5	Camera	24	1	1			1	3	22	1.20	
	#6	3 Section Head w/BP	26	8.7	4			1	26	65	1.20	
	#7	2.5'x3' Sign	34			2.5	3	1	7.5	22.5	1.13	
	#8	3 Section Head w/BP	37	8.7	4			1	26	65	1.20	
	#9	Camera	39	1	1			1	3	22	1.20	
	#10	3'x3.5' Sign	45			3	3.5	1	10.5	26.7	1.13	
	#11	4 Section Head w/BP	48	11	5			1	34	80	1.20	
	#12											
	#13											
#14												
#15												
#16												
#17												
#18												
#19												
#20												
For Arm #2	#1											
	#2											
	#3											
	#4											
	#5											
	#6											
	#7											
	#8											
	#9											
	#10											
	#11											
	#12											
	#13											
#14												
#15												
#16												
#17												
#18												
#19												
#20												



16362-3-1 - VA - 90 MPH - MP-3 Std. Loads - Type A - 49' Arm

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	17.000	16.852	47.19	0.5286	0.53	1.493	14.57	0.80
2	I	1.06	1.06	16.852	16.704	46.77	0.5286	1.59	1.480	14.45	0.80
3	I	1.06	2.12	16.704	16.555	46.35	0.5286	2.65	1.467	14.33	0.80
4	I	1.06	3.18	16.555	16.407	45.93	0.5286	3.71	1.454	14.20	0.80
5	I	1.06	4.24	16.407	16.259	45.51	0.5286	4.76	1.441	14.08	0.80
6	I	1.06	5.29	16.259	16.111	45.09	0.5286	5.82	1.428	13.96	0.80
7	I	1.06	6.35	16.111	15.962	44.67	0.5286	6.88	1.415	13.83	0.80
8	I	1.06	7.41	15.962	15.814	44.25	0.5286	7.94	1.402	13.71	0.80
9	I	1.06	8.47	15.814	15.666	43.83	0.5286	9.00	1.389	13.59	0.80
10	I	1.06	9.53	15.666	15.518	43.41	0.5286	10.06	1.376	13.46	0.80
11	I	1.06	10.59	15.518	15.369	42.99	0.5286	11.12	1.363	13.34	0.80
12	I	1.06	11.65	15.369	15.221	42.57	0.5286	12.18	1.350	13.22	0.80
13	I	1.06	12.71	15.221	15.073	42.15	0.5285	13.23	1.337	13.10	1.00
14	I	1.06	13.76	15.073	14.925	41.73	0.5285	14.29	1.323	12.97	1.00
15	I	1.06	14.82	14.925	14.776	41.32	0.5285	15.35	1.310	12.85	1.00
16	I	1.06	15.88	14.776	14.628	40.90	0.5285	16.41	1.297	12.73	1.00
17	I	1.06	16.94	14.628	14.480	40.48	0.5285	17.47	1.284	12.60	1.00
18	J	0.50	18.00	14.480	14.410	18.97	0.2498	18.25	0.602	5.91	1.00
19	I	0.50	18.50	14.410	14.340	18.87	0.2498	18.75	0.599	5.88	1.00
20	I	0.50	19.00	14.340	14.270	18.78	0.2498	19.25	0.596	5.85	1.00
						802					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in <sup>4</sup> )	461.13	282.74	0.00	270.41
Section Modulus (in <sup>3</sup> )	55.06	39.74	0.00	
Cross-Section Area (in <sup>2</sup> )	13.15	11.17	0.00	
Width-Thickness Ratio	68.00	57.92	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	17.484	17.484	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.984
Shaft Deflection From Arm#2 GP I Load (in)	0.000

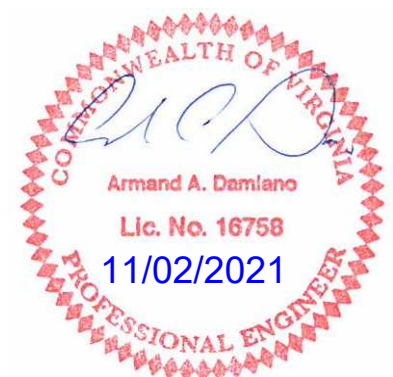




16362-3-1 - VA - 90 MPH - MP-3 Std. Loads - Type A - 49' Arm

## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	18.85	0.000	18.67	1.100	0.000	0.00
2	0.450	12.62	18.68	0.000	18.50	1.100	0.000	0.00
3	0.450	12.62	18.52	0.000	18.34	1.100	0.000	0.00
4	0.450	12.62	18.35	0.000	18.18	1.100	0.000	0.00
5	0.450	12.62	18.19	0.001	18.01	1.100	0.000	0.00
6	0.450	12.62	18.02	0.001	17.85	1.100	0.000	0.00
7	0.450	12.62	17.86	0.001	17.69	1.100	0.000	0.00
8	0.450	12.62	17.69	0.001	17.52	1.100	0.000	0.00
9	0.450	12.62	17.53	0.002	17.36	1.100	0.000	0.00
10	0.450	12.62	17.36	0.002	17.20	1.100	0.000	0.00
11	0.450	12.62	17.20	0.002	17.03	1.100	0.000	0.00
12	0.450	12.62	17.03	0.003	16.87	1.100	0.000	0.00
13	0.450	15.77	21.08	0.004	16.71	1.100	0.000	0.00
14	0.450	15.77	20.87	0.005	16.54	1.100	0.000	0.00
15	0.450	15.77	20.66	0.005	16.38	1.100	0.000	0.00
16	0.450	15.77	20.46	0.006	16.22	1.100	0.000	0.00
17	0.450	15.77	20.25	0.006	16.05	1.100	0.000	0.00
18	0.450	15.77	9.49	0.003	7.52	1.100	0.000	0.00
19	0.450	15.77	9.45	0.003	7.49	1.100	0.000	0.00
20	0.450	15.77	9.40	0.003	7.45	1.100	0.000	0.00
Fix. #1	1.200	33.65	80.76	0.010	40.38	1.200	0.000	0.00
Fix. #2	1.200	33.65	80.76	0.010	40.38	1.200	0.000	0.00
Fix. #3	1.200	42.06	578.33	0.137	289.16	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-1 - VA - 90 MPH - MP-3 Std. Loads - Type A - 49' Arm

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	2.45	0.00	14.000	13.657	78.1	1.2199	1.22	2.823	2.823	27.76
2	I	2.45	2.45	13.657	13.314	76.1	1.2198	3.67	2.753	2.753	27.10
3	I	2.45	4.90	13.314	12.971	74.1	1.2197	6.12	2.683	2.683	26.44
4	I	2.45	7.35	12.971	12.628	72.2	1.2195	8.57	2.613	2.613	25.78
5	I	2.45	9.80	12.628	12.285	70.2	1.2194	11.02	2.543	2.543	25.12
6	I	2.45	12.25	12.285	11.942	68.2	1.2192	13.47	2.473	2.473	24.46
7	I	2.45	14.70	11.942	11.599	66.3	1.2191	15.92	2.403	2.403	23.80
8	I	2.45	17.15	11.599	11.256	64.3	1.2189	18.37	2.333	2.333	23.14
9	I	2.45	19.60	11.256	10.913	62.3	1.2187	20.82	2.263	2.263	22.48
10	I	2.45	22.05	10.913	10.570	60.4	1.2185	23.27	2.193	2.193	21.82
11	I	2.45	24.50	10.570	10.227	58.4	1.2183	25.72	2.123	2.123	21.16
12	I	2.45	26.95	10.227	9.884	56.4	1.2180	28.17	2.053	2.053	20.50
13	I	2.45	29.40	9.884	9.541	54.5	1.2178	30.62	1.983	1.983	19.84
14	I	2.45	31.85	9.541	9.198	52.5	1.2175	33.07	1.913	1.913	19.18
15	I	2.45	34.30	9.198	8.855	50.5	1.2172	35.52	1.843	1.843	18.52
16	I	2.45	36.75	8.855	8.512	48.6	1.2169	37.97	1.773	1.773	17.86
17	I	2.45	39.20	8.512	8.169	46.6	1.2166	40.42	1.703	1.703	17.20
18	I	2.45	41.65	8.169	7.826	44.6	1.2162	42.87	1.633	1.633	16.54
19	I	2.45	44.10	7.826	7.483	42.6	1.2159	45.32	1.563	1.563	15.88
20	I	2.45	46.55	7.483	7.140	40.7	1.2154	47.77	1.493	1.493	15.22
		<u>49.00</u>				<u>1187</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	66	7.50	30.000	1.000	90.00
Fix. #3	105	16.00	13.750	2.000	126.00
Fix. #4	22.5	23.00	7.500	1.000	22.50
Fix. #5	22	24.00	1.000	1.000	9.00
Fix. #6	65	26.00	8.700	1.000	78.00
Fix. #7	22.5	34.00	7.500	1.000	22.50
Fix. #8	65	37.00	8.700	1.000	78.00
Fix. #9	22	39.00	1.000	1.000	9.00
Fix. #10	26.7	45.00	10.500	1.000	31.50
Fix. #11	80	48.00	11.000	1.000	102.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	32.649	0.000
Cross-Section Area (in^2)	9.477	0.000
Width-Thickness Ratio	63.93	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	36.300	0.000
Allow. Shear Stress (ksi)	18.150	0.000



16362-3-1 - VA - 90 MPH - MP-3 Std. Loads - Type A - 49' Arm

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000 Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	44.52	35.29	1.100	0.000	0.00	0	0.644	0.00	0.00	
2	1.00	0.450	15.77	43.42	34.42	1.100	0.000	0.00	0	0.666	0.00	0.00	
3	1.00	0.450	15.77	42.32	33.54	1.100	0.000	0.00	0	0.688	0.00	0.00	
4	1.00	0.450	15.77	41.21	32.67	1.100	0.000	0.00	0	0.712	0.00	0.00	
5	1.00	0.450	15.77	40.11	31.79	1.100	0.000	0.00	0	0.738	0.00	0.00	
6	1.00	0.450	15.77	39.00	30.91	1.100	0.000	0.00	0	0.765	0.00	0.00	
7	1.00	0.450	15.77	37.90	30.04	1.100	0.000	0.00	0	0.794	0.00	0.00	
8	1.00	0.450	15.77	36.79	29.16	1.100	0.000	0.00	0	0.825	0.00	0.00	
9	1.00	0.450	15.77	35.69	28.29	1.100	0.000	0.00	0	0.859	0.00	0.00	
10	1.00	0.450	15.77	34.58	27.41	1.100	0.000	0.00	0	0.895	0.00	0.00	
11	1.00	0.450	15.77	33.48	26.54	1.100	0.000	0.00	0	0.933	0.00	0.00	
12	1.00	0.450	15.77	32.38	25.66	1.100	0.000	0.00	0	0.975	0.00	0.00	
13	1.00	0.450	15.77	31.27	24.79	1.100	0.000	0.00	0	1.020	0.00	0.00	
14	1.00	0.450	15.77	30.17	23.91	1.100	0.000	0.00	0	1.069	0.00	0.00	
15	1.00	0.450	15.77	29.06	23.04	1.100	0.000	0.00	1	1.100	0.00	0.00	
16	1.00	0.450	15.77	27.96	22.16	1.100	0.000	0.00	1	1.100	0.00	0.00	
17	1.00	0.462	16.2	27.59	21.29	1.100	0.000	0.00	1	1.100	0.00	0.00	
18	1.00	0.488	17.11	27.94	20.41	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.517	18.12	28.32	19.53	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.549	19.23	28.71	18.66	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	42.03	1260.90	630.45	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	365.92	182.96	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	39.66	416.43	208.22	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	462.66	231.33	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



16362-3-1 - VA - 90 MPH - MP-3 Std. Loads - Type A - 49' Arm  
Flange Analysis - Arm #1

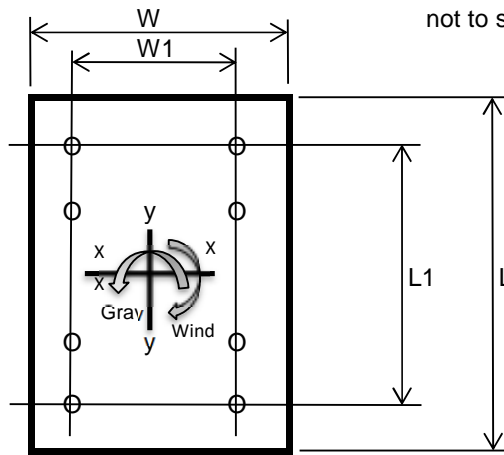
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Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1706	2713	-	lbs
Shear (Wind)	4865	2626	-	lbs
Torsion (Arm Rise)	12491	6742	-	ft-lbs
Moment (Gravity)	39946	65204	-	ft-lbs
Moment (Wind)	117926	63047	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	14.00	in
Tube Wall Thick.	0.219	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.00
W	24
W1	19.50
L	24
L1	19.50
L2 - Dist. between bolts (Typ.)	6.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	596.99	596.99	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1073.57	1073.57	in <sup>4</sup>
Bolt Tensile Stress - ft	15.05	14.51	ksi
Bolt Shear Stress - fv	1.82	1.1	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.36	0.34	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	0	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	9.51	15.52	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	28.55	15.26	ksi
Combined applied stress for interaction (SRSS)	30.09	21.77	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-1 - VA - 90 MPH - MP-3 Std. Loads - Type A - 49' Arm

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

<b>Arm#1 Base</b>											
Gp I	1706		1706	39946		39947		361	14682		0.41
Gp II	1706	4865	5156	39946	117926	124508	12491	1089	45762	2296	0.97
Gp III	2713	2626	3776	65204	63047	90700	6742	797	33336	1239	0.70
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Arm#1 Joint</b>											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Arm#2 Base</b>											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Arm#2 Joint</b>											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Lum#1 Base</b>											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Lum#2 Base</b>											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-1 - VA - 90 MPH - MP-3 Std. Loads - Type A - 49' Arm

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

**Shaft Base**

Gp I	2673		39946	0	39946		203		8706		0.25
Gp II	2673	6069	59958	113887	128706	117926	203	924	28050	12850	0.92
Gp III	4091	3379	54005	84197	100028	63047	311	514	21800	6870	0.56
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9967										

**Shaft At Arm**

Gp I	1763		39946	0	39946		158		12062		0.34
Gp II	1763	4893	12491	39968	41874	117926	158	877	12645	17805	0.87
Gp III	2770	2648	6742	65221	65569	63047	248	475	19800	9519	0.59
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9967										



**Gusset Box Stress Check  
For Flange Style F1  
Used On Shaft Types A & D  
Wind Velocity of 90 mph  
Using Governing Load: 49'**

**Input Information**

Gusset Plate Thickness	0.375	in.	
Gusset Yield Strength Fy	50000	psi	A572 Gr 50
Shaft Base Diameter	17.00	in.	
Height To C.L. of Arm Attach.	18.00	ft.	
Shaft Dia. C.L. of Arm Attach.	14.48	in.	Width Between Gussets
Flange Plate Height	24.0	in.	
Flange Plate Width	24.0	in.	
Box Cross-Sectional Area	28.86	sq.in.	

**Applied Loads Onto Flange Box Taken From Pole Analysis - 49'**

Gravity Moment	39,946	ft-lbs
Wind Moment	117,926	ft-lbs
Torsion Moment	12491	ft-lbs
Direct Shear	5156	lbs

**Computing Moments of Inertia**

For Gravity			For Wind		
d	24	in	d	15.23	in
b	15.23	in	b	24	in
d'	23.25	in	d'	14.48	in
b'	14.48	in	b'	23.25	in
Inertia	2379.48	in <sup>4</sup>	Inertia	1182.98	in <sup>4</sup>

**Computing Stress**

Gravity = $Mc/I =$	2418	psi	
Wind = $Mc/I =$	9110	psi	
Torsion = $M/[2t(a-b)(b-t)] =$	569	psi	Roark's Table 10.1 #16
Shear = $2.25 * V / A =$	402	psi	

**Allowables**

Bending = $0.66 F_y 1.33 =$	43890	psi
Torsion Limited by b/t ratio	15,430	psi
b/t =	64.0	
$12000 / F_y^{0.5} =$	54.0	

**Result**

CSR = 0.33 Which is  $\leq 1$  Therefore OK  
To be conservative bending stresses were added not SRSS



16362-3-1 - VA - 90 MPH - MP-3 Std. Loads - Type A - 49' Arm  
 Weld Analysis

**INPUTS**

	<b>Gp II</b>	<b>GpIII</b>		<b>Arm Dimensions</b>	
<b>Applied Loads To Flange Connection</b>					
Vert. Shr	1706	2713	lbs	Diameter (d)	14.0 in
Horz. Shr	4865	2626	lbs	Tube Wall Thk	0.219 in
Torsion Moment	12491	6742	ft-lbs	Plate Thk (D)	2 in
Gravity Moment	39946	65204	ft-lbs	Plate Yield (Fy)	50 ksi
Wind Moment	117926	63047	ft-lbs		
<b>Applied Loads To Base Plate Connection</b>				<b>Shaft Dimensions</b>	
Axial	0	0	lbs	Diameter (d)	16.0 in
Shear	0	0	lbs	Tube Wall Thk	<b>0.25</b> in
Shear	0	0	lbs	Plate Thk (D)	2 in
Bending Moment	0	0	ft-lbs	Plate Yield (Fy)	36 ksi
Bending Moment	0	0	ft-lbs	Arm Attach. Elev.	<b>18.0</b> ft
Torsion Moment	0	0	ft-lbs		

**Additional Load Factor To Apply As Per Signal Plans & Specifications = 1.00**

**Electrodes**

**AASHTO Gp II & III Factor = 1.33**

**E70 Electrodes (Used with plates having Fy = 36 ksi)**

Fv = 0.27 Fu (AASHTO Bridge Spec 10.32.2)

Fv = 0.27 x 58000 = 15660 psi

Allowable = Fv \* Gp Factor = 20828 psi

**E70 Electrodes (Used with plates having Fy = 50 ksi)**

Fv = 0.27 x 65000 = 17550 psi

Allowable = Fv \* Gp Factor = 23342 psi

Reference: *Design of Welded Structures*, Omer W. Blodgett

Method: Weld As A Line



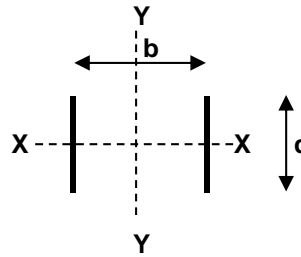


16362-3-1 - VA - 90 MPH - MP-3 Std. Loads - Type A - 49' Arm  
Weld Analysis - Continued

**ARM CONNECTING PLATES**

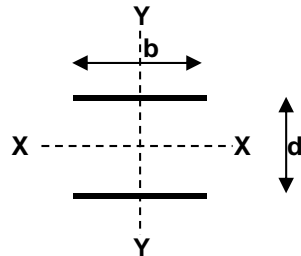
**Side Plates**

Vertical Length (d)	24.50	in
Horz. Dist Between Plates (b)	13.48	in
Thickness	<b>0.375</b>	in
Weld Size	<b>0.25</b>	in
Weld Throat (t <sub>1</sub> )	0.177	in
$A_1 = A_{w1} * t_1 = 2 * d * t_1$	=	8.66 in <sup>2</sup>
$S_{x1} = S_{wx1} * t_1 = (d^2 / 3) * t_1$	=	35.36 in <sup>3</sup>
$S_{y1} = S_{wy1} * t_1 = b * d * t_1$	=	58.37 in <sup>3</sup>
$J_1 = J_{w1} * t_1 = t_1 * d(3b^2 + d^2) / 6$	=	826.70 in <sup>4</sup>



**Top & Bottom Plates**

Vert. Dist Between Plates (d)	24.50	in
Horz. Length (b)	21.17	in
Thickness	<b>0.375</b>	in
Weld Size	<b>0.25</b>	in
Weld Throat (t <sub>2</sub> )	0.177	in
$A_2 = A_{w2} * t_2 = t_2 * 2 * b$	=	7.5 in <sup>2</sup>
$S_{x2} = S_{wx2} * t_2 = t_2 * b * d$	=	91.7 in <sup>3</sup>
$S_{y2} = S_{wy2} * t_2 = t_2 * (b^2 / 3)$	=	26.4 in <sup>3</sup>
$J_2 = J_{w2} * t_2 = t_2 * (b^3 + 3bd^2) / 6$	=	1402.9 in <sup>4</sup>



**Combined Analysis**

$\sigma_1 = \text{Gravity Mom} / (S_{x1} + S_{x2})$	=	3773.0	Gp II	6159.0	psi
$\sigma_2 = \text{Wind Mom} / (S_{y1} + S_{y2})$	=	16690.0	Gp III	8923.0	psi
$\sigma_2 = [\text{Tor. Mom} * C / (J_1 + J_2)] + [\text{Res. Shr} / (A_1 + A_2)]$	=	1260.0		742.0	psi
Res. Weld Stress = $\sigma_r = \text{Sqrt}[(\sigma_1 + \sigma_2)^2 + \sigma_3^2]$	=	20502		15101	psi
Allowable: E70 Electrodes * AASHTO Gp Factor	=	23341.5		23341.5	psi
<b>Actual Weld Stress vs. Allowable</b>		<b>Passes</b>		<b>Passes</b>	



16362-3-1 - VA - 90 MPH - MP-3 Std. Loads - Type A - 49' Arm

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	6069 lbs
Bending Moment	128706 ft-lbs
Torsion Moment	117926 ft-lbs
Num. Anchor Bolts	6
Bolt Circle	24 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	30 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	17.00 in

**ANALYSIS - ANCHOR BOLTS**

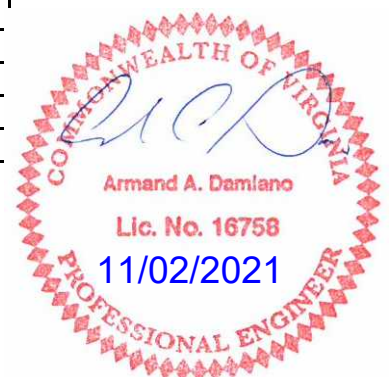
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1082.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	17.114 ksi
Bolt Direct Shear Stress	0.44 ksi
Bolt Torsion Shear Stress	8.546 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	17.114 ksi
$f_v =$	8.986 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.63 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	12.701 in
Dist. Shaft Face To Bolt Center	3.5 in
Design Moment	150 in-kip
Section Modulus of Failure Plane	8.46 in <sup>3</sup>
Applied Plate Stress	17.74 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	12.052 in
Dist From Shaft To Nut Face	1.938 in
Design Moment	83 in-kip
Section Modulus of Failure Plane	8.03 in <sup>3</sup>
Applied Plate Stress	10.34 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-1 - VA - 90 MPH - MP-3 Std. Loads - Type A - 49' Arm

Anchor Bolt & Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1082.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	0 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

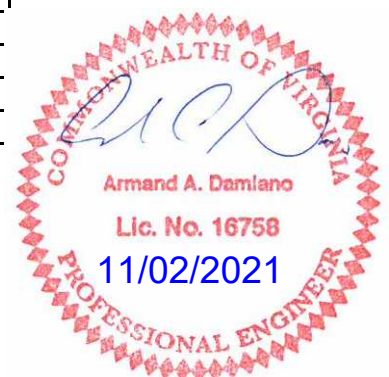
Anchor Bolt Length	60.0 in
Anchor Bolt Max. Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	127540 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	11 in
T Reduced For Group Action	63770 lbs
Maximum Applied Tensile Load	42785 lbs
Computed Factor-of Safety	1.49 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	42785 lbs
Total Tensile Load	256710 lbs
Concrete Failure Surface Area	4002.39 in <sup>2</sup>
Concrete Shear Strength	438440 psi
Computed Factor-of Safety	1.7 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	42785 lbs
Total Tensile Load	256710 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	45.36 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	<b>6</b> Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm Case1

11/02/21

**General**

Wind Vel. - mph	90	No	Roadway - mph	55	<b>Fatigue Importance Factors</b>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	0		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

**Pole Variables**

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Member E (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.00	19.50	-	-	-	0	55	29000	29000	-
Traffic Arm #1	0.3125	0.14	18.50	28.00	18.00	-	3.93	0	55	29000	29000	180
	0.1880	0.14	15.37	49.99	-	2.93		0	55	29000		
Traffic Arm #2								0	55	29000	29000	90
								0	55	29000		
Lum Arm #1								0	36	29000	29000	180
Lum Arm #2								0	36	29000	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8		Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes	
A.B. Bolt Circle	26.00	in	Foundation Diameter	48	in
Baseplate Dia.	32.00	in	Concrete Cover	4	in
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	15.25	in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.		Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1		Arm #2	
Flange Bolt Qty.	8		NA	
Bolt Diameter	1.50	in		in
Flange Plate Length (V)	27.00	in		in
Flange Plate Width (H)	27.00	in		in
Spac. Between Bolt (V)	22.50	in		in
Spac. Between Bolt (H)	22.50	in		in
Flange Plate Thk.	2.25	in		in
Flange Plate Yield (Fy)	50	ksi		ksi
Gusset Thk.	0.500	in		in
Plate Center Hole	6.00	in		in
Weld Type	Full Pen.			

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.32	0.41	0.43	0.42							29.50	0.00
GP II CSR	0.80	0.86	0.84	0.96								
GP III CSR	0.57	0.65	0.66	0.72							47.63	
Nat.Wind (psi)	2695	572	5414	5706								

Arm #1 Flange Bolt (Max.) CSR	0.70
Arm #1 Flange Bolt Fatigue CSR	0.50
Arm #1 Flange Plate (Max.) CSR	0.97
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.64
Handhole at Toe (Fatigue) CSR	0.40
Minimum Qty of Vertical Reinf. Bars	9

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.80
Anchor Bolt Max. Fatigue Stress Ratio	0.34
Base Plate Max. CSR	0.71
Anchorage Capacity S.F.	1.26
Concrete Pull Out Capacity S.F.	1.20

**Ground Line Reactions**

	Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
	7044	8170	212843	245142



16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm Case1

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1										
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	9			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	19	13.75	4			2	42	105	1.20
	#4	2.5'x3' Sign	23			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	30	8.7	4			1	26	65	1.20
	#6	3 Section Head w/BP	41	8.7	4			1	26	65	1.20
	#7	Camera	45	1	1			1	3	22	1.20
	#8	2.5'x3' Sign	49			2.5	3	1	7.5	22.5	1.13
	#9	3 Section Head w/BP	52	8.7	4			1	26	65	1.20
	#10	2.5'x3' Sign	60			2.5	3	1	7.5	22.5	1.13
	#11	3 Section Head w/BP	63	8.7	4			1	26	65	1.20
	#12	Camera	67	1	1			1	3	22	1.20
	#13	3'x3.5' Sign	71			3	3.5	1	10.5	26.7	1.13
	#14	4 Section Head w/BP	74	11	5			1	34	80	1.20
	#15										
#16											
#17											
#18											
#19											
#20											
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
#16											
#17											
#18											
#19											
#20											



16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm Case1

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.000	19.852	82.99	0.5288	0.53	1.758	17.07	0.80
2	I	1.06	1.06	19.852	19.704	82.36	0.5288	1.59	1.745	16.95	0.80
3	I	1.06	2.12	19.704	19.555	81.73	0.5287	2.65	1.732	16.82	0.80
4	I	1.06	3.18	19.555	19.407	81.10	0.5287	3.71	1.719	16.70	0.80
5	I	1.06	4.24	19.407	19.259	80.47	0.5287	4.76	1.706	16.58	0.80
6	I	1.06	5.29	19.259	19.111	79.84	0.5287	5.82	1.693	16.45	0.80
7	I	1.06	6.35	19.111	18.962	79.21	0.5287	6.88	1.680	16.33	0.80
8	I	1.06	7.41	18.962	18.814	78.58	0.5287	7.94	1.667	16.21	0.80
9	I	1.06	8.47	18.814	18.666	77.95	0.5287	9.00	1.654	16.08	0.80
10	I	1.06	9.53	18.666	18.518	77.32	0.5287	10.06	1.640	15.96	0.80
11	I	1.06	10.59	18.518	18.369	76.69	0.5287	11.12	1.627	15.84	0.80
12	I	1.06	11.65	18.369	18.221	76.06	0.5287	12.18	1.614	15.71	0.80
13	I	1.06	12.71	18.221	18.073	75.43	0.5287	13.23	1.601	15.59	1.00
14	I	1.06	13.76	18.073	17.925	74.81	0.5287	14.29	1.588	15.47	1.00
15	I	1.06	14.82	17.925	17.776	74.18	0.5287	15.35	1.575	15.34	1.00
16	I	1.06	15.88	17.776	17.628	73.55	0.5287	16.41	1.562	15.22	1.00
17	I	1.06	16.94	17.628	17.480	72.92	0.5287	17.47	1.549	15.10	1.00
18	J	0.50	18.00	17.480	17.410	34.21	0.2498	18.25	0.727	7.09	1.00
19	I	0.50	18.50	17.410	17.340	34.07	0.2498	18.75	0.724	7.06	1.00
20	I	0.50	19.00	17.340	17.270	33.93	0.2498	19.25	0.721	7.03	1.00
						1428					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	1112.50	736.61	0.00	709.82
Section Modulus (in^3)	113.38	86.13	0.00	
Cross-Section Area (in^2)	23.11	20.14	0.00	
Width-Thickness Ratio	53.33	46.61	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	20.948	20.948	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

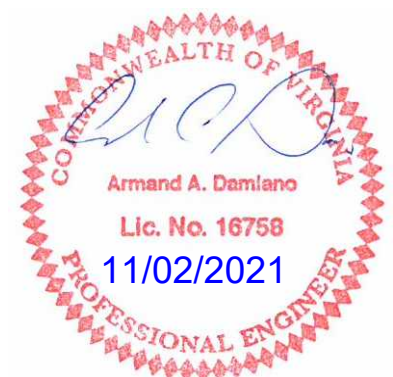
Shaft Deflection From Arm#1 GP I Load (in)	1.040
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm Case1

## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.19	0.000	21.98	1.100	4.576	8.05
2	0.450	12.62	22.02	0.000	21.81	1.100	4.576	7.99
3	0.450	12.62	21.86	0.000	21.65	1.100	4.576	7.93
4	0.450	12.62	21.69	0.000	21.49	1.100	4.576	7.87
5	0.450	12.62	21.53	0.000	21.32	1.100	4.576	7.81
6	0.450	12.62	21.36	0.000	21.16	1.100	4.576	7.75
7	0.450	12.62	21.20	0.000	21.00	1.100	4.576	7.69
8	0.450	12.62	21.03	0.001	20.83	1.100	4.576	7.63
9	0.450	12.62	20.87	0.001	20.67	1.100	4.576	7.57
10	0.450	12.62	20.70	0.001	20.51	1.100	4.576	7.51
11	0.450	12.62	20.54	0.001	20.34	1.100	4.576	7.45
12	0.450	12.62	20.37	0.001	20.18	1.100	4.576	7.39
13	0.450	15.77	25.25	0.002	20.02	1.100	4.576	7.33
14	0.450	15.77	25.04	0.002	19.85	1.100	4.576	7.27
15	0.450	15.77	24.84	0.002	19.69	1.100	4.576	7.21
16	0.450	15.77	24.63	0.003	19.52	1.100	4.576	7.15
17	0.450	15.77	24.43	0.003	19.36	1.100	4.576	7.09
18	0.450	15.77	11.46	0.002	9.09	1.100	4.576	3.33
19	0.450	15.77	11.42	0.002	9.05	1.100	4.576	3.31
20	0.450	15.77	11.37	0.002	9.01	1.100	4.576	3.30
Fix. #1	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.056	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm Case1

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	4.18	0.00	18.500	17.915	249.8	2.0780	2.08	6.340	6.340	61.72
2	I	4.18	4.18	17.915	17.330	241.6	2.0776	6.26	6.136	6.136	59.80
3	I	4.18	8.36	17.330	16.745	233.5	2.0772	10.43	5.932	5.932	57.88
4	I	4.18	12.54	16.745	16.160	225.3	2.0768	14.61	5.729	5.729	55.96
5	I	4.18	16.71	16.160	15.575	217.1	2.0763	18.79	5.525	5.525	54.04
6	I	4.18	20.89	15.575	14.990	209.0	2.0758	22.97	5.321	5.321	52.12
7	J	2.93	25.07	15.370	14.960	229.9	1.4584	26.53	3.703	3.703	36.28
8	O	3.62	28.00	14.960	14.453	105.6	1.7996	29.80	4.436	4.436	43.52
9	O	3.62	31.62	14.453	13.946	101.9	1.7992	33.42	4.284	4.284	42.08
10	O	3.62	35.24	13.946	13.439	98.3	1.7988	37.04	4.131	4.131	40.64
11	O	3.62	38.86	13.439	12.933	94.6	1.7984	40.66	3.978	3.978	39.20
12	O	3.62	42.48	12.933	12.426	90.9	1.7979	44.28	3.825	3.825	37.75
13	O	3.62	46.10	12.426	11.919	87.2	1.7974	47.90	3.672	3.672	36.31
14	O	3.62	49.72	11.919	11.412	83.5	1.7969	51.52	3.519	3.519	34.87
15	O	3.62	53.34	11.412	10.905	79.8	1.7963	55.14	3.366	3.366	33.43
16	O	3.62	56.96	10.905	10.399	76.1	1.7956	58.76	3.213	3.213	31.99
17	O	3.62	60.58	10.399	9.892	72.4	1.7949	62.37	3.060	3.060	30.55
18	O	3.62	64.20	9.892	9.385	68.8	1.7941	65.99	2.908	2.908	29.11
19	O	3.62	67.82	9.385	8.878	65.1	1.7933	69.61	2.755	2.755	27.67
20	O	3.62	71.44	8.878	8.371	61.4	1.7923	73.23	2.602	2.602	26.23
		<u>75.06</u>				<u>2692</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	9.00	37.500	1.000	112.50
Fix. #3	105	19.00	13.750	2.000	126.00
Fix. #4	22.5	23.00	7.500	1.000	22.50
Fix. #5	65	30.00	8.700	1.000	78.00
Fix. #6	65	41.00	8.700	1.000	78.00
Fix. #7	22	45.00	1.000	1.000	9.00
Fix. #8	22.5	49.00	7.500	1.000	22.50
Fix. #9	65	52.00	8.700	1.000	78.00
Fix. #10	22.5	60.00	7.500	1.000	22.50
Fix. #11	65	63.00	8.700	1.000	78.00
Fix. #12	22	67.00	1.000	1.000	9.00
Fix. #13	26.7	71.00	10.500	1.000	31.50
Fix. #14	80	74.00	11.000	1.000	102.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	81.146	34.016
Cross-Section Area (in^2)	17.846	8.962
Width-Thickness Ratio	59.20	81.76
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	33.901
Allow. Shear Stress (ksi)	18.150	16.085





16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm Case1

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	
1	1.00	0.450	15.77	99.98	79.25	1.100	4.576	29.01	0	0.451	0.00	0.00	
2	1.00	0.450	15.77	96.77	76.70	1.100	4.576	28.08	0	0.470	0.00	0.00	
3	1.00	0.450	15.77	93.55	74.15	1.100	4.576	27.15	0	0.491	0.00	0.00	
4	1.00	0.450	15.77	90.34	71.61	1.100	4.576	26.21	0	0.514	0.00	0.00	
5	1.00	0.450	15.77	87.13	69.06	1.100	4.576	25.28	0	0.539	0.00	0.00	
6	1.00	0.450	15.77	83.92	66.52	1.100	4.576	24.35	0	0.566	0.00	0.00	
7	1.00	0.450	15.77	80.71	64.00	1.100	4.576	23.42	0	0.591	0.00	0.00	
8	1.00	0.450	15.77	77.50	61.48	1.100	4.576	22.50	0	0.616	0.00	0.00	
9	1.00	0.450	15.77	74.29	58.96	1.100	4.576	21.58	0	0.641	0.00	0.00	
10	1.00	0.450	15.77	71.08	56.44	1.100	4.576	20.66	0	0.666	0.00	0.00	
11	1.00	0.450	15.77	67.87	53.92	1.100	4.576	19.74	0	0.691	0.00	0.00	
12	1.00	0.450	15.77	64.66	51.40	1.100	4.576	18.82	0	0.716	0.00	0.00	
13	1.00	0.450	15.77	61.45	48.88	1.100	4.576	17.90	0	0.741	0.00	0.00	
14	1.00	0.450	15.77	58.24	46.36	1.100	4.576	16.98	0	0.766	0.00	0.00	
15	1.00	0.450	15.77	55.03	43.84	1.100	4.576	16.06	0	0.791	0.00	0.00	
16	1.00	0.450	15.77	51.82	41.32	1.100	4.576	15.14	0	0.816	0.00	0.00	
17	1.00	0.450	15.77	48.61	38.80	1.100	4.576	14.22	1	0.841	0.00	0.00	
18	1.00	0.450	15.77	45.40	36.28	1.100	4.576	13.30	1	0.866	0.00	0.00	
19	1.00	0.450	15.77	42.19	33.76	1.100	4.576	12.38	1	0.891	0.00	0.00	
20	1.00	0.450	15.77	38.98	31.24	1.100	4.576	11.46	1	0.916	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #13	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #14	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



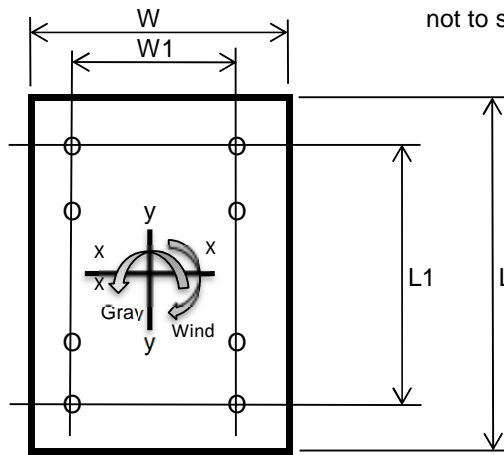
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	3385	4995	-	lbs
Shear (Wind)	6858	3819	-	lbs
Torsion (Arm Rise)	26974	15020	-	ft-lbs
Moment (Gravity)	104449	163666	-	ft-lbs
Moment (Wind)	245142	135389	-	ft-lbs
Nat. Wind Moment	-	-	36609	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	18.50	in
Tube Wall Thick.	0.3125	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	29.19	30.62	ksi
Bolt Shear Stress - fv	3.25	2.02	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.68	0.70	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	3.46	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.5	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	16.37	25.65	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	39.07	21.58	ksi
Combined applied stress for interaction (SRSS)	42.36	33.52	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



## 16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm Case1

## Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

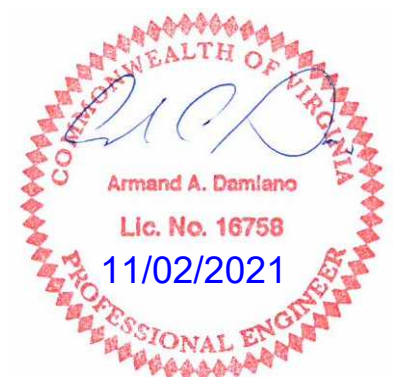
Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.3	
Dop - Baseplate center hole diameter	15.25	in
Cop - Center hole to shaft diameter ratio	0.7625	
Kf - Fatigue stress concentration factor for finite life	2.49	
Ki - Fatigue stress concentration factor for infinite life	5.82	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.3125	in
Dt - Arm base diameter	18.50	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	1.72	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.324324	
Kf - Fatigue stress concentration factor for finite life	1.81	
Ki - Fatigue stress concentration factor for infinite life	3.65	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



## 16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm Case1

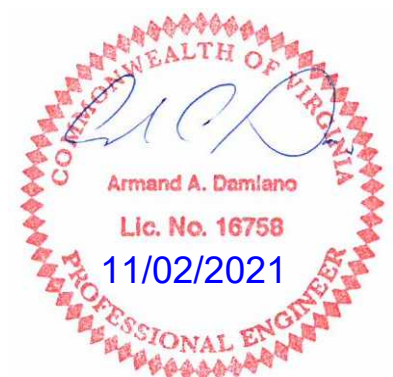
## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	19.57	in
Shaft Thickness	0.375	in
Total Area	27.3136	in <sup>2</sup>
Ix	1143	in <sup>4</sup>
Iy	1250	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	25461	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	10.26	ksi
CSR	0.64	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.83	ksi
CSR	0.40	
Therefore	<b>OK</b>	



16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm Case1

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear	Shear	Bending	Torsion	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	3385		3385	104449		104449		380	15447		0.43
Gp II	3385	6858	7649	104449	245142	266467	26974	858	39406	1995	0.84
Gp III	4995	3819	6288	163666	135389	212408	15020	705	31412	1111	0.66
Gp IV Natural		1042	1042		36609	36609	4100	117	5414	304	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	1771		1771	40013		40013		396	14116		0.42
Gp II	1771	3803	4196	40013	110853	117854	14958	937	41576	2639	0.96
Gp III	2769	2130	3494	66111	60571	89663	8377	780	31631	1478	0.72
Gp IV Natural		585	585		16172	16172	2302	131	5706	407	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#1 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#2 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm Case1

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	4978		104449	0	104449		215		11055		0.32
Gp II	4978	8170	134533	164934	212843	245142	215	708	22528	12973	0.80
Gp III	7044	4658	83757	189203	206913	135389	305	404	21900	7165	0.57
Gp IV Natural			25461	0	25461				2695		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9974										

<b>Shaft At Arm</b>											
Gp I	3488		104449	0	104449		173		14553		0.41
Gp II	3488	6892	26974	104474	107900	245142	173	685	15033	17077	0.86
Gp III	5097	3846	15020	163686	164374	135389	253	382	22902	9432	0.65
Gp IV Natural			4107	0	4107				572		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9974										



**Gusset Box Stress Check  
For Flange Style F2  
Used On Shaft Types B1 & E1  
Wind Velocity of 90 mph  
Using Governing Load: 75' Case 1**

**Input Information**

Gusset Plate Thickness	0.50	in.	
Gusset Yield Strength Fy	50000	psi	A572 Gr 50
Shaft Base Diameter	20.00	in.	
Height To C.L. of Arm Attach.	18.00	ft.	
Shaft Dia. C.L. of Arm Attach.	17.48	in.	Width Between Gussets
Flange Plate Height	27.0	in.	
Flange Plate Width	27.0	in.	
Box Cross-Sectional Area	44.48	sq.in.	

**Applied Loads Onto Flange Box Taken From Pole Analysis - 75' Case 1**

Gravity Moment	104,449	ft-lbs
Wind Moment	245,142	ft-lbs
Torsion Moment	26974	ft-lbs
Direct Shear	7649	lbs

**Computing Moments of Inertia**

For Gravity			For Wind		
d	27	in	d	18.48	in
b	18.48	in	b	27	in
d'	26	in	d'	17.48	in
b'	17.48	in	b'	26	in
Inertia	4709.45	in <sup>4</sup>	Inertia	2627.79	in <sup>4</sup>

**Computing Stress**

Gravity = $Mc/I$ =	3593	psi	
Wind = $Mc/I$ =	10344	psi	
Torsion = $M/[2t(a-b)(b-t)]$ =	679	psi	Roark's Table 10.1 #16
Shear = $2.25 * V / A$ =	387	psi	

**Allowables**

Bending = $0.66 F_y 1.33$ =	43890	psi
Torsion Limited by b/t ratio	21,945	psi
b/t =	54.0	
$12000 / F_y^{0.5}$ =	54.0	

**Result**

CSR = 0.37 Which is  $\leq 1$  Therefore OK  
To be conservative bending stresses were added not SRSS



16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm  
Weld Analysis

Page S4

**INPUTS**

	<b>Gp II</b>	<b>GpIII</b>			
<b>Applied Loads To Flange Connection</b>			<b>Arm Dimensions</b>		
Vert. Shr	3385	4995	lbs	Diameter (d)	18.5 in
Horz. Shr	6858	3819	lbs	Tube Wall Thk	0.3125 in
Torsion Moment	26974	15020	ft-lbs	Plate Thk (D)	2.25 in
Gravity Moment	104449	163666	ft-lbs	Plate Yield (Fy)	50 ksi
Wind Moment	245142	135389	ft-lbs		
<b>Applied Loads To Base Plate Connection</b>			<b>Shaft Dimensions</b>		
Axial	0	0	lbs	Diameter (d)	19.5 in
Shear	0	0	lbs	Tube Wall Thk	<b>0.375</b> in
Shear	0	0	lbs	Plate Thk (D)	2 in
Bending Moment	0	0	ft-lbs	Plate Yield (Fy)	36 ksi
Bending Moment	0	0	ft-lbs	Arm Attach. Elev.	<b>18.0</b> ft
Torsion Moment	0	0	ft-lbs		

Additional Load Factor To Apply As Per Signal Plans & Specifications = **1.00**

**Electrodes**

**AASHTO Gp II & III Factor = 1.33**

**E70 Electrodes (Used with plates having Fy = 36 ksi)**

Fv = 0.27 Fu (AASHTO Bridge Spec 10.32.2)

Fv = 0.27 x 58000 = 15660 psi

Allowable = Fv \* Gp Factor = 20828 psi

**E70 Electrodes (Used with plates having Fy = 50 ksi)**

Fv = 0.27 x 65000 = 17550 psi

Allowable = Fv \* Gp Factor = 23342 psi

Reference: *Design of Welded Structures*, Omer W. Blodgett

Method: Weld As A Line



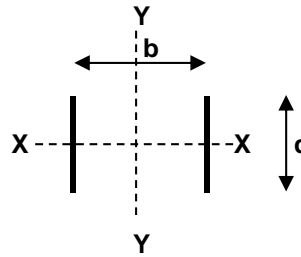


16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm  
Weld Analysis - Continued

**ARM CONNECTING PLATES**

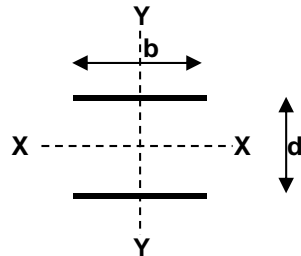
**Side Plates**

Vertical Length (d)	27.00	in
Horz. Dist Between Plates (b)	16.98	in
Thickness	<b>0.5</b>	in
Weld Size	<b>0.375</b>	in
Weld Throat (t <sub>1</sub> )	0.265	in
$A_1 = A_{w1} * t_1 = 2 * d * t_1$	=	14.32 in <sup>2</sup>
$S_{x1} = S_{wx1} * t_1 = (d^2 / 3) * t_1$	=	64.43 in <sup>3</sup>
$S_{y1} = S_{wy1} * t_1 = b * d * t_1$	=	121.55 in <sup>3</sup>
$J_1 = J_{w1} * t_1 = t_1 * d(3b^2 + d^2) / 6$	=	1901.70 in <sup>4</sup>



**Top & Bottom Plates**

Vert. Dist Between Plates (d)	27.00	in
Horz. Length (b)	26.67	in
Thickness	<b>0.5</b>	in
Weld Size	<b>0.375</b>	in
Weld Throat (t <sub>2</sub> )	0.265	in
$A_2 = A_{w2} * t_2 = t_2 * 2 * b$	=	14.1 in <sup>2</sup>
$S_{x2} = S_{wx2} * t_2 = t_2 * b * d$	=	190.9 in <sup>3</sup>
$S_{y2} = S_{wy2} * t_2 = t_2 * (b^2 / 3)$	=	62.9 in <sup>3</sup>
$J_2 = J_{w2} * t_2 = t_2 * (b^3 + 3bd^2) / 6$	=	3416.0 in <sup>4</sup>



**Combined Analysis**

$\sigma_1 = \text{Gravity Mom} / (S_{x1} + S_{x2})$	=	4909.0	Gp II	7692.0	psi
$\sigma_2 = \text{Wind Mom} / (S_{y1} + S_{y2})$	=	15952.0	Gp III	8810.0	psi
$\sigma_2 = [\text{Tor. Mom} * C / (J_1 + J_2)] + [\text{Res. Shr} / (A_1 + A_2)]$	=	1240.0		762.0	psi
Res. Weld Stress = $\sigma_r = \text{Sqrt}[(\sigma_1 + \sigma_2)^2 + \sigma_3^2]$	=	20898		16520	psi
Allowable: E70 Electrodes * AASHTO Gp Factor	=	23341.5		23341.5	psi
<b>Actual Weld Stress vs. Allowable</b>		<b>Passes</b>		<b>Passes</b>	



16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm Case1

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	8170 lbs
Bending Moment	212843 ft-lbs
Torsion Moment	245142 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.00 in

**ANALYSIS - ANCHOR BOLTS**

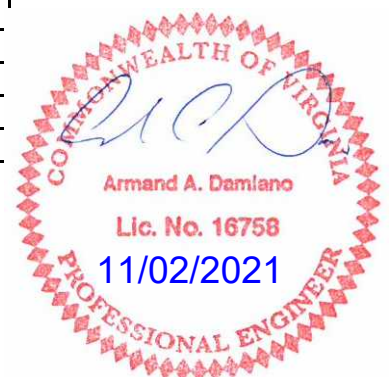
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	19.601 ksi
Bolt Direct Shear Stress	0.445 ksi
Bolt Torsion Shear Stress	12.299 ksi
Combined Bolt Stress	
Fv = .3 Fy * Allowable Increase Factor	21.945 ksi
Ft = .5Fy * Allowable Increase Factor	36.575 ksi
ft =	19.601 ksi
fv =	12.744 ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.8 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3 in
Design Moment	148 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	22.36 ksi
Allowable Plate Stress = .66Fy*Allow.Incr.	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.438 in
Design Moment	71 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	11.26 ksi
Allowable Plate Stress = .66Fy*Allow.Incr.	31.6 ksi
Therefore	<b>OK</b>



16362-3-2 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 75' Arm Case1

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	25461 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	2.35 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.34
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

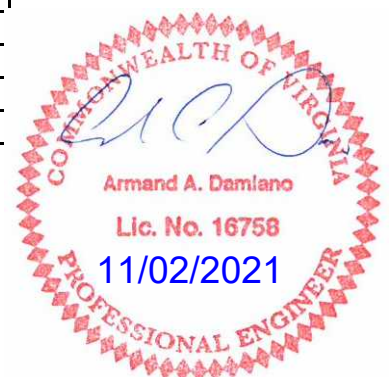
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	49003 lbs
Computed Factor-of Safety	1.26 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	49003 lbs
Total Tensile Load	392024 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.2 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	49003 lbs
Total Tensile Load	392024 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	<b>9</b> Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm Case2

11/02/21

**General**

Wind Vel. - mph	90		Roadway - mph	55		<b>Fatigue Importance Factors</b>	
Natural Wind	11.2		Plate Yield (ksi)	36		Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870		Galloping	0.65 No
Fatigue Cat.	2		Vel. Conver. Cv	0.930		Vortex Shedding	0.00 No
Recurrence (yr)	25		Gust Effect G	1.300		Natural Wind Gust	0.80 Yes
Hurricane Region	0	No	Elev. Pole Bot.(ft)	1		Truck Gust	0.85 No
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>		Wind Pressure - Appendix C	Yes
# Lum. Arms	0		State	VA			

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	22.50	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.3750	0.14	19.00	29.00	18.00	-	3.93	0	55	29000	180
	0.2500	0.14	15.87	49.04	-	3.02		0	55	29000	
Traffic Arm #2								0	55	29000	90
								0	55	29000	
Lum Arm #1								0	36	29000	180
Lum Arm #2								0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8		Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes	
A.B. Bolt Circle	29.00	in	Foundation Diameter	48	in
Baseplate Dia.	35.00	in	Concrete Cover	4	in
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	17.75	in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.		Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1		Arm #2	
Flange Bolt Qty.	8		NA	
Bolt Diameter	1.50	in		in
Flange Plate Length (V)	29.50	in		in
Flange Plate Width (H)	29.50	in		in
Spac. Between Bolt (V)	25.00	in		in
Spac. Between Bolt (H)	25.00	in		in
Flange Plate Thk.	2.75	in		in
Flange Plate Yield (Fy)	50	ksi		ksi
Gusset Thk.	0.500	in		in
Plate Center Hole	6.00	in		in
Weld Type	Full Pen.			

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.35	0.44	0.48	0.40							30.14	0.00
GP II CSR	0.81	0.94	0.92	0.99								
GP III CSR	0.58	0.68	0.71	0.70							47.71	
Nat.Wind (psi)	2156	440	5703	5967								

Arm #1 Flange Bolt (Max.) CSR	0.86
Arm #1 Flange Bolt Fatigue CSR	0.59
Arm #1 Flange Plate (Max.) CSR	0.85
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.52
Handhole at Toe (Fatigue) CSR	0.32
Minimum Qty of Vertical Reinf. Bars	10

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.94
Anchor Bolt Max. Fatigue Stress Ratio	0.31
Base Plate Max. CSR	0.75
Anchorage Capacity S.F.	1.09
Concrete Pull Out Capacity S.F.	1.20

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
8374	8242	262406	342355



16362-3-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm Case2

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft.)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1										
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	3 Section Head w/BP	20	8.7	4			1	26	65	1.20
	#3	3 Section Head w/BP	32	8.7	4			1	26	65	1.20
	#4	2.5'x3' Sign	41			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	44	8.7	4			1	26	65	1.20
	#6	2.5'x3' Sign	47			2.5	3	1	7.5	22.5	1.13
	#7	3 Section Head w/BP	50	8.7	4			1	26	65	1.20
	#8	2.5'x3' Sign	52			2.5	3	1	7.5	22.5	1.13
	#9	Camera	54	1	1			1	3	22	1.20
	#10	3 Section Head w/BP	56	8.7	4			1	26	65	1.20
	#11	2.5'x3' Sign	58			2.5	3	1	7.5	22.5	1.13
	#12	5 Section Head w/BP	62	13.75	4			2	42	105	1.20
	#13	3'x3.5' Sign	65			3	3.5	1	10.5	26.7	1.13
	#14	Camera	66	1	1			1	3	22	1.20
	#15	4 Section Head w/BP	68	11	5			1	34	80	1.20
	#16	3'x3.5' Sign	71			3	3.5	1	10.5	26.7	1.13
	#17	4 Section Head w/BP	74	11	5			1	34	80	1.20
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
	#12										
	#13										
#14											
#15											
#16											
#17											
#18											
#19											
#20											



16362-3-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm Case2

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	22.500	22.352	93.60	0.5288	0.53	1.979	19.15	0.80
2	I	1.06	1.06	22.352	22.204	92.97	0.5288	1.59	1.966	19.02	0.80
3	I	1.06	2.12	22.204	22.055	92.34	0.5288	2.65	1.953	18.90	0.80
4	I	1.06	3.18	22.055	21.907	91.71	0.5288	3.71	1.940	18.78	0.80
5	I	1.06	4.24	21.907	21.759	91.08	0.5288	4.76	1.926	18.65	0.80
6	I	1.06	5.29	21.759	21.611	90.45	0.5288	5.82	1.913	18.53	0.80
7	I	1.06	6.35	21.611	21.462	89.82	0.5288	6.88	1.900	18.41	0.80
8	I	1.06	7.41	21.462	21.314	89.19	0.5288	7.94	1.887	18.29	0.80
9	I	1.06	8.47	21.314	21.166	88.56	0.5288	9.00	1.874	18.16	0.80
10	I	1.06	9.53	21.166	21.018	87.93	0.5288	10.06	1.861	18.04	0.80
11	I	1.06	10.59	21.018	20.869	87.30	0.5288	11.12	1.848	17.92	0.80
12	I	1.06	11.65	20.869	20.721	86.68	0.5288	12.18	1.835	17.79	0.80
13	I	1.06	12.71	20.721	20.573	86.05	0.5288	13.23	1.822	17.67	1.00
14	I	1.06	13.76	20.573	20.425	85.42	0.5288	14.29	1.809	17.55	1.00
15	I	1.06	14.82	20.425	20.276	84.79	0.5288	15.35	1.796	17.42	1.00
16	I	1.06	15.88	20.276	20.128	84.16	0.5288	16.41	1.783	17.30	1.00
17	I	1.06	16.94	20.128	19.980	83.53	0.5288	17.47	1.769	17.18	1.00
18	J	0.50	18.00	19.980	19.910	39.23	0.2499	18.25	0.831	8.07	1.00
19	I	0.50	18.50	19.910	19.840	39.09	0.2499	18.75	0.828	8.04	1.00
20	I	0.50	19.00	19.840	19.770	38.95	0.2499	19.25	0.825	8.01	1.00
						1623					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	1594.12	1109.10	0.00	1073.84
Section Modulus (in^3)	144.10	113.14	0.00	
Cross-Section Area (in^2)	26.05	23.08	0.00	
Width-Thickness Ratio	60.00	53.28	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	22.985	22.985	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

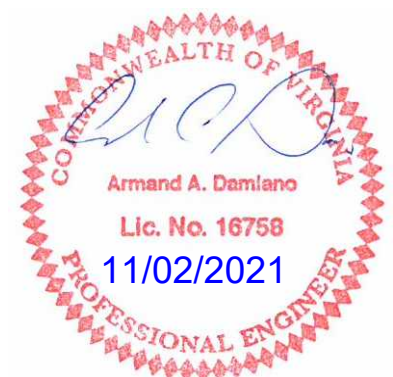
Shaft Deflection From Arm#1 GP I Load (in)	0.995
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm Case2

## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	24.97	0.000	24.73	1.100	4.576	9.05
2	0.450	12.62	24.81	0.000	24.57	1.100	4.576	8.99
3	0.450	12.62	24.64	0.000	24.41	1.100	4.576	8.94
4	0.450	12.62	24.48	0.000	24.24	1.100	4.576	8.88
5	0.450	12.62	24.31	0.000	24.08	1.100	4.576	8.82
6	0.450	12.62	24.15	0.000	23.92	1.100	4.576	8.76
7	0.450	12.62	23.98	0.000	23.75	1.100	4.576	8.70
8	0.450	12.62	23.82	0.000	23.59	1.100	4.576	8.64
9	0.450	12.62	23.65	0.001	23.43	1.100	4.576	8.58
10	0.450	12.62	23.49	0.001	23.26	1.100	4.576	8.52
11	0.450	12.62	23.32	0.001	23.10	1.100	4.576	8.46
12	0.450	12.62	23.16	0.001	22.94	1.100	4.576	8.40
13	0.450	15.77	28.73	0.002	22.77	1.100	4.576	8.34
14	0.450	15.77	28.52	0.002	22.61	1.100	4.576	8.28
15	0.450	15.77	28.32	0.002	22.45	1.100	4.576	8.22
16	0.450	15.77	28.11	0.002	22.28	1.100	4.576	8.16
17	0.450	15.77	27.90	0.002	22.12	1.100	4.576	8.10
18	0.450	15.77	13.11	0.001	10.39	1.100	4.576	3.80
19	0.450	15.77	13.06	0.001	10.35	1.100	4.576	3.79
20	0.450	15.77	13.01	0.001	10.32	1.100	4.576	3.78
Fix. #1	1.200	33.65	80.76	0.003	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.003	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.038	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm Case2

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	4.33	0.00	19.000	18.394	318.0	2.1533	2.15	6.746	6.746	65.62
2	I	4.33	4.33	18.394	17.788	307.5	2.1529	6.48	6.528	6.528	63.56
3	I	4.33	8.66	17.788	17.181	297.0	2.1525	10.81	6.309	6.309	61.50
4	I	4.33	12.99	17.181	16.575	286.5	2.1520	15.14	6.090	6.090	59.44
5	I	4.33	17.32	16.575	15.969	275.9	2.1516	19.47	5.872	5.872	57.38
6	I	4.33	21.65	15.969	15.363	265.4	2.1510	23.80	5.653	5.653	55.32
7	J	3.02	25.98	15.870	15.447	303.3	1.5032	27.48	3.941	3.941	38.56
8	O	3.54	29.00	15.447	14.952	141.4	1.7604	30.76	4.484	4.484	43.93
9	O	3.54	32.54	14.952	14.456	136.7	1.7601	34.30	4.338	4.338	42.55
10	O	3.54	36.08	14.456	13.960	132.1	1.7597	37.84	4.191	4.191	41.17
11	O	3.54	39.62	13.960	13.465	127.4	1.7593	41.38	4.045	4.045	39.79
12	O	3.54	43.16	13.465	12.969	122.7	1.7589	44.92	3.899	3.899	38.42
13	O	3.54	46.70	12.969	12.474	118.0	1.7585	48.46	3.753	3.753	37.04
14	O	3.54	50.24	12.474	11.978	113.3	1.7580	52.00	3.607	3.607	35.66
15	O	3.54	53.78	11.978	11.482	108.6	1.7575	55.54	3.460	3.460	34.28
16	O	3.54	57.32	11.482	10.987	103.9	1.7570	59.08	3.314	3.314	32.90
17	O	3.54	60.86	10.987	10.491	99.2	1.7564	62.62	3.168	3.168	31.53
18	O	3.54	64.40	10.491	9.996	94.5	1.7557	66.16	3.022	3.022	30.15
19	O	3.54	67.94	9.996	9.500	89.9	1.7550	69.70	2.876	2.876	28.77
20	O	3.54	71.48	9.500	9.004	85.2	1.7542	73.23	2.729	2.729	27.39
		<u>75.02</u>				<u>3527</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	65	20.00	8.700	1.000	78.00
Fix. #3	65	32.00	8.700	1.000	78.00
Fix. #4	22.5	41.00	7.500	1.000	22.50
Fix. #5	65	44.00	8.700	1.000	78.00
Fix. #6	22.5	47.00	7.500	1.000	22.50
Fix. #7	65	50.00	8.700	1.000	78.00
Fix. #8	22.5	52.00	7.500	1.000	22.50
Fix. #9	22	54.00	1.000	1.000	9.00
Fix. #10	65	56.00	8.700	1.000	78.00
Fix. #11	22.5	58.00	7.500	1.000	22.50
Fix. #12	105	62.00	13.750	2.000	126.00
Fix. #13	26.7	65.00	10.500	1.000	31.50
Fix. #14	22	66.00	1.000	1.000	9.00
Fix. #15	80	68.00	11.000	1.000	102.00
Fix. #16	26.7	71.00	10.500	1.000	31.50
Fix. #17	80	74.00	11.000	1.000	102.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	102.116	47.882
Cross-Section Area (in^2)	21.931	12.262
Width-Thickness Ratio	50.67	63.48
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	36.300
Allow. Shear Stress (ksi)	18.150	18.150





16362-3-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm Case2

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000 Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	106.39	84.33	1.100	4.576	30.87	0	0.450	0.00	0.00	
2	1.00	0.450	15.77	102.94	81.60	1.100	4.576	29.87	0	0.454	0.00	0.00	
3	1.00	0.450	15.77	99.49	78.86	1.100	4.576	28.87	0	0.475	0.00	0.00	
4	1.00	0.450	15.77	96.04	76.13	1.100	4.576	27.87	0	0.497	0.00	0.00	
5	1.00	0.450	15.77	92.59	73.39	1.100	4.576	26.87	0	0.521	0.00	0.00	
6	1.00	0.450	15.77	89.14	70.66	1.100	4.576	25.87	0	0.548	0.00	0.00	
7	1.00	0.450	15.77	82.15	67.92	1.100	4.576	24.87	0	0.575	0.00	0.00	
8	1.00	0.450	15.77	77.71	64.18	1.100	4.576	23.87	0	0.602	0.00	0.00	
9	1.00	0.450	15.77	73.27	60.44	1.100	4.576	22.87	0	0.629	0.00	0.00	
10	1.00	0.450	15.77	68.83	56.70	1.100	4.576	21.87	0	0.656	0.00	0.00	
11	1.00	0.450	15.77	64.39	52.96	1.100	4.576	20.87	0	0.683	0.00	0.00	
12	1.00	0.450	15.77	59.95	49.22	1.100	4.576	19.87	0	0.710	0.00	0.00	
13	1.00	0.450	15.77	55.51	45.48	1.100	4.576	18.87	0	0.737	0.00	0.00	
14	1.00	0.450	15.77	51.07	41.74	1.100	4.576	17.87	0	0.764	0.00	0.00	
15	1.00	0.450	15.77	46.63	38.00	1.100	4.576	16.87	0	0.791	0.00	0.00	
16	1.00	0.450	15.77	42.19	34.26	1.100	4.576	15.87	0	0.818	0.00	0.00	
17	1.00	0.450	15.77	37.75	30.52	1.100	4.576	14.87	0	0.845	0.00	0.00	
18	1.00	0.450	15.77	33.31	26.78	1.100	4.576	13.87	1	0.872	0.00	0.00	
19	1.00	0.450	15.77	28.87	23.04	1.100	4.576	12.87	1	0.899	0.00	0.00	
20	1.00	0.450	15.77	24.43	19.30	1.100	4.576	11.87	1	0.926	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #7	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #12	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	1	1.200	0.00	0.00	0.00
Fix. #13	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #14	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #15	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #16	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #17	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



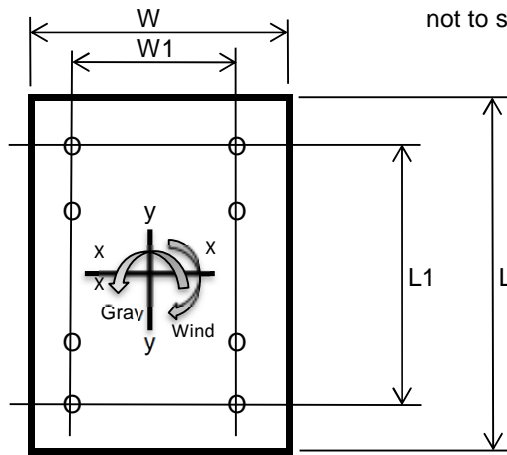
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	4326	6091	-	lbs
Shear (Wind)	6873	3843	-	lbs
Torsion (Arm Rise)	27017	15106	-	ft-lbs
Moment (Gravity)	145635	222371	-	ft-lbs
Moment (Wind)	342355	184645	-	ft-lbs
Nat. Wind Moment	-	-	48528	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	19.00	in
Tube Wall Thick.	0.375	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.75
W	29.5
W1	25.00
L	29.5
L1	25.00
L2 - Dist. between bolts (Typ.)	8.33



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	979.65	979.65	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1763.77	1763.77	in <sup>4</sup>
Bolt Tensile Stress - ft	36.68	37.50	ksi
Bolt Shear Stress - fv	3.06	1.97	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Fv =	44.22	44.22	ksi
Allowable Shear Stress = Ft =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.85	0.86	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	4.13	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.59	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	14.47	22.09	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	34.56	18.64	ksi
Combined applied stress for interaction (SRSS)	37.47	28.90	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



## 16362-3-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm Case2

## Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

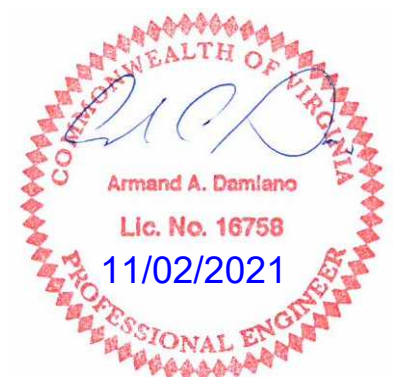
Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	22.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	29.00	in
Cbc - Bolt circle ratio	1.288889	
Dop - Baseplate center hole diameter	17.75	in
Cop - Center hole to shaft diameter ratio	0.788889	
Kf - Fatigue stress concentration factor for finite life	2.72	
Ki - Fatigue stress concentration factor for infinite life	6.44	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.375	in
Dt - Arm base diameter	19.00	in
Ttp - Thickness of baseplate	2.75	in
Dbc - Bolt circle diameter	35.36	in
Cbc - Bolt circle ratio	1.86	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.315789	
Kf - Fatigue stress concentration factor for finite life	1.76	
Ki - Fatigue stress concentration factor for infinite life	3.73	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



## 16362-3-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm Case2

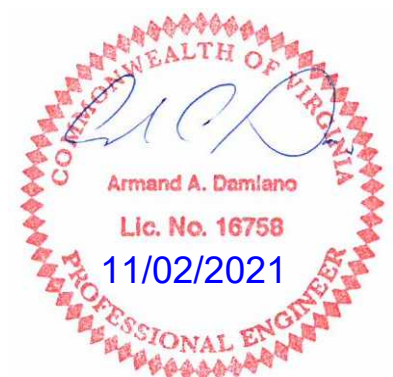
## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	22.07	in
Shaft Thickness	0.375	in
Total Area	30.273	in <sup>2</sup>
Ix	1605	in <sup>4</sup>
Iy	1798	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	25891	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	8.40	ksi
CSR	0.52	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.25	ksi
CSR	0.32	
Therefore	<b>OK</b>	



16362-3-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm Case2

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

<b>Arm#1 Base</b>											
Gp I	4326		4326	145635		145635		395	17115		0.48
Gp II	4326	6873	8121	145635	342355	372044	27017	741	43721	1588	0.92
Gp III	6091	3843	7202	222371	184645	289038	15106	657	33966	888	0.71
Gp IV Natural		1054	1054		48528	48528	4143	97	5703	244	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

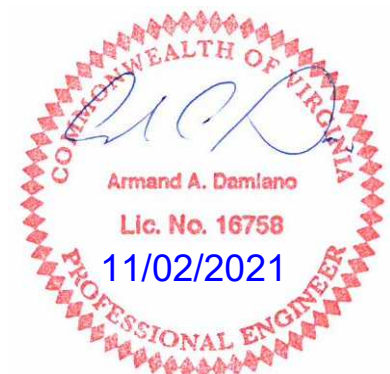
<b>Arm#1 Joint</b>											
Gp I	2489		2489	57675		57675		406	14455		0.40
Gp II	2489	5878	6384	57675	174805	184074	23107	1042	46132	2896	0.99
Gp III	3804	3174	4954	94096	92625	132036	12476	809	33091	1564	0.70
Gp IV Natural		835	835		23809	23809	3284	137	5967	412	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Arm#2 Base</b>											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Arm#2 Joint</b>											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Lum#1 Base</b>											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Lum#2 Base</b>											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm Case2

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	6114		145635	0	145635		235		12128		0.35
Gp II	6114	8242	150725	190866	243203	342355	235	633	20253	14255	0.81
Gp III	8374	4734	84272	248506	262406	184645	321	364	21852	7688	0.58
Gp IV Natural			25891	0	25891				2156		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9977										

<b>Shaft At Arm</b>											
Gp I	4443		145635	0	145635		192		15446		0.44
Gp II	4443	6912	27017	145664	148148	342355	192	599	15712	18155	0.94
Gp III	6208	3874	15106	222394	222906	184645	269	336	23641	9792	0.68
Gp IV Natural			4151	0	4151				440		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9977										



**Gusset Box Stress Check  
For Flange Style F3  
Used On Shaft Types B2 & E2  
Wind Velocity of 90 mph  
Using Governing Load: 75' Case 2**

**Input Information**

Gusset Plate Thickness	0.50	in.	
Gusset Yield Strength Fy	50000	psi	A572 Gr 50
Shaft Base Diameter	22.50	in.	
Height To C.L. of Arm Attach.	18.00	ft.	
Shaft Dia. C.L. of Arm Attach.	19.98	in.	Width Between Gussets
Flange Plate Height	29.5	in.	
Flange Plate Width	29.5	in.	
Box Cross-Sectional Area	49.48	sq.in.	

**Applied Loads Onto Flange Box Taken From Pole Analysis - 75' Case 2**

Gravity Moment	145,635	ft-lbs
Wind Moment	342,355	ft-lbs
Torsion Moment	27017	ft-lbs
Direct Shear	8121	lbs

**Computing Moments of Inertia**

For Gravity			For Wind		
d	29.5	in	d	20.98	in
b	20.98	in	b	29.5	in
d'	28.5	in	d'	19.98	in
b'	19.98	in	b'	28.5	in
Inertia	6340.58	in <sup>4</sup>	Inertia	3758.58	in <sup>4</sup>

**Computing Stress**

Gravity = $Mc/I =$	4066	psi	
Wind = $Mc/I =$	11466	psi	
Torsion = $M/[2t(a-b)(b-t)] =$	546	psi	Roark's Table 10.1 #16
Shear = $2.25 * V / A =$	370	psi	

**Allowables**

Bending = $0.66 F_y 1.33 =$	43890	psi
Torsion Limited by b/t ratio	18,156	psi
b/t =	59.0	
$12000 / F_y^{0.5} =$	54.0	

**Result**

CSR = 0.40 Which is  $\leq 1$  Therefore OK  
To be conservative bending stresses were added not SRSS



16362-2-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm  
Weld Analysis

Page S4

**INPUTS**

	<b>Gp II</b>	<b>GpIII</b>			
<b>Applied Loads To Flange Connection</b>			<b>Arm Dimensions</b>		
Vert. Shr	4326	6091 lbs	Diameter (d)	19.0	in
Horz. Shr	6873	3843 lbs	Tube Wall Thk	0.375	in
Torsion Moment	27017	15106 ft-lbs	Plate Thk (D)	2.75	in
Gravity Moment	145635	222371 ft-lbs	Plate Yield (Fy)	50	ksi
Wind Moment	342355	184645 ft-lbs			
<b>Applied Loads To Base Plate Connection</b>			<b>Shaft Dimensions</b>		
Axial	0	0 lbs	Diameter (d)	22.5	in
Shear	0	0 lbs	Tube Wall Thk	<b>0.375</b>	in
Shear	0	0 lbs	Plate Thk (D)	2	in
Bending Moment	0	0 ft-lbs	Plate Yield (Fy)	36	ksi
Bending Moment	0	0 ft-lbs	Arm Attach. Elev.	<b>18.0</b>	ft
Torsion Moment	0	0 ft-lbs			

**Additional Load Factor To Apply As Per Signal Plans & Specifications = 1.00**

**Electrodes**

**AASHTO Gp II & III Factor = 1.33**

**E70 Electrodes (Used with plates having Fy = 36 ksi)**

$F_v = 0.27 F_u$  (AASHTO Bridge Spec 10.32.2)

$F_v = 0.27 \times 58000 = 15660$  psi

Allowable =  $F_v \times \text{Gp Factor} = 20828$  psi

**E70 Electrodes (Used with plates having Fy = 50 ksi)**

$F_v = 0.27 \times 65000 = 17550$  psi

Allowable =  $F_v \times \text{Gp Factor} = 23342$  psi

Reference: *Design of Welded Structures*, Omer W. Blodgett

Method: Weld As A Line



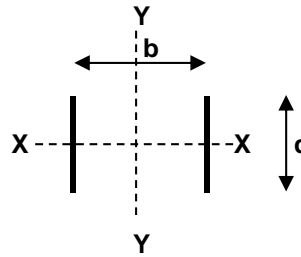


16362-2-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm  
Weld Analysis - Continued

**ARM CONNECTING PLATES**

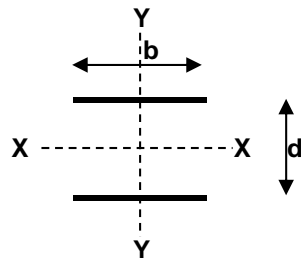
**Side Plates**

Vertical Length (d)	30.00	in
Horz. Dist Between Plates (b)	19.98	in
Thickness	<b>0.5</b>	in
Weld Size	<b>0.375</b>	in
Weld Throat (t <sub>1</sub> )	0.265	in
$A_1 = A_{w1} * t_1 = 2 * d * t_1$	=	15.91 in <sup>2</sup>
$S_{x1} = S_{wx1} * t_1 = (d^2 / 3) * t_1$	=	79.54 in <sup>3</sup>
$S_{y1} = S_{wy1} * t_1 = b * d * t_1$	=	158.92 in <sup>3</sup>
$J_1 = J_{w1} * t_1 = t_1 * d(3b^2 + d^2) / 6$	=	2780.60 in <sup>4</sup>



**Top & Bottom Plates**

Vert. Dist Between Plates (d)	30.00	in
Horz. Length (b)	31.38	in
Thickness	<b>0.5</b>	in
Weld Size	<b>0.375</b>	in
Weld Throat (t <sub>2</sub> )	0.265	in
$A_2 = A_{w2} * t_2 = t_2 * 2 * b$	=	16.6 in <sup>2</sup>
$S_{x2} = S_{wx2} * t_2 = t_2 * b * d$	=	249.6 in <sup>3</sup>
$S_{y2} = S_{wy2} * t_2 = t_2 * (b^2 / 3)$	=	87.1 in <sup>3</sup>
$J_2 = J_{w2} * t_2 = t_2 * (b^3 + 3bd^2) / 6$	=	5110.4 in <sup>4</sup>



**Combined Analysis**

$\sigma_1 = \text{Gravity Mom} / (S_{x1} + S_{x2})$	=	5310.0	Gp II	8107.0	psi
$\sigma_2 = \text{Wind Mom} / (S_{y1} + S_{y2})$	=	16703.0	Gp III	9009.0	psi
$\sigma_2 = [\text{Tor. Mom} * C / (J_1 + J_2)] + [\text{Res. Shr} / (A_1 + A_2)]$	=	990.0		636.0	psi
Res. Weld Stress = $\sigma_r = \text{Sqrt}[(\sigma_1 + \sigma_2)^2 + \sigma_3^2]$	=	22036		17128	psi
Allowable: E70 Electrodes * AASHTO Gp Factor	=	23341.5		23341.5	psi
<b>Actual Weld Stress vs. Allowable</b>		<b>Passes</b>		<b>Passes</b>	



16362-3-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm Case2

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	8242 lbs
Bending Moment	262406 ft-lbs
Torsion Moment	342355 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	29 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	35 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	22.50 in

**ANALYSIS - ANCHOR BOLTS**

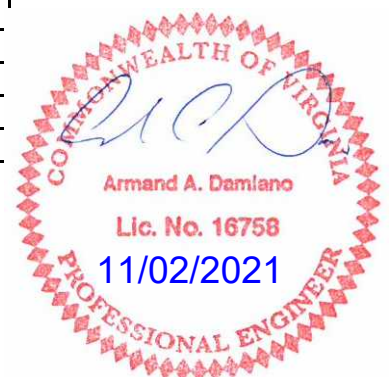
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	2106.48 in <sup>4</sup>
c Dist. (Section 5.17.7)	14.50 in
Bolt Tensile Stress	21.676 ksi
Bolt Direct Shear Stress	0.448 ksi
Bolt Torsion Shear Stress	15.399 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	21.676 ksi
$f_v =$	15.847 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.94 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	11.183 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	177 in-kip
Section Modulus of Failure Plane	7.45 in <sup>3</sup>
Applied Plate Stress	23.76 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	10.717 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	92 in-kip
Section Modulus of Failure Plane	7.14 in <sup>3</sup>
Applied Plate Stress	12.89 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-3 - VA - 90 MPH - MP-3 Std. Loads - Type B2 - 75' Arm Case2

Anchor Bolt & Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	25891 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	2106.48 in <sup>4</sup>
c Dist. (Section 5.17.7)	14.50 in
Bolt Tensile Stress	2.14 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.31
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	118588 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	8.5 in
T Reduced For Group Action	59294 lbs
Maximum Applied Tensile Load	54190 lbs
Computed Factor-of Safety	1.09 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	54190 lbs
Total Tensile Load	433520 lbs
Concrete Failure Surface Area	4772.08 in <sup>2</sup>
Concrete Shear Strength	522755 psi
Computed Factor-of Safety	1.2 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	54190 lbs
Total Tensile Load	433520 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	43.59 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	<b>10</b> Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

11/02/21

**General**

Wind Vel. - mph	90	No	Roadway - mph	55	<i>Fatigue Importance Factors</i>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	2		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	0		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

**Pole Variables**

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.50	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.3125	0.14	17.50	25.00	18.00	-	3.67	0	55	29000	180
	0.1880	0.14	14.79	47.92	-	2.92		0	55	29000	
Traffic Arm #2	0.2500	0.14	15.58	23.69	18.00	-	3.14	0	55	29000	270
	0.1793	0.14	13.00	39.00	-	2.69		0	55	29000	
Lum Arm #1								0	36	29000	180
Lum Arm #2								0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8		Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes	
A.B. Bolt Circle	26.00	in	Foundation Diameter	48	in
Baseplate Dia.	32.00	in	Concrete Cover	4	in
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	15.25	in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.		Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1		Arm #2	
Flange Bolt Qty.	8		8	
Bolt Diameter	1.50	in	1.50	in
Flange Plate Length (V)	27.00	in	27.00	in
Flange Plate Width (H)	27.00	in	27.00	in
Spac. Between Bolt (V)	22.50	in	22.50	in
Spac. Between Bolt (H)	22.50	in	22.50	in
Flange Plate Thk.	2.25	in	2.25	in
Flange Plate Yield (Fy)	50.00	ksi	50.00	ksi
Gusset Thk.	0.500	in	0.500	in
Plate Center Hole	6.00	in	6.00	in
Weld Type	Full Pen.		Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1	Lum#2	Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Arm #1	Arm #2
GP I CSR	0.31	0.40	0.41	0.41	0.43	0.34			24.48	18.16
GP II CSR	0.89	0.98	0.84	0.97	0.99	0.88				
GP III CSR	0.64	0.69	0.65	0.71	0.73	0.63			39.98	30.48
Nat.Wind (psi)	2901	568	5428	5792	6306	5372				

Arm #1 Flange Bolt (Max.) CSR	0.61
Arm #1 Flange Bolt Fatigue CSR	0.45
Arm #1 Flange Plate (Max.) CSR	0.89
Arm #2 Flange Bolt (Max.) CSR	0.44
Arm #2 Flange Bolt Fatigue CSR	0.33
Arm #2 Flange Plate (Max.) CSR	0.70
Handhole at Root (Fatigue) CSR	0.69
Handhole at Toe (Fatigue) CSR	0.43
Minimum Qty of Vertical Reinf. Bars	10

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	7 ksi
Anchor Bolt Max. CSR	0.91
Anchor Bolt Max. Fatigue Stress Ratio	0.38
Base Plate Max. CSR	0.74
Anchorage Capacity S.F.	1.1
Concrete Pull Out Capacity S.F.	1.04

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
9874	7510	244315	280422



16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70/60' Arms

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft.)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1										
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	12			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	25	13.75	4			2	42	105	1.20
	#4	2.5'x3' Sign	29			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	36	8.7	4			1	26	65	1.20
	#6	Camera	40	1	1			1	3	22	1.20
	#7	2.5'x3' Sign	44			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	47	8.7	4			1	26	65	1.20
	#9	2.5'x3' Sign	55			2.5	3	1	7.5	22.5	1.13
	#10	3 Section Head w/BP	58	8.7	4			1	26	65	1.20
	#11	Camera	62	1	1			1	3	22	1.20
	#12	3'x3.5' Sign	66			3	3.5	1	10.5	26.7	1.13
	#13	4 Section Head w/BP	69	11	5			1	34	80	1.20
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	12.5			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	26	13.75	4			2	42	105	1.20
	#4	2.5'x3' Sign	34			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	37	8.7	4			1	26	65	1.20
	#6	Camera	46	1	1			1	3	22	1.20
	#7	2.5'x3' Sign	45			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	48	8.7	4			1	26	65	1.20
	#9	Camera	57	1	1			1	3	22	1.20
	#10	3'x3.5' Sign	56			3	3.5	1	10.5	26.7	1.13
	#11	4 Section Head w/BP	59	11	5			1	34	80	1.20
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										



16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.500	20.352	85.11	0.5288	0.53	1.802	17.48	0.80
2	I	1.06	1.06	20.352	20.204	84.48	0.5288	1.59	1.789	17.36	0.80
3	I	1.06	2.12	20.204	20.055	83.85	0.5288	2.65	1.776	17.24	0.80
4	I	1.06	3.18	20.055	19.907	83.22	0.5288	3.71	1.763	17.12	0.80
5	I	1.06	4.24	19.907	19.759	82.59	0.5288	4.76	1.750	16.99	0.80
6	I	1.06	5.29	19.759	19.611	81.96	0.5287	5.82	1.737	16.87	0.80
7	I	1.06	6.35	19.611	19.462	81.33	0.5287	6.88	1.724	16.75	0.80
8	I	1.06	7.41	19.462	19.314	80.70	0.5287	7.94	1.711	16.62	0.80
9	I	1.06	8.47	19.314	19.166	80.07	0.5287	9.00	1.698	16.50	0.80
10	I	1.06	9.53	19.166	19.018	79.44	0.5287	10.06	1.685	16.38	0.80
11	I	1.06	10.59	19.018	18.869	78.82	0.5287	11.12	1.671	16.25	0.80
12	I	1.06	11.65	18.869	18.721	78.19	0.5287	12.18	1.658	16.13	0.80
13	I	1.06	12.71	18.721	18.573	77.56	0.5287	13.23	1.645	16.01	1.00
14	I	1.06	13.76	18.573	18.425	76.93	0.5287	14.29	1.632	15.88	1.00
15	I	1.06	14.82	18.425	18.276	76.30	0.5287	15.35	1.619	15.76	1.00
16	I	1.06	15.88	18.276	18.128	75.67	0.5287	16.41	1.606	15.64	1.00
17	I	1.06	16.94	18.128	17.980	75.04	0.5287	17.47	1.593	15.51	1.00
18	J	0.50	18.00	17.980	17.910	35.22	0.2498	18.25	0.748	7.28	1.00
19	I	0.50	18.50	17.910	17.840	35.08	0.2498	18.75	0.745	7.26	1.00
20	I	0.50	19.00	17.840	17.770	34.94	0.2498	19.25	0.742	7.23	1.00
						<u>1467</u>					

Fix. #1		30	10.50	2.40	18.00	0.80
Fix. #2		30	10.50	2.40	18.00	0.80
Fix. #3		105	15.00	13.75	126.00	1.00
Fix. #4		0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in <sup>4</sup> )	1199.72	803.12	803.12	774.72
Section Modulus (in <sup>3</sup> )	119.23	91.24	91.24	
Cross-Section Area (in <sup>2</sup> )	23.70	20.73	20.73	
Width-Thickness Ratio	54.67	47.95	47.95	
Compact Limit	68.55	68.55	68.55	
Non-Compact Limit	137.09	137.09	137.09	
Maximum Limit	237.27	237.27	237.27	
Allow. Bending Stress (ksi)	36.300	36.300	36.300	
Allow. Compressive Str (ksi)	21.411	21.411	21.411	
Allow. Shear Stress (ksi)	18.150	18.150	18.150	

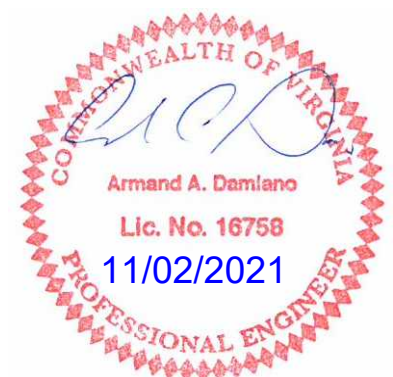
Shaft Deflection From Arm#1 GP I Load (in)	0.811
Shaft Deflection From Arm#2 GP I Load (in)	0.541



16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70/60' Arms

## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.74	0.000	22.53	1.100	4.576	8.25
2	0.450	12.62	22.58	0.000	22.37	1.100	4.576	8.19
3	0.450	12.62	22.41	0.000	22.20	1.100	4.576	8.13
4	0.450	12.62	22.25	0.000	22.04	1.100	4.576	8.07
5	0.450	12.62	22.08	0.000	21.87	1.100	4.576	8.01
6	0.450	12.62	21.92	0.000	21.71	1.100	4.576	7.95
7	0.450	12.62	21.75	0.000	21.55	1.100	4.576	7.89
8	0.450	12.62	21.59	0.001	21.38	1.100	4.576	7.83
9	0.450	12.62	21.42	0.001	21.22	1.100	4.576	7.77
10	0.450	12.62	21.26	0.001	21.06	1.100	4.576	7.71
11	0.450	12.62	21.09	0.001	20.89	1.100	4.576	7.65
12	0.450	12.62	20.93	0.001	20.73	1.100	4.576	7.59
13	0.450	15.77	25.95	0.002	20.57	1.100	4.576	7.53
14	0.450	15.77	25.74	0.002	20.40	1.100	4.576	7.47
15	0.450	15.77	25.53	0.002	20.24	1.100	4.576	7.41
16	0.450	15.77	25.33	0.003	20.08	1.100	4.576	7.35
17	0.450	15.77	25.12	0.003	19.91	1.100	4.576	7.29
18	0.450	15.77	11.79	0.001	9.35	1.100	4.576	3.42
19	0.450	15.77	11.75	0.002	9.31	1.100	4.576	3.41
20	0.450	15.77	11.70	0.002	9.27	1.100	4.576	3.39
Fix. #1	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.052	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	3.68	0.00	17.500	16.985	208.1	1.8308	1.83	5.288	5.288	51.57
2	I	3.68	3.68	16.985	16.470	201.8	1.8306	5.51	5.130	5.130	50.08
3	I	3.68	7.36	16.470	15.954	195.5	1.8303	9.19	4.972	4.972	48.59
4	I	3.68	11.04	15.954	15.439	189.1	1.8299	12.87	4.814	4.814	47.10
5	I	3.68	14.72	15.439	14.924	182.8	1.8296	16.55	4.656	4.656	45.61
6	I	3.68	18.40	14.924	14.409	176.5	1.8292	20.23	4.498	4.498	44.12
7	J	2.92	22.08	14.790	14.381	220.1	1.4532	23.53	3.549	3.549	34.83
8	O	3.46	25.00	14.381	13.897	97.1	1.7209	26.72	4.079	4.079	40.07
9	O	3.46	28.46	13.897	13.412	93.7	1.7205	30.18	3.939	3.939	38.75
10	O	3.46	31.92	13.412	12.927	90.3	1.7202	33.64	3.799	3.799	37.43
11	O	3.46	35.38	12.927	12.443	86.9	1.7197	37.10	3.659	3.659	36.12
12	O	3.46	38.85	12.443	11.958	83.6	1.7193	40.57	3.519	3.519	34.80
13	O	3.46	42.31	11.958	11.474	80.2	1.7188	44.03	3.380	3.380	33.48
14	O	3.46	45.77	11.474	10.989	76.8	1.7183	47.49	3.240	3.240	32.16
15	O	3.46	49.23	10.989	10.504	73.5	1.7178	50.95	3.100	3.100	30.85
16	O	3.46	52.69	10.504	10.020	70.1	1.7171	54.41	2.960	2.960	29.53
17	O	3.46	56.15	10.020	9.535	66.7	1.7165	57.87	2.820	2.820	28.21
18	O	3.46	59.62	9.535	9.050	63.3	1.7157	61.33	2.681	2.681	26.89
19	O	3.46	63.08	9.050	8.566	60.0	1.7149	64.79	2.541	2.541	25.58
20	O	3.46	66.54	8.566	8.081	56.6	1.7140	68.25	2.401	2.401	24.26
		<u>70.00</u>				<u>2373</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	12.00	37.500	1.000	112.50
Fix. #3	105	25.00	13.750	2.000	126.00
Fix. #4	22.5	29.00	7.500	1.000	22.50
Fix. #5	65	36.00	8.700	1.000	78.00
Fix. #6	22	40.00	1.000	1.000	9.00
Fix. #7	22.5	44.00	7.500	1.000	22.50
Fix. #8	65	47.00	8.700	1.000	78.00
Fix. #9	22.5	55.00	7.500	1.000	22.50
Fix. #10	65	58.00	8.700	1.000	78.00
Fix. #11	22	62.00	1.000	1.000	9.00
Fix. #12	26.7	66.00	10.500	1.000	31.50
Fix. #13	80	69.00	11.000	1.000	102.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	72.468	31.467
Cross-Section Area (in^2)	16.865	8.620
Width-Thickness Ratio	56.00	78.67
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	34.389
Allow. Shear Stress (ksi)	18.150	17.040





16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000 Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	83.39	66.10	1.100	4.576	24.20	0	0.484	0.00	0.00	
2	1.00	0.450	15.77	80.89	64.12	1.100	4.576	23.47	0	0.503	0.00	0.00	
3	1.00	0.450	15.77	78.40	62.15	1.100	4.576	22.75	0	0.524	0.00	0.00	
4	1.00	0.450	15.77	75.91	60.17	1.100	4.576	22.03	0	0.546	0.00	0.00	
5	1.00	0.450	15.77	73.42	58.20	1.100	4.576	21.30	0	0.571	0.00	0.00	
6	1.00	0.450	15.77	70.93	56.22	1.100	4.576	20.58	0	0.597	0.00	0.00	
7	1.00	0.450	15.77	55.97	44.36	1.100	4.576	16.24	0	0.601	0.00	0.00	
8	1.00	0.450	15.77	64.32	50.98	1.100	4.576	18.66	0	0.626	0.00	0.00	
9	1.00	0.450	15.77	62.11	49.23	1.100	4.576	18.02	0	0.655	0.00	0.00	
10	1.00	0.450	15.77	59.91	47.49	1.100	4.576	17.38	0	0.686	0.00	0.00	
11	1.00	0.450	15.77	57.70	45.74	1.100	4.576	16.74	0	0.721	0.00	0.00	
12	1.00	0.450	15.77	55.50	43.99	1.100	4.576	16.10	0	0.758	0.00	0.00	
13	1.00	0.450	15.77	53.30	42.24	1.100	4.576	15.46	0	0.799	0.00	0.00	
14	1.00	0.450	15.77	51.09	40.50	1.100	4.576	14.83	0	0.844	0.00	0.00	
15	1.00	0.450	15.77	48.89	38.75	1.100	4.576	14.19	0	0.894	0.00	0.00	
16	1.00	0.450	15.77	46.68	37.00	1.100	4.576	13.55	0	0.949	0.00	0.00	
17	1.00	0.450	15.77	44.48	35.25	1.100	4.576	12.91	1	1.011	0.00	0.00	
18	1.00	0.450	15.77	42.27	33.51	1.100	4.576	12.27	1	1.080	0.00	0.00	
19	1.00	0.450	15.77	40.07	31.76	1.100	4.576	11.63	1	1.100	0.00	0.00	
20	1.00	0.463	16.25	39.02	30.01	1.100	4.576	10.99	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



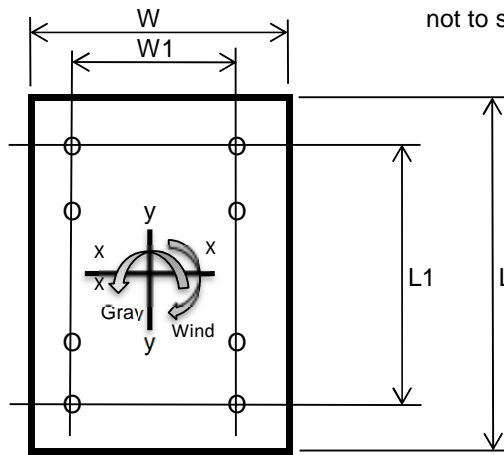
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	3001	4442	-	lbs
Shear (Wind)	6345	3518	-	lbs
Torsion (Arm Rise)	23274	12905	-	ft-lbs
Moment (Gravity)	88146	139512	-	ft-lbs
Moment (Wind)	223585	122410	-	ft-lbs
Nat. Wind Moment	-	-	32774	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	17.50	in
Tube Wall Thick.	0.3125	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	25.90	26.38	ksi
Bolt Shear Stress - fv	2.84	1.76	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.6	0.61	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	3.1	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.45	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	14.17	22.43	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	36.56	20.02	ksi
Combined applied stress for interaction (SRSS)	39.21	30.07	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70/60' Arms

Arm #2 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	3.00	0.00	15.580	15.160	121.2	1.4932	1.49	3.843	3.843	37.63
2	I	3.00	3.00	15.160	14.740	117.9	1.4930	4.49	3.738	3.738	36.64
3	I	3.00	6.00	14.740	14.320	114.5	1.4928	7.49	3.633	3.633	35.65
4	I	3.00	9.00	14.320	13.900	111.1	1.4926	10.49	3.528	3.528	34.66
5	I	3.00	12.00	13.900	13.480	107.8	1.4923	13.49	3.423	3.423	33.67
6	I	3.00	15.00	13.480	13.060	104.4	1.4921	16.49	3.318	3.318	32.68
7	I	3.00	18.00	13.060	12.640	101.0	1.4918	19.49	3.213	3.213	31.69
8	J	2.69	21.00	13.000	12.623	152.9	1.3384	22.34	2.872	2.872	28.33
9	O	3.03	23.69	12.623	12.200	70.9	1.5043	25.19	3.130	3.130	30.92
10	O	3.03	26.72	12.200	11.776	68.5	1.5040	28.22	3.023	3.023	29.91
11	O	3.03	29.74	11.776	11.353	66.0	1.5037	31.25	2.916	2.916	28.91
12	O	3.03	32.77	11.353	10.929	63.6	1.5033	34.27	2.809	2.809	27.90
13	O	3.03	35.79	10.929	10.505	61.1	1.5029	37.30	2.702	2.702	26.89
14	O	3.03	38.82	10.505	10.082	58.7	1.5025	40.32	2.596	2.596	25.89
15	O	3.03	41.85	10.082	9.658	56.2	1.5021	43.35	2.489	2.489	24.88
16	O	3.03	44.87	9.658	9.234	53.7	1.5016	46.37	2.382	2.382	23.87
17	O	3.03	47.90	9.234	8.811	51.3	1.5011	49.40	2.275	2.275	22.87
18	O	3.03	50.92	8.811	8.387	48.8	1.5005	52.42	2.168	2.168	21.86
19	O	3.03	53.95	8.387	7.964	46.4	1.4999	55.45	2.061	2.061	20.85
20	O	3.03	56.97	7.964	7.540	43.9	1.4991	58.47	1.955	1.955	19.85
		60.00				1620					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	12.50	37.500	1.000	112.50
Fix. #3	105	26.00	13.750	2.000	126.00
Fix. #4	22.5	34.00	7.500	1.000	22.50
Fix. #5	65	37.00	8.700	1.000	78.00
Fix. #6	22	46.00	1.000	1.000	9.00
Fix. #7	22.5	45.00	7.500	1.000	22.50
Fix. #8	65	48.00	8.700	1.000	78.00
Fix. #9	22	57.00	1.000	1.000	9.00
Fix. #10	26.7	56.00	10.500	1.000	31.50
Fix. #11	80	59.00	11.000	1.000	102.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#2 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	46.120	23.135
Cross-Section Area (in^2)	12.034	7.218
Width-Thickness Ratio	62.32	72.50
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	35.489
Allow. Shear Stress (ksi)	18.150	18.150



16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

Arm #2 Analysis Continued

Sec. Num.	Kz	Truck Induced Gust											Gallop Loads (lbs)
		Group 2			Group 3	Natural Wind Gust			Hght Corr. Factor = 1.00				
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	60.60	48.03	1.100	4.576	17.58	0	0.562	0.00	0.00	
2	1.00	0.450	15.77	58.94	46.72	1.100	4.576	17.10	0	0.582	0.00	0.00	
3	1.00	0.450	15.77	57.28	45.41	1.100	4.576	16.62	0	0.604	0.00	0.00	
4	1.00	0.450	15.77	55.63	44.09	1.100	4.576	16.14	0	0.628	0.00	0.00	
5	1.00	0.450	15.77	53.97	42.78	1.100	4.576	15.66	0	0.653	0.00	0.00	
6	1.00	0.450	15.77	52.32	41.47	1.100	4.576	15.18	0	0.680	0.00	0.00	
7	1.00	0.450	15.77	50.66	40.16	1.100	4.576	14.70	0	0.709	0.00	0.00	
8	1.00	0.450	15.77	45.29	35.90	1.100	4.576	13.14	0	0.711	0.00	0.00	
9	1.00	0.450	15.77	49.35	39.12	1.100	4.576	14.32	0	0.741	0.00	0.00	
10	1.00	0.450	15.77	47.67	37.79	1.100	4.576	13.83	0	0.776	0.00	0.00	
11	1.00	0.450	15.77	45.99	36.45	1.100	4.576	13.34	0	0.813	0.00	0.00	
12	1.00	0.450	15.77	44.30	35.11	1.100	4.576	12.85	0	0.853	0.00	0.00	
13	1.00	0.450	15.77	42.62	33.78	1.100	4.576	12.37	0	0.897	0.00	0.00	
14	1.00	0.450	15.77	40.93	32.44	1.100	4.576	11.88	0	0.946	0.00	0.00	
15	1.00	0.450	15.77	39.25	31.11	1.100	4.576	11.39	0	0.999	0.00	0.00	
16	1.00	0.450	15.77	37.56	29.77	1.100	4.576	10.90	1	1.057	0.00	0.00	
17	1.00	0.450	15.77	35.88	28.44	1.100	4.576	10.41	1	1.100	0.00	0.00	
18	1.00	0.450	15.77	34.19	27.10	1.100	4.576	9.92	1	1.100	0.00	0.00	
19	1.00	0.474	16.63	34.28	25.77	1.100	4.576	9.43	1	1.100	0.00	0.00	
20	1.00	0.508	17.82	34.83	24.43	1.100	4.576	8.94	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



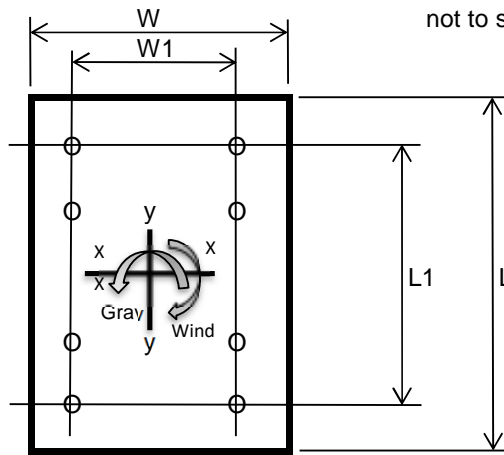
Flange Analysis - Arm #2

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2161	3337	-	lbs
Shear (Wind)	5418	2974	-	lbs
Torsion (Arm Rise)	17035	9351	-	ft-lbs
Moment (Gravity)	58769	96007	-	ft-lbs
Moment (Wind)	169305	91613	-	ft-lbs
Nat. Wind Moment	-	-	24233	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	15.58	in
Tube Wall Thick.	0.25	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	18.86	18.47	ksi
Bolt Shear Stress - fv	2.14	1.32	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.44	0.43	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	2.29	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.33	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	9.97	16.28	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	29.20	15.80	ksi
Combined applied stress for interaction (SRSS)	30.86	22.69	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



## 16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

## Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.268293	
Dop - Baseplate center hole diameter	15.25	in
Cop - Center hole to shaft diameter ratio	0.743902	
Kf - Fatigue stress concentration factor for finite life	2.37	
Ki - Fatigue stress concentration factor for infinite life	5.48	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.3125	in
Dt - Arm base diameter	17.50	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	1.82	
Dop - Baseplate center hole diameter	6.00	in
Cop - Center hole to arm diameter ratio	0.342857	
Kf - Fatigue stress concentration factor for finite life	1.84	
Ki - Fatigue stress concentration factor for infinite life	3.76	
Fatigue Allowable	7	ksi

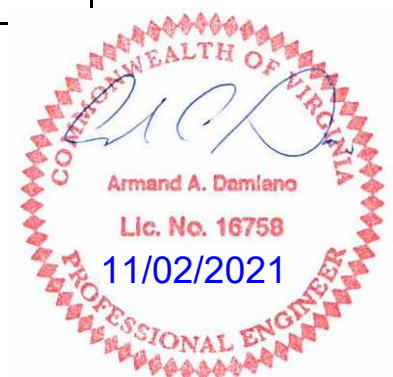
Note: Maximum diagonal distance between bolts used as bolt circle

**ARM 2 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.25	in
Dt - Arm base diameter	15.58	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.042349	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.385109	
Kf - Fatigue stress concentration factor for finite life	1.83	
Ki - Fatigue stress concentration factor for infinite life	3.50	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



## 16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

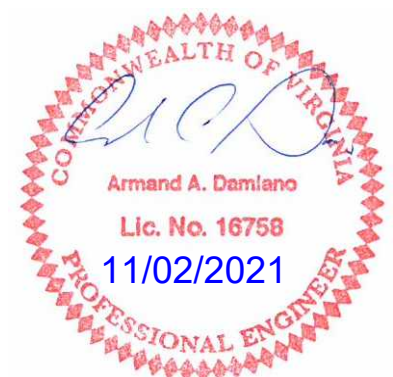
## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	20.07	in
Shaft Thickness	0.375	in
Total Area	27.9058	in <sup>2</sup>
Ix	1226	in <sup>4</sup>
Iy	1349	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	28824	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	11.11	ksi
CSR	0.69	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	3.04	ksi
CSR	0.43	
Therefore	<b>OK</b>	



16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear	Shear	Bending	Torsion	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	3001		3001	88146		88146		356	14597		0.41
Gp II	3001	6345	7019	88146	223585	240333	23274	833	39797	1927	0.84
Gp III	4442	3518	5667	139512	122410	185601	12905	673	30734	1069	0.65
Gp IV Natural		956	956		32774	32774	3507	114	5428	291	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	1737		1737	36325		36326		404	13853		0.41
Gp II	1737	4255	4596	36325	105504	111583	15607	1067	42553	2976	0.97
Gp III	2769	2338	3624	60449	57281	83278	8575	841	31759	1636	0.71
Gp IV Natural		628	628		15186	15186	2305	146	5792	440	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	2161		2161	58769		58770		360	15292		0.43
Gp II	2161	5418	5834	58769	169305	179215	17035	970	46630	2217	0.99
Gp III	3337	2974	4470	96007	91613	132705	9351	743	34529	1217	0.73
Gp IV Natural		799	799		24233	24233	2514	133	6306	328	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	1273		1273	22969		22969		353	11914		0.34
Gp II	1273	3402	3632	22969	73942	77428	10695	1007	40161	2774	0.88
Gp III	2084	1852	2789	39262	39603	55767	5823	773	28926	1511	0.63
Gp IV Natural		493	493		10356	10356	1552	137	5372	403	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#1 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#2 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-





16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	6794		88146	58769	105941		287		10663		0.31
Gp II	6794	7510	152209	187376	241407	280422	287	634	24297	14112	0.89
Gp III	9874	4277	147016	195131	244315	152880	417	361	24590	7694	0.64
Gp IV Natural			23347	16904	28824				2901		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9965										

<b>Shaft At Arm</b>											
Gp I	5268		88146	58769	105941		254		13934		0.40
Gp II	5268	6380	75511	100006	125312	280422	254	616	16482	18441	0.98
Gp III	7884	3546	104972	146259	180030	152880	380	343	23678	10054	0.69
Gp IV Natural			3514	2513	4320				568		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9965										



**Gusset Box Stress Check  
For Flange Style F2  
Used On Shaft Type C  
Wind Velocity of 90 mph  
Using Governing Load: 70'**

**Input Information**

Gusset Plate Thickness	0.50	in.	
Gusset Yield Strength Fy	50000	psi	A572 Gr 50
Shaft Base Diameter	20.50	in.	
Height To C.L. of Arm Attach.	18.00	ft.	
Shaft Dia. C.L. of Arm Attach.	17.98	in.	Width Between Gussets
Flange Plate Height	27.0	in.	
Flange Plate Width	27.0	in.	
Box Cross-Sectional Area	44.98	sq.in.	

**Applied Loads Onto Flange Box Taken From Pole Analysis - 70'**

Gravity Moment	88,146	ft-lbs
Wind Moment	223,585	ft-lbs
Torsion Moment	23274	ft-lbs
Direct Shear	7019	lbs

**Computing Moments of Inertia**

For Gravity			For Wind		
d	27	in	d	18.98	in
b	18.98	in	b	27	in
d'	26	in	d'	17.98	in
b'	17.98	in	b'	26	in
Inertia	4797.24	in <sup>4</sup>	Inertia	2790.14	in <sup>4</sup>

**Computing Stress**

Gravity = $Mc/I =$	2977	psi	
Wind = $Mc/I =$	9126	psi	
Torsion = $M/[2t(a-b)(b-t)] =$	570	psi	Roark's Table 10.1 #16
Shear = $2.25 * V / A =$	352	psi	

**Allowables**

Bending = $0.66 F_y 1.33 =$	43890	psi
Torsion Limited by b/t ratio	21,945	psi
b/t = 54.0		
$12000 / F_y^{0.5} =$	54.0	

**Result**

CSR = 0.32 Which is  $\leq 1$  Therefore OK  
To be conservative bending stresses were added not SRSS



16362-3-4 - VA - 90 MPH - MP-3 Std. Loads-Type C-70'/60' Arms  
Weld Analysis

**INPUTS**

	<b>Gp II</b>	<b>GpIII</b>		<b>Arm Dimensions</b>	
<b>Applied Loads To Flange Connection</b>					
Vert. Shr	3001	4442	lbs	Diameter (d)	17.5 in
Horz. Shr	6345	3518	lbs	Tube Wall Thk	0.3125 in
Torsion Moment	23274	12905	ft-lbs	Plate Thk (D)	2.25 in
Gravity Moment	88146	139512	ft-lbs	Plate Yield (Fy)	50 ksi
Wind Moment	223585	122410	ft-lbs		
<b>Applied Loads To Base Plate Connection</b>				<b>Shaft Dimensions</b>	
Axial	0	0	lbs	Diameter (d)	20.5 in
Shear	0	0	lbs	Tube Wall Thk	<b>0.375</b> in
Shear	0	0	lbs	Plate Thk (D)	2 in
Bending Moment	0	0	ft-lbs	Plate Yield (Fy)	36 ksi
Bending Moment	0	0	ft-lbs	Arm Attach. Elev.	<b>18.0</b> ft
Torsion Moment	0	0	ft-lbs		

**Additional Load Factor To Apply As Per Signal Plans & Specifications = 1.00**

**Electrodes**

**AASHTO Gp II & III Factor = 1.33**

**E70 Electrodes (Used with plates having Fy = 36 ksi)**

Fv = 0.27 Fu (AASHTO Bridge Spec 10.32.2)

Fv = 0.27 x 58000 = 15660 psi

Allowable = Fv \* Gp Factor = 20828 psi

**E70 Electrodes (Used with plates having Fy = 50 ksi)**

Fv = 0.27 x 65000 = 17550 psi

Allowable = Fv \* Gp Factor = 23342 psi

Reference: *Design of Welded Structures*, Omer W. Blodgett

Method: Weld As A Line

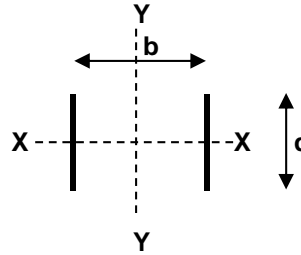


16362-3-4 - VA - 90 MPH - MP-3 Std. Loads-Type C-70'/60' Arms  
Weld Analysis - Continued

**ARM CONNECTING PLATES**

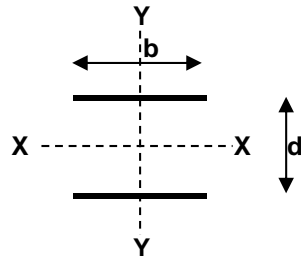
**Side Plates**

Vertical Length (d)	28.00	in	
Horz. Dist Between Plates (b)	17.98	in	
Thickness	<b>0.5</b>	in	
Weld Size	<b>0.375</b>	in	
Weld Throat (t <sub>1</sub> )	0.265	in	
A <sub>1</sub> = A <sub>w1</sub> * t <sub>1</sub> = 2 * d * t <sub>1</sub>	=	14.85	in <sup>2</sup>
S <sub>x1</sub> = S <sub>wx1</sub> * t <sub>1</sub> = (d <sup>2</sup> / 3) * t <sub>1</sub>	=	69.29	in <sup>3</sup>
S <sub>y1</sub> = S <sub>wy1</sub> * t <sub>1</sub> = b * d * t <sub>1</sub>	=	133.47	in <sup>3</sup>
J <sub>1</sub> = J <sub>w1</sub> * t <sub>1</sub> = t <sub>1</sub> * d(3b <sup>2</sup> + d <sup>2</sup> ) / 6	=	2169.90	in <sup>4</sup>



**Top & Bottom Plates**

Vert. Dist Between Plates (d)	28.00	in	
Horz. Length (b)	28.24	in	
Thickness	<b>0.5</b>	in	
Weld Size	<b>0.375</b>	in	
Weld Throat (t <sub>2</sub> )	0.265	in	
A <sub>2</sub> = A <sub>w2</sub> * t <sub>2</sub> = t <sub>2</sub> * 2 * b	=	15.0	in <sup>2</sup>
S <sub>x2</sub> = S <sub>wx2</sub> * t <sub>2</sub> = t <sub>2</sub> * b * d	=	209.7	in <sup>3</sup>
S <sub>y2</sub> = S <sub>wy2</sub> * t <sub>2</sub> = t <sub>2</sub> * (b <sup>2</sup> / 3)	=	70.5	in <sup>3</sup>
J <sub>2</sub> = J <sub>w2</sub> * t <sub>2</sub> = t <sub>2</sub> * (b <sup>3</sup> + 3bd <sup>2</sup> ) / 6	=	3930.7	in <sup>4</sup>



**Combined Analysis**

σ <sub>1</sub> = Gravity Mom / (S <sub>x1</sub> + S <sub>x2</sub> )	=	3792.0	Gp II	6002.0	psi
σ <sub>2</sub> = Wind Mom / (S <sub>y1</sub> + S <sub>y2</sub> )	=	13155.0	Gp II	7203.0	psi
σ <sub>2</sub> = [Tor. Mom * C / (J <sub>1</sub> + J <sub>2</sub> )] + [Res. Shr / (A <sub>1</sub> + A <sub>2</sub> )]	=	997.0	Gp II	613.0	psi
Res. Weld Stress = σ <sub>r</sub> = Sqrt[ (σ <sub>1</sub> + σ <sub>2</sub> ) <sup>2</sup> + σ <sub>3</sub> <sup>2</sup> ]	=	16977	Gp II	13220	psi
Allowable: E70 Electrodes * AASHTO Gp Factor	=	23341.5	Gp II	23341.5	psi
<b>Actual Weld Stress vs. Allowable</b>		<b>Passes</b>		<b>Passes</b>	



16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	7510 lbs
Bending Moment	244315 ft-lbs
Torsion Moment	280422 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.50 in

**ANALYSIS - ANCHOR BOLTS**

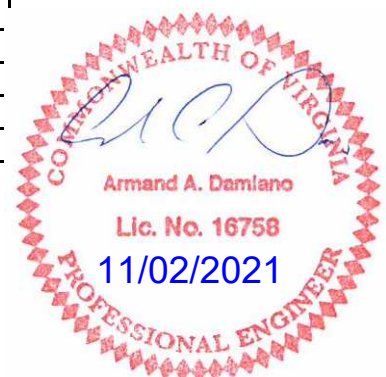
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	22.5 ksi
Bolt Direct Shear Stress	0.409 ksi
Bolt Torsion Shear Stress	14.068 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	22.5 ksi
$f_v =$	14.477 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.91 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	2.75 in
Design Moment	155 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	23.42 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.188 in
Design Moment	67 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	10.62 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-4 - VA - 90 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	28824 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	2.66 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.38
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

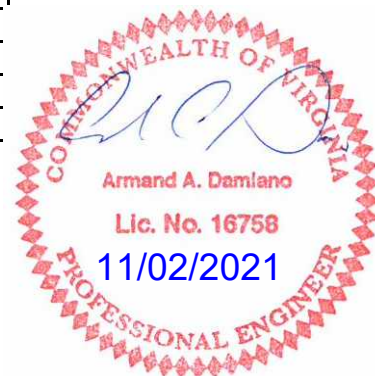
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	56250 lbs
Computed Factor-of Safety	1.1 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	56250 lbs
Total Tensile Load	450000 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.04 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	56250 lbs
Total Tensile Load	450000 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	<b>10</b> Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-5 - VA - 90 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

11/02/21

**General**

Wind Vel.- mph	90	No	Roadway - mph	55	<i>Fatigue Importance Factors</i>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.00
Fatigue Cat.	0		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.00
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.00
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	1		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.2500	0.14	17.50	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.2190	0.14	14.00	49.00	18.00	-	2.57	0	55	29000	180
Traffic Arm #2						-		0	55	29000	90
Lum Arm #1	0.3750		2.88	24.00	18.00	-	5	0	36	29000	180
Lum Arm #2						-		0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	6	Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	Double Top Nuts	Yes	
A.B. Bolt Circle	24.00	Foundation Diameter	48	in
Baseplate Dia.	30.00	Concrete Cover	4	in
Baseplate Thk.	2.00	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	12.50	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.	Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50	in
Flange Plate Length (V)	24.00	in
Flange Plate Width (H)	24.00	in
Spac. Between Bolt (V)	19.50	in
Spac. Between Bolt (H)	19.50	in
Flange Plate Thk.	2.00	in
Flange Plate Yield (Fy)	50	ksi
Gusset Thk.	0.375	in
Plate Center Hole	6.00	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.24	0.32	0.41								14.52	0.00
GP II CSR	0.93	0.83	0.97				0.90					
GP III CSR	0.56	0.57	0.70				0.67				23.96	
Nat.Wind (psi)	0	0										

Arm #1 Flange Bolt (Max.) CSR	0.36
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.69
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.00
Handhole at Toe (Fatigue) CSR	0.00
Minimum Qty of Vertical Reinf. Bars	7

Fatigue Allowable - Shaft to Baseplate	
Fatigue Allowable - Arm#1 to Flange	
Fatigue Allowable - Arm#2 to Flange	
Anchor Bolt Max. CSR	0.67
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.58
Anchorage Capacity S.F.	1.33
Concrete Pull Out Capacity S.F.	1.53

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
4977	6663	143595	119643



16362-3-5 - VA - 90 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.2
	#2	Ped Head	10.5	2.4	1			1	6	30	1.2
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.2
	#4										
Lum #1	#1	Cobra Head w/Camera	24	2	1			4.54	9	57	1
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	12'x2.5' Sign	7.5			12	2.5	1	30	66	1.20
	#3	5 Section Head w/BP	16	13.75	4			2	42	105	1.20
	#4		2.5'x3' Sign	23			2.5	3	1	7.5	22.5
	#5	Camera	24	1	1			1	3	22	1.20
	#6	3 Section Head w/BP	26	8.7	4			1	26	65	1.20
	#7	2.5'x3' Sign	34			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	37	8.7	4			1	26	65	1.20
	#9	Camera	39	1	1			1	3	22	1.20
	#10	3'x3.5' Sign	45			3	3.5	1	10.5	26.7	1.13
	#11	4 Section Head w/BP	48	11	5			1	34	80	1.20
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
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	#11										
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	#13										
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	#18										
	#19										
	#20										





16362-3-5 - VA - 90 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	17.500	17.352	48.60	0.5287	0.53	1.538	14.99	0.80
2	I	1.06	1.06	17.352	17.204	48.18	0.5287	1.59	1.524	14.87	0.80
3	I	1.06	2.12	17.204	17.055	47.76	0.5286	2.65	1.511	14.74	0.80
4	I	1.06	3.18	17.055	16.907	47.34	0.5286	3.71	1.498	14.62	0.80
5	I	1.06	4.24	16.907	16.759	46.92	0.5286	4.76	1.485	14.50	0.80
6	I	1.06	5.29	16.759	16.611	46.51	0.5286	5.82	1.472	14.37	0.80
7	I	1.06	6.35	16.611	16.462	46.09	0.5286	6.88	1.459	14.25	0.80
8	I	1.06	7.41	16.462	16.314	45.67	0.5286	7.94	1.446	14.13	0.80
9	I	1.06	8.47	16.314	16.166	45.25	0.5286	9.00	1.433	14.00	0.80
10	I	1.06	9.53	16.166	16.018	44.83	0.5286	10.06	1.420	13.88	0.80
11	I	1.06	10.59	16.018	15.869	44.41	0.5286	11.12	1.407	13.76	0.80
12	I	1.06	11.65	15.869	15.721	43.99	0.5286	12.18	1.394	13.63	0.80
13	I	1.06	12.71	15.721	15.573	43.57	0.5286	13.23	1.381	13.51	1.00
14	I	1.06	13.76	15.573	15.425	43.15	0.5286	14.29	1.368	13.39	1.00
15	I	1.06	14.82	15.425	15.276	42.73	0.5286	15.35	1.354	13.26	1.00
16	I	1.06	15.88	15.276	15.128	42.31	0.5286	16.41	1.341	13.14	1.00
17	I	1.06	16.94	15.128	14.980	41.89	0.5285	17.47	1.328	13.02	1.00
18	J	0.00	18.00	14.980	14.980	0.00	0.0000	0.00	0.000	0.00	1.00
19	I	0.00	18.00	14.980	14.980	0.00	0.0000	0.00	0.000	0.00	1.00
20	J	7.00	18.00	14.980	14.000	266.40	3.4605	3.46	8.453	82.96	1.00
						1036					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in <sup>4</sup> )	503.67	313.61	0.00	255.09
Section Modulus (in <sup>3</sup> )	58.40	42.58	0.00	
Cross-Section Area (in <sup>2</sup> )	13.54	11.56	0.00	
Width-Thickness Ratio	70.00	59.92	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	35.991	36.300	0.000	
Allow. Compressive Str (ksi)	11.295	11.295	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

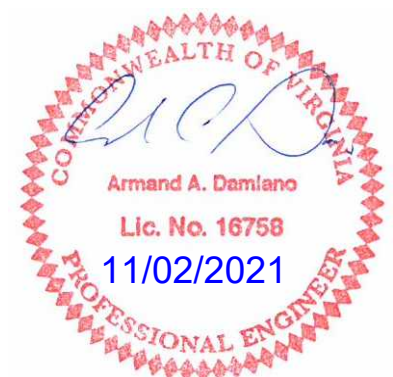
Shaft Deflection From Arm#1 GP I Load (in)	0.897
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-5 - VA - 90 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

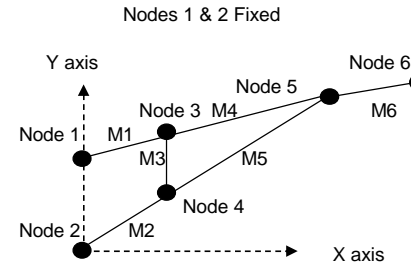
## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	19.40	0.000	19.22	1.100	0.000	0.00
2	0.450	12.62	19.24	0.000	19.06	1.100	0.000	0.00
3	0.450	12.62	19.07	0.000	18.89	1.100	0.000	0.00
4	0.450	12.62	18.91	0.000	18.73	1.100	0.000	0.00
5	0.450	12.62	18.74	0.001	18.57	1.100	0.000	0.00
6	0.450	12.62	18.58	0.001	18.40	1.100	0.000	0.00
7	0.450	12.62	18.41	0.001	18.24	1.100	0.000	0.00
8	0.450	12.62	18.25	0.002	18.08	1.100	0.000	0.00
9	0.450	12.62	18.08	0.002	17.91	1.100	0.000	0.00
10	0.450	12.62	17.92	0.003	17.75	1.100	0.000	0.00
11	0.450	12.62	17.75	0.003	17.58	1.100	0.000	0.00
12	0.450	12.62	17.59	0.004	17.42	1.100	0.000	0.00
13	0.450	15.77	21.77	0.005	17.26	1.100	0.000	0.00
14	0.450	15.77	21.57	0.006	17.09	1.100	0.000	0.00
15	0.450	15.77	21.36	0.007	16.93	1.100	0.000	0.00
16	0.450	15.77	21.15	0.007	16.77	1.100	0.000	0.00
17	0.450	15.77	20.95	0.008	16.60	1.100	0.000	0.00
18	0.450	15.77	0.00	0.000	0.00	1.100	0.000	0.00
19	0.450	15.77	0.00	0.000	0.00	1.100	0.000	0.00
20	0.450	15.77	133.30	0.002	105.66	1.100	0.000	0.00
Fix. #1	1.200	33.65	80.76	0.012	40.38	1.200	0.000	0.00
Fix. #2	1.200	33.65	80.76	0.012	40.38	1.200	0.000	0.00
Fix. #3	1.200	42.06	578.33	0.174	289.16	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-5 - VA - 90 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum. - Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-44.01	-40.6	0	0	0
Node #2	0	0	0	0	-46.58	-42.9	0	0	0
Node #3	100	59.5	0	0	-87	-80.8	0	0	0
Node #4	100	48.8	0	0	-90.64	-84.2	0	0	0
Node #5	200	79	0	0	-123.35	-113.7	0	0	0
Node #6	288	87	0	0	-93.99	-104.2	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-88.02	1.1	1	-81.07	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-93.14	1.1	1	-85.79	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.95	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-85.28	1.1	1	-78.55	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-87.44	1.1	1	-80.54	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-73.97	1.1	1	-68.12	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-57.00	1	1	-70.09					

AASHTO Gp	2
Mntg Hght =	23.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2629.3	lbs
P1y	-827.0	lbs
P1z	275.9	lbs
M1x	10140.5	in-lbs
M1y	-38193.6	in-lbs
M1z	-716.1	in-lbs
P2x	2629.3	lbs
P2y	1312.5	lbs
P2z	190.5	lbs
M2x	10472.0	in-lbs
M2y	-31056.0	in-lbs
M2z	-770.7	in-lbs

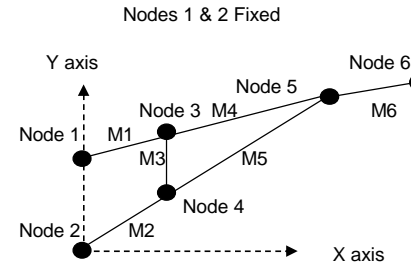
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-939	160	24009	-585	0.7
#2	989	101	19780	-1140	0.9
#3	1807	536	10558	-492	0.42
#4	-919	72	9114	-25	0.25
#5	936	83	10111	-347	0.55
#6	3	95	7530	-1	0.23

V09.19.15



16362-3-5 - VA - 90 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum. - Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-51.2	-20.3	0	0	0
Node #2	0	0	0	0	-54.18	-21.5	0	0	0
Node #3	100	59.5	0	0	-101.41	-40.4	0	0	0
Node #4	100	48.8	0	0	-105.65	-42.1	0	0	0
Node #5	200	79	0	0	-143.49	-56.9	0	0	0
Node #6	288	87	0	0	-124.03	-52.1	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-102.39	1.1	1	-40.53	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-108.35	1.1	1	-42.89	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.98	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-99.21	1.1	1	-39.27	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-101.72	1.1	1	-40.27	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-86.04	1.1	1	-34.06	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-81.00	1	1	-35.04					

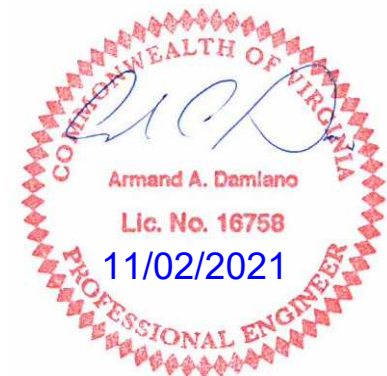
AASHTO Gp	3
Mntg Hght =	23.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-3247.7	lbs
P1y	-1031.5	lbs
P1z	138.0	lbs
M1x	5071.8	in-lbs
M1y	-19102.3	in-lbs
M1z	-1257.5	in-lbs
P2x	3247.7	lbs
P2y	1611.4	lbs
P2z	95.3	lbs
M2x	5237.5	in-lbs
M2y	-15532.5	in-lbs
M2z	-1306.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1160	82	12031	-293	0.33
#2	1221	53	9922	-570	0.67
#3	2226	413	8306	-247	0.38
#4	-1137	45	4616	-13	0.11
#5	1159	49	5109	-174	0.46
#6	4	91	7207	-1	0.22

V09.19.15



16362-3-5 - VA - 90 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	2.45	0.00	14.000	13.657	78.1	1.2199	1.22	2.823	2.823	27.76
2	I	2.45	2.45	13.657	13.314	76.1	1.2198	3.67	2.753	2.753	27.10
3	I	2.45	4.90	13.314	12.971	74.1	1.2197	6.12	2.683	2.683	26.44
4	I	2.45	7.35	12.971	12.628	72.2	1.2195	8.57	2.613	2.613	25.78
5	I	2.45	9.80	12.628	12.285	70.2	1.2194	11.02	2.543	2.543	25.12
6	I	2.45	12.25	12.285	11.942	68.2	1.2192	13.47	2.473	2.473	24.46
7	I	2.45	14.70	11.942	11.599	66.3	1.2191	15.92	2.403	2.403	23.80
8	I	2.45	17.15	11.599	11.256	64.3	1.2189	18.37	2.333	2.333	23.14
9	I	2.45	19.60	11.256	10.913	62.3	1.2187	20.82	2.263	2.263	22.48
10	I	2.45	22.05	10.913	10.570	60.4	1.2185	23.27	2.193	2.193	21.82
11	I	2.45	24.50	10.570	10.227	58.4	1.2183	25.72	2.123	2.123	21.16
12	I	2.45	26.95	10.227	9.884	56.4	1.2180	28.17	2.053	2.053	20.50
13	I	2.45	29.40	9.884	9.541	54.5	1.2178	30.62	1.983	1.983	19.84
14	I	2.45	31.85	9.541	9.198	52.5	1.2175	33.07	1.913	1.913	19.18
15	I	2.45	34.30	9.198	8.855	50.5	1.2172	35.52	1.843	1.843	18.52
16	I	2.45	36.75	8.855	8.512	48.6	1.2169	37.97	1.773	1.773	17.86
17	I	2.45	39.20	8.512	8.169	46.6	1.2166	40.42	1.703	1.703	17.20
18	I	2.45	41.65	8.169	7.826	44.6	1.2162	42.87	1.633	1.633	16.54
19	I	2.45	44.10	7.826	7.483	42.6	1.2159	45.32	1.563	1.563	15.88
20	I	2.45	46.55	7.483	7.140	40.7	1.2154	47.77	1.493	1.493	15.22
		<u>49.00</u>				<u>1187</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	66	7.50	30.000	1.000	90.00
Fix. #3	105	16.00	13.750	2.000	126.00
Fix. #4	22.5	23.00	7.500	1.000	22.50
Fix. #5	22	24.00	1.000	1.000	9.00
Fix. #6	65	26.00	8.700	1.000	78.00
Fix. #7	22.5	34.00	7.500	1.000	22.50
Fix. #8	65	37.00	8.700	1.000	78.00
Fix. #9	22	39.00	1.000	1.000	9.00
Fix. #10	26.7	45.00	10.500	1.000	31.50
Fix. #11	80	48.00	11.000	1.000	102.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	32.649	0.000
Cross-Section Area (in^2)	9.477	0.000
Width-Thickness Ratio	63.93	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	36.300	0.000
Allow. Shear Stress (ksi)	18.150	0.000



16362-3-5 - VA - 90 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	
1	1.00	0.450	15.77	44.52	35.29	1.100	0.000	0.00	0	0.644	0.00	0.00	
2	1.00	0.450	15.77	43.42	34.42	1.100	0.000	0.00	0	0.666	0.00	0.00	
3	1.00	0.450	15.77	42.32	33.54	1.100	0.000	0.00	0	0.688	0.00	0.00	
4	1.00	0.450	15.77	41.21	32.67	1.100	0.000	0.00	0	0.712	0.00	0.00	
5	1.00	0.450	15.77	40.11	31.79	1.100	0.000	0.00	0	0.738	0.00	0.00	
6	1.00	0.450	15.77	39.00	30.91	1.100	0.000	0.00	0	0.765	0.00	0.00	
7	1.00	0.450	15.77	37.90	30.04	1.100	0.000	0.00	0	0.794	0.00	0.00	
8	1.00	0.450	15.77	36.79	29.16	1.100	0.000	0.00	0	0.825	0.00	0.00	
9	1.00	0.450	15.77	35.69	28.29	1.100	0.000	0.00	0	0.859	0.00	0.00	
10	1.00	0.450	15.77	34.58	27.41	1.100	0.000	0.00	0	0.895	0.00	0.00	
11	1.00	0.450	15.77	33.48	26.54	1.100	0.000	0.00	0	0.933	0.00	0.00	
12	1.00	0.450	15.77	32.38	25.66	1.100	0.000	0.00	0	0.975	0.00	0.00	
13	1.00	0.450	15.77	31.27	24.79	1.100	0.000	0.00	0	1.020	0.00	0.00	
14	1.00	0.450	15.77	30.17	23.91	1.100	0.000	0.00	0	1.069	0.00	0.00	
15	1.00	0.450	15.77	29.06	23.04	1.100	0.000	0.00	1	1.100	0.00	0.00	
16	1.00	0.450	15.77	27.96	22.16	1.100	0.000	0.00	1	1.100	0.00	0.00	
17	1.00	0.462	16.2	27.59	21.29	1.100	0.000	0.00	1	1.100	0.00	0.00	
18	1.00	0.488	17.11	27.94	20.41	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.517	18.12	28.32	19.53	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.549	19.23	28.71	18.66	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	42.03	1260.90	630.45	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	365.92	182.96	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	39.66	416.43	208.22	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	462.66	231.33	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



16362-3-5 - VA - 90 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

Flange Analysis - Arm #1

V06-21-16

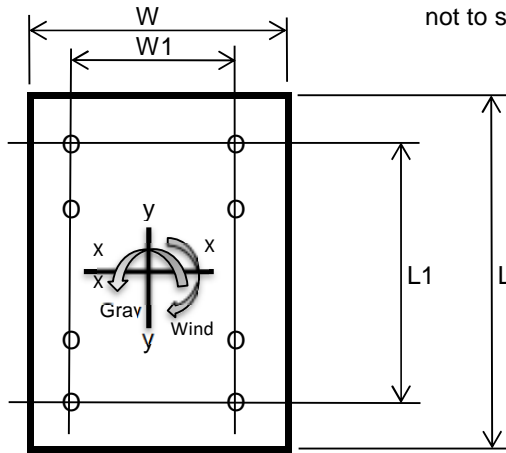
Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1706	2713	-	lbs
Shear (Wind)	4865	2626	-	lbs
Torsion (Arm Rise)	12491	6742	-	ft-lbs
Moment (Gravity)	39946	65204	-	ft-lbs
Moment (Wind)	117926	63047	-	ft-lbs
Nat. Wind Moment	-	-	0	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs

Diameter of tube	14.00	in
Tube Wall Thick.	0.219	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.00
W	24
W1	19.50
L	24
L1	19.50
L2 - Dist. between bolts (Typ.)	6.50



Worst Bolt Load (Corner Bolt P1)

	Results GpII	Results GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	596.99	596.99	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1073.57	1073.57	in <sup>4</sup>
Bolt Tensile Stress - ft	15.05	14.51	ksi
Bolt Shear Stress - fv	1.82	1.1	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.36	0.34	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	0	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0	<b>OK</b>	

Plate Analysis

Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	9.51	15.52	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	28.55	15.26	ksi
Combined applied stress for interaction (SRSS)	30.09	21.77	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-5 - VA - 90 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear	Shear	Bending	Torsion	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	1706		1706	39946		39947		361	14682		0.41
Gp II	1706	4865	5156	39946	117926	124508	12491	1089	45762	2296	0.97
Gp III	2713	2626	3776	65204	63047	90700	6742	797	33336	1239	0.70
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-





16362-3-5 - VA - 90 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	3392		39946	0	39946		251		8209		0.24
Gp II	3392	6663	59958	130478	143595	119643	251	985	29507	12293	0.93
Gp III	4977	3711	54005	93213	107727	63906	368	549	22137	6566	0.56
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9964										

<b>Shaft At Arm</b>											
Gp I	2458		39946	0	39946		213		11257		0.32
Gp II	2458	5465	12491	46178	47838	119643	213	946	13481	16859	0.83
Gp III	3560	2965	6742	68456	68787	63906	308	513	19385	9005	0.57
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9964										



16362-3-5 - VA - 90 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	6663 lbs
Bending Moment	143595 ft-lbs
Torsion Moment	119643 ft-lbs
Num. Anchor Bolts	6
Bolt Circle	24 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	30 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	17.50 in

**ANALYSIS - ANCHOR BOLTS**

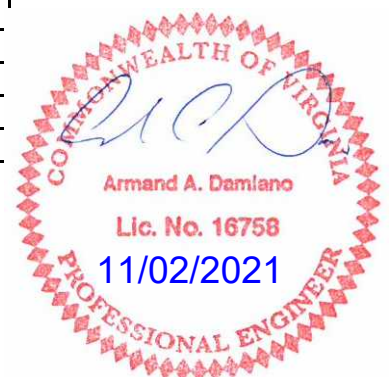
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1082.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	19.094 ksi
Bolt Direct Shear Stress	0.483 ksi
Bolt Torsion Shear Stress	8.67 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	19.094 ksi
$f_v =$	9.153 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.67 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	12.701 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	156 in-kip
Section Modulus of Failure Plane	8.46 in <sup>3</sup>
Applied Plate Stress	18.44 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	12.052 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	81 in-kip
Section Modulus of Failure Plane	8.03 in <sup>3</sup>
Applied Plate Stress	10.09 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-5 - VA - 90 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1082.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	0 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

Anchor Bolt Length	60.0 in
Anchor Bolt Max. Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	127540 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	11 in
T Reduced For Group Action	63770 lbs
Maximum Applied Tensile Load	47735 lbs
Computed Factor-of Safety	1.33 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	47735 lbs
Total Tensile Load	286410 lbs
Concrete Failure Surface Area	4002.39 in <sup>2</sup>
Concrete Shear Strength	438440 psi
Computed Factor-of Safety	1.53 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	47735 lbs
Total Tensile Load	286410 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	45.36 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	7 Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

11/02/21

**General**

Wind Vel. - mph	90	No	Roadway - mph	55	<i>Fatigue Importance Factors</i>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	1		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.00	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.3125	0.14	18.50	28.00	18.00	-	3.93	0	55	29000	180
	0.1880	0.14	15.37	49.99	-	2.93		0	55	29000	
Traffic Arm #2								0	55	29000	90
								0	55	29000	
Lum Arm #1	0.3750		2.88	24.00	24.00	-	5	0	36	29000	180
Lum Arm #2						-		0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8		Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes	
A.B. Bolt Circle	26.00	in	Foundation Diameter	48	in
Baseplate Dia.	32.00	in	Concrete Cover	4	in
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	15.25	in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.		Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50 in	in
Flange Plate Length (V)	27.00 in	in
Flange Plate Width (H)	27.00 in	in
Spac. Between Bolt (V)	22.50 in	in
Spac. Between Bolt (H)	22.50 in	in
Flange Plate Thk.	2.25 in	in
Flange Plate Yield (Fy)	50 ksi	ksi
Gusset Thk.	0.500 in	in
Plate Center Hole	6.00 in	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	<i>Shaft At</i>		<i>Arm#1</i>		<i>Arm#2</i>		<i>Lum#1</i>		<i>Lum#2</i>		<i>Tip Deflection (in)</i>	
	Base	Flange	Root	Joint	Root	Joint	Root	Root			Arm #1	Arm #2
GP I CSR	0.32	0.41	0.43	0.42							29.50	0.00
GP II CSR	0.84	0.90	0.84	0.96			0.95					
GP III CSR	0.59	0.67	0.66	0.72			0.69				47.63	
Nat.Wind (psi)	2778	593	5414	5706								

Arm #1 Flange Bolt (Max.) CSR	0.70
Arm #1 Flange Bolt Fatigue CSR	0.50
Arm #1 Flange Plate (Max.) CSR	0.97
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.66
Handhole at Toe (Fatigue) CSR	0.42
Minimum Qty of Vertical Reinf. Bars	9

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.83
Anchor Bolt Max. Fatigue Stress Ratio	0.35
Base Plate Max. CSR	0.76
Anchorage Capacity S.F.	1.17
Concrete Pull Out Capacity S.F.	1.11

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
8063	8801	229416	247004



16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1	Cobra Head w/Camera	24	2	1			4.54	9	57	1.00
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	9			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	19	13.75	4			2	42	105	1.20
	#4	2.5'x3' Sign	23			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	30	8.7	4			1	26	65	1.20
	#6	3 Section Head w/BP	41	8.7	4			1	26	65	1.20
	#7	Camera	45	1	1			1	3	22	1.20
	#8	2.5'x3' Sign	49			2.5	3	1	7.5	22.5	1.13
	#9	3 Section Head w/BP	52	8.7	4			1	26	65	1.20
	#10	2.5'x3' Sign	60			2.5	3	1	7.5	22.5	1.13
	#11	3 Section Head w/BP	63	8.7	4			1	26	65	1.20
	#12	Camera	67	1	1			1	3	22	1.20
	#13	3'x3.5' Sign	71			3	3.5	1	10.5	26.7	1.13
	#14	4 Section Head w/BP	74	11	5			1	34	80	1.20
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										



16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.000	19.852	82.99	0.5288	0.53	1.758	17.07	0.80
2	I	1.06	1.06	19.852	19.704	82.36	0.5288	1.59	1.745	16.95	0.80
3	I	1.06	2.12	19.704	19.555	81.73	0.5287	2.65	1.732	16.82	0.80
4	I	1.06	3.18	19.555	19.407	81.10	0.5287	3.71	1.719	16.70	0.80
5	I	1.06	4.24	19.407	19.259	80.47	0.5287	4.76	1.706	16.58	0.80
6	I	1.06	5.29	19.259	19.111	79.84	0.5287	5.82	1.693	16.45	0.80
7	I	1.06	6.35	19.111	18.962	79.21	0.5287	6.88	1.680	16.33	0.80
8	I	1.06	7.41	18.962	18.814	78.58	0.5287	7.94	1.667	16.21	0.80
9	I	1.06	8.47	18.814	18.666	77.95	0.5287	9.00	1.654	16.08	0.80
10	I	1.06	9.53	18.666	18.518	77.32	0.5287	10.06	1.640	15.96	0.80
11	I	1.06	10.59	18.518	18.369	76.69	0.5287	11.12	1.627	15.84	0.80
12	I	1.06	11.65	18.369	18.221	76.06	0.5287	12.18	1.614	15.71	0.80
13	I	1.06	12.71	18.221	18.073	75.43	0.5287	13.23	1.601	15.59	1.00
14	I	1.06	13.76	18.073	17.925	74.81	0.5287	14.29	1.588	15.47	1.00
15	I	1.06	14.82	17.925	17.776	74.18	0.5287	15.35	1.575	15.34	1.00
16	I	1.06	15.88	17.776	17.628	73.55	0.5287	16.41	1.562	15.22	1.00
17	I	1.06	16.94	17.628	17.480	72.92	0.5287	17.47	1.549	15.10	1.00
18	J	3.00	18.00	17.480	17.060	203.18	1.4939	19.49	4.318	42.10	1.00
19	I	3.00	21.00	17.060	16.640	198.13	1.4938	22.49	4.213	41.12	1.00
20	J	1.00	24.00	16.640	16.500	64.92	0.4993	24.50	1.381	13.49	1.00
						1792					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in <sup>4</sup> )	1112.50	736.61	0.00	617.12
Section Modulus (in <sup>3</sup> )	113.38	86.13	0.00	
Cross-Section Area (in <sup>2</sup> )	23.11	20.14	0.00	
Width-Thickness Ratio	53.33	46.61	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	14.993	14.993	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	1.040
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

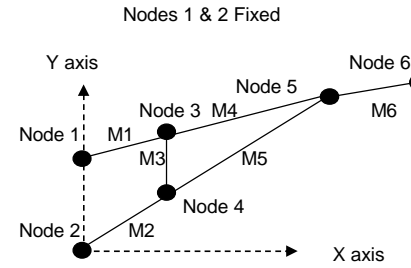
## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.19	0.000	21.98	1.100	4.576	8.05
2	0.450	12.62	22.02	0.000	21.81	1.100	4.576	7.99
3	0.450	12.62	21.86	0.000	21.65	1.100	4.576	7.93
4	0.450	12.62	21.69	0.000	21.49	1.100	4.576	7.87
5	0.450	12.62	21.53	0.000	21.32	1.100	4.576	7.81
6	0.450	12.62	21.36	0.000	21.16	1.100	4.576	7.75
7	0.450	12.62	21.20	0.001	21.00	1.100	4.576	7.69
8	0.450	12.62	21.03	0.001	20.83	1.100	4.576	7.63
9	0.450	12.62	20.87	0.001	20.67	1.100	4.576	7.57
10	0.450	12.62	20.70	0.001	20.51	1.100	4.576	7.51
11	0.450	12.62	20.54	0.002	20.34	1.100	4.576	7.45
12	0.450	12.62	20.37	0.002	20.18	1.100	4.576	7.39
13	0.450	15.77	25.25	0.003	20.02	1.100	4.576	7.33
14	0.450	15.77	25.04	0.003	19.85	1.100	4.576	7.27
15	0.450	15.77	24.84	0.003	19.69	1.100	4.576	7.21
16	0.450	15.77	24.63	0.004	19.52	1.100	4.576	7.15
17	0.450	15.77	24.43	0.004	19.36	1.100	4.576	7.09
18	0.450	15.77	68.09	0.015	53.97	1.100	4.576	19.76
19	0.450	15.77	66.43	0.018	52.66	1.100	4.576	19.28
20	0.450	15.77	21.78	0.007	17.26	1.100	4.576	6.32
Fix. #1	1.200	33.65	80.76	0.006	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.006	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.077	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum. - Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-44.01	-40.6	0	0	0
Node #2	0	0	0	0	-46.58	-42.9	0	0	0
Node #3	100	59.5	0	0	-87	-84.8	0	0	0
Node #4	100	48.8	0	0	-90.64	-88.2	0	0	0
Node #5	200	79	0	0	-123.35	-125	0	0	0
Node #6	288	87	0	0	-93.99	-114.6	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-88.02	1.1	1	-81.07	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-93.14	1.1	1	-85.79	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.95	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-85.28	1.1	1.1	-86.40	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-87.44	1.1	1.1	-88.59	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-73.97	1.1	1.1	-74.94	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-77.10					

AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2629.3	lbs
P1y	-827.0	lbs
P1z	294.4	lbs
M1x	10996.1	in-lbs
M1y	-41528.6	in-lbs
M1z	-716.1	in-lbs
P2x	2629.3	lbs
P2y	1312.5	lbs
P2z	201.7	lbs
M2x	11346.6	in-lbs
M2y	-33776.2	in-lbs
M2z	-770.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-939	173	26099	-644	0.76
#2	989	109	21500	-1250	0.95
#3	1807	572	11253	-534	0.45
#4	-919	78	10031	-29	0.28
#5	936	91	11105	-380	0.58
#6	3	101	7955	-1	0.24

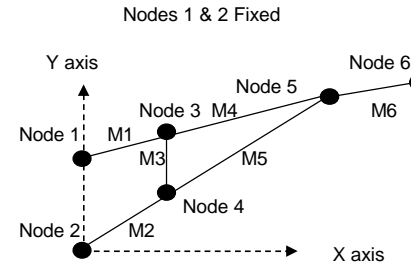
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16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum. - Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-51.2	-20.3	0	0	0
Node #2	0	0	0	0	-54.18	-21.5	0	0	0
Node #3	100	59.5	0	0	-101.41	-42.4	0	0	0
Node #4	100	48.8	0	0	-105.65	-44.1	0	0	0
Node #5	200	79	0	0	-143.49	-62.5	0	0	0
Node #6	288	87	0	0	-124.03	-57.3	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-102.39	1.1	1	-40.53	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-108.35	1.1	1	-42.89	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.98	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-99.21	1.1	1.1	-43.20	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-101.72	1.1	1.1	-44.29	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-86.04	1.1	1.1	-37.47	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-38.55					

AASHTO Gp	3
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-3247.7	lbs
P1y	-1031.5	lbs
P1z	147.2	lbs
M1x	5498.0	in-lbs
M1y	-20764.3	in-lbs
M1z	-1257.5	in-lbs
P2x	3247.7	lbs
P2y	1611.4	lbs
P2z	100.9	lbs
M2x	5673.3	in-lbs
M2y	-16888.1	in-lbs
M2z	-1306.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1160	88	13070	-322	0.36
#2	1221	57	10777	-625	0.69
#3	2226	425	8530	-267	0.39
#4	-1137	47	5068	-15	0.12
#5	1159	52	5600	-190	0.48
#6	4	93	7320	-1	0.23

V09.19.15



16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	4.18	0.00	18.500	17.915	249.8	2.0780	2.08	6.340	6.340	61.72
2	I	4.18	4.18	17.915	17.330	241.6	2.0776	6.26	6.136	6.136	59.80
3	I	4.18	8.36	17.330	16.745	233.5	2.0772	10.43	5.932	5.932	57.88
4	I	4.18	12.54	16.745	16.160	225.3	2.0768	14.61	5.729	5.729	55.96
5	I	4.18	16.71	16.160	15.575	217.1	2.0763	18.79	5.525	5.525	54.04
6	I	4.18	20.89	15.575	14.990	209.0	2.0758	22.97	5.321	5.321	52.12
7	J	2.93	25.07	15.370	14.960	229.9	1.4584	26.53	3.703	3.703	36.28
8	O	3.62	28.00	14.960	14.453	105.6	1.7996	29.80	4.436	4.436	43.52
9	O	3.62	31.62	14.453	13.946	101.9	1.7992	33.42	4.284	4.284	42.08
10	O	3.62	35.24	13.946	13.439	98.3	1.7988	37.04	4.131	4.131	40.64
11	O	3.62	38.86	13.439	12.933	94.6	1.7984	40.66	3.978	3.978	39.20
12	O	3.62	42.48	12.933	12.426	90.9	1.7979	44.28	3.825	3.825	37.75
13	O	3.62	46.10	12.426	11.919	87.2	1.7974	47.90	3.672	3.672	36.31
14	O	3.62	49.72	11.919	11.412	83.5	1.7969	51.52	3.519	3.519	34.87
15	O	3.62	53.34	11.412	10.905	79.8	1.7963	55.14	3.366	3.366	33.43
16	O	3.62	56.96	10.905	10.399	76.1	1.7956	58.76	3.213	3.213	31.99
17	O	3.62	60.58	10.399	9.892	72.4	1.7949	62.37	3.060	3.060	30.55
18	O	3.62	64.20	9.892	9.385	68.8	1.7941	65.99	2.908	2.908	29.11
19	O	3.62	67.82	9.385	8.878	65.1	1.7933	69.61	2.755	2.755	27.67
20	O	3.62	71.44	8.878	8.371	61.4	1.7923	73.23	2.602	2.602	26.23
		<u>75.06</u>				<u>2692</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	9.00	37.500	1.000	112.50
Fix. #3	105	19.00	13.750	2.000	126.00
Fix. #4	22.5	23.00	7.500	1.000	22.50
Fix. #5	65	30.00	8.700	1.000	78.00
Fix. #6	65	41.00	8.700	1.000	78.00
Fix. #7	22	45.00	1.000	1.000	9.00
Fix. #8	22.5	49.00	7.500	1.000	22.50
Fix. #9	65	52.00	8.700	1.000	78.00
Fix. #10	22.5	60.00	7.500	1.000	22.50
Fix. #11	65	63.00	8.700	1.000	78.00
Fix. #12	22	67.00	1.000	1.000	9.00
Fix. #13	26.7	71.00	10.500	1.000	31.50
Fix. #14	80	74.00	11.000	1.000	102.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	81.146	34.016
Cross-Section Area (in^2)	17.846	8.962
Width-Thickness Ratio	59.20	81.76
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	33.901
Allow. Shear Stress (ksi)	18.150	16.085



16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	
1	1.00	0.450	15.77	99.98	79.25	1.100	4.576	29.01	0	0.451	0.00	0.00	
2	1.00	0.450	15.77	96.77	76.70	1.100	4.576	28.08	0	0.470	0.00	0.00	
3	1.00	0.450	15.77	93.55	74.15	1.100	4.576	27.15	0	0.491	0.00	0.00	
4	1.00	0.450	15.77	90.34	71.61	1.100	4.576	26.21	0	0.514	0.00	0.00	
5	1.00	0.450	15.77	87.13	69.06	1.100	4.576	25.28	0	0.539	0.00	0.00	
6	1.00	0.450	15.77	83.92	66.52	1.100	4.576	24.35	0	0.566	0.00	0.00	
7	1.00	0.450	15.77	80.71	64.00	1.100	4.576	23.42	0	0.591	0.00	0.00	
8	1.00	0.450	15.77	77.50	61.48	1.100	4.576	22.50	0	0.616	0.00	0.00	
9	1.00	0.450	15.77	74.29	58.96	1.100	4.576	21.57	0	0.641	0.00	0.00	
10	1.00	0.450	15.77	71.08	56.44	1.100	4.576	20.65	0	0.666	0.00	0.00	
11	1.00	0.450	15.77	67.87	53.92	1.100	4.576	19.72	0	0.691	0.00	0.00	
12	1.00	0.450	15.77	64.66	51.40	1.100	4.576	18.80	0	0.716	0.00	0.00	
13	1.00	0.450	15.77	61.45	48.88	1.100	4.576	17.87	0	0.741	0.00	0.00	
14	1.00	0.450	15.77	58.24	46.36	1.100	4.576	16.95	0	0.766	0.00	0.00	
15	1.00	0.450	15.77	55.03	43.84	1.100	4.576	16.02	0	0.791	0.00	0.00	
16	1.00	0.450	15.77	51.82	41.32	1.100	4.576	15.10	0	0.816	0.00	0.00	
17	1.00	0.450	15.77	48.61	38.80	1.100	4.576	14.17	1	0.841	0.00	0.00	
18	1.00	0.450	15.77	45.40	36.28	1.100	4.576	13.25	1	0.866	0.00	0.00	
19	1.00	0.450	15.77	42.19	33.76	1.100	4.576	12.32	1	0.891	0.00	0.00	
20	1.00	0.450	15.77	38.98	31.24	1.100	4.576	11.40	1	0.916	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #13	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #14	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



Flange Analysis - Arm #1

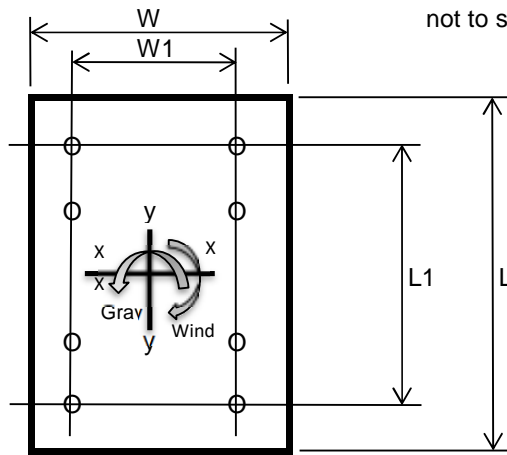
Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	3385	4995	-	lbs
Shear (Wind)	6858	3819	-	lbs
Torsion (Arm Rise)	26974	15020	-	ft-lbs
Moment (Gravity)	104449	163666	-	ft-lbs
Moment (Wind)	245142	135389	-	ft-lbs
Nat. Wind Moment	-	-	36609	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs

Diameter of tube	18.50	in
Tube Wall Thick.	0.3125	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)

	Results GpII	Results GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	29.19	30.62	ksi
Bolt Shear Stress - fv	3.25	2.02	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.68	0.70	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	3.46	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.5	<b>OK</b>	

Plate Analysis

Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	16.37	25.65	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	39.07	21.58	ksi
Combined applied stress for interaction (SRSS)	42.36	33.52	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.3	
Dop - Baseplate center hole diameter	15.25	in
Cop - Center hole to shaft diameter ratio	0.7625	
Kf - Fatigue stress concentration factor for finite life	2.49	
Ki - Fatigue stress concentration factor for infinite life	5.82	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.3125	in
Dt - Arm base diameter	18.50	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	1.72	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.324324	
Kf - Fatigue stress concentration factor for finite life	1.81	
Ki - Fatigue stress concentration factor for infinite life	3.65	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

## Lower Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	19.57	in
Shaft Thickness	0.375	in
Total Area	27.3136	in <sup>2</sup>
Ix	1143	in <sup>4</sup>
Iy	1250	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	26248	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	10.58	ksi
CSR	0.66	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.91	ksi
CSR	0.42	
Therefore	<b>OK</b>	



16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

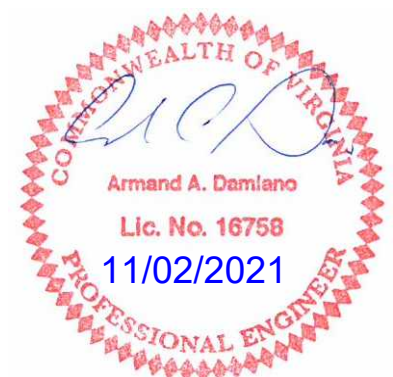
## Upper Hand Hole Stresses

**INPUTS**

Handhole Width	3.00	in
Handhole Height	5.00	in
Distance From Base Plate To Hand Hole Center Line	216	in
Radial Orientation	0	Degrees
Rim Thickness	0.50	in
Rim Depth	3.50	in
Rim Projection	0.375	in
Shaft Diameter (At hand hole location)	17.48	in
Shaft Thickness	0.375	in
Total Area	22.198	in <sup>2</sup>
Ix	752	in <sup>4</sup>
Iy	811	in <sup>4</sup>
Controlling Moment - Galloping	4257	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	2.32	ksi
CSR	0.15	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.60	ksi
CSR	0.09	
Therefore	<b>OK</b>	



16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					
<b>Arm#1 Base</b>											
Gp I	3385		3385	104449		104449		380	15447		0.43
Gp II	3385	6858	7649	104449	245142	266467	26974	858	39406	1995	0.84
Gp III	4995	3819	6288	163666	135389	212408	15020	705	31412	1111	0.66
Gp IV Natural		1042	1042		36609	36609	4100	117	5414	304	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-
<b>Arm#1 Joint</b>											
Gp I	1771		1771	40013		40013		396	14116		0.42
Gp II	1771	3803	4196	40013	110853	117854	14958	937	41576	2639	0.96
Gp III	2769	2130	3494	66111	60571	89663	8377	780	31631	1478	0.72
Gp IV Natural		585	585		16172	16172	2302	131	5706	407	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-
<b>Arm#2 Base</b>											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-
<b>Arm#2 Joint</b>											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-





16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	5827		104449	0	104449		252		11055		0.32
Gp II	5827	8801	134533	185829	229416	247004	252	762	24282	13072	0.84
Gp III	8063	5009	83757	200446	217241	136320	349	434	22993	7214	0.59
Gp IV Natural			26248	0	26248				2778		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9971										

<b>Shaft At Arm</b>											
Gp I	4337		104449	0	104449		215		14553		0.41
Gp II	4337	7510	26974	114242	117383	247004	215	746	16355	17207	0.90
Gp III	6041	4191	15020	168722	169389	136320	300	417	23600	9497	0.67
Gp IV Natural			4257	0	4257				593		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9971										



16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	8801 lbs
Bending Moment	229416 ft-lbs
Torsion Moment	247004 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.00 in

**ANALYSIS - ANCHOR BOLTS**

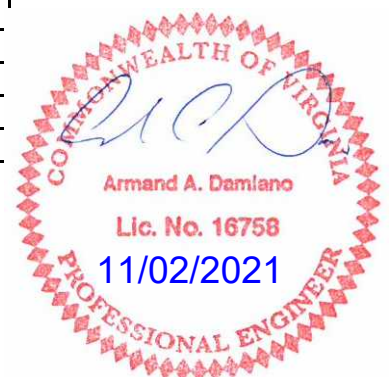
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	21.128 ksi
Bolt Direct Shear Stress	0.479 ksi
Bolt Torsion Shear Stress	12.392 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	21.128 ksi
$f_v =$	12.871 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.83 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3 in
Design Moment	159 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	24.02 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.438 in
Design Moment	76 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	12.05 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-6 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	26248 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	2.42 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.35
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	52820 lbs
Computed Factor-of Safety	1.17 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	52820 lbs
Total Tensile Load	422560 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.11 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	52820 lbs
Total Tensile Load	422560 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	<b>9</b> Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

11/02/21

**General**

Wind Vel. - mph	90	No	Roadway - mph	55	<b>Fatigue Importance Factors</b>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	1		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	22.50	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.3750	0.14	19.00	29.00	18.00	-	3.93	0	55	29000	180
	0.2500	0.14	15.87	49.04	-	3.02		0	55	29000	
Traffic Arm #2								0	55	29000	90
								0	55	29000	
Lum Arm #1	0.3750		2.88	24.00	24.00	-	5	0	36	29000	180
Lum Arm #2						-		0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8		Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes	
A.B. Bolt Circle	29.00	in	Foundation Diameter	48	in
Baseplate Dia.	35.00	in	Concrete Cover	4	in
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	17.75	in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.		Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50 in	in
Flange Plate Length (V)	29.50 in	in
Flange Plate Width (H)	29.50 in	in
Spac. Between Bolt (V)	25.00 in	in
Spac. Between Bolt (H)	25.00 in	in
Flange Plate Thk.	2.75 in	in
Flange Plate Yield (Fy)	50 ksi	ksi
Gusset Thk.	0.500 in	in
Plate Center Hole	6.00 in	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.35	0.44	0.48	0.40							30.14	0.00
GP II CSR	0.85	0.97	0.92	0.99			0.95					
GP III CSR	0.60	0.69	0.71	0.70			0.69				47.71	
Nat.Wind (psi)	2231	458	5703	5967								

Arm #1 Flange Bolt (Max.) CSR	0.86
Arm #1 Flange Bolt Fatigue CSR	0.59
Arm #1 Flange Plate (Max.) CSR	0.85
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.54
Handhole at Toe (Fatigue) CSR	0.33
Minimum Qty of Vertical Reinf. Bars	10

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.96
Anchor Bolt Max. Fatigue Stress Ratio	0.32
Base Plate Max. CSR	0.78
Anchorage Capacity S.F.	1.05
Concrete Pull Out Capacity S.F.	1.15

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
9459	8891	273380	344216



16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft.)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1	Cobra Head w/Camera	24	2	1			4.54	9	57	1.00
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	3 Section Head w/BP	20	8.7	4			1	26	65	1.20
	#3	3 Section Head w/BP	32	8.7	4			1	26	65	1.20
	#4	2.5'x3' Sign	41			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	44	8.7	4			1	26	65	1.20
	#6	2.5'x3' Sign	47			2.5	3	1	7.5	22.5	1.13
	#7	3 Section Head w/BP	50	8.7	4			1	26	65	1.20
	#8	2.5'x3' Sign	52			2.5	3	1	7.5	22.5	1.13
	#9	Camera	54	1	1			1	3	22	1.20
	#10	3 Section Head w/BP	56	8.7	4			1	26	65	1.20
	#11	2.5'x3' Sign	58			2.5	3	1	7.5	22.5	1.13
	#12	5 Section Head w/BP	62	13.75	4			2	42	105	1.20
	#13	3'x3.5' Sign	65			3	3.5	1	10.5	26.7	1.13
	#14	Camera	66	1	1			1	3	22	1.20
	#15	4 Section Head w/BP	68	11	5			1	34	80	1.20
	#16	3'x3.5' Sign	71			3	3.5	1	10.5	26.7	1.13
	#17	4 Section Head w/BP	74	11	5			1	34	80	1.20
	#18										
#19											
#20											
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
	#12										



16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	22.500	22.352	93.60	0.5288	0.53	1.979	19.15	0.80
2	I	1.06	1.06	22.352	22.204	92.97	0.5288	1.59	1.966	19.02	0.80
3	I	1.06	2.12	22.204	22.055	92.34	0.5288	2.65	1.953	18.90	0.80
4	I	1.06	3.18	22.055	21.907	91.71	0.5288	3.71	1.940	18.78	0.80
5	I	1.06	4.24	21.907	21.759	91.08	0.5288	4.76	1.926	18.65	0.80
6	I	1.06	5.29	21.759	21.611	90.45	0.5288	5.82	1.913	18.53	0.80
7	I	1.06	6.35	21.611	21.462	89.82	0.5288	6.88	1.900	18.41	0.80
8	I	1.06	7.41	21.462	21.314	89.19	0.5288	7.94	1.887	18.29	0.80
9	I	1.06	8.47	21.314	21.166	88.56	0.5288	9.00	1.874	18.16	0.80
10	I	1.06	9.53	21.166	21.018	87.93	0.5288	10.06	1.861	18.04	0.80
11	I	1.06	10.59	21.018	20.869	87.30	0.5288	11.12	1.848	17.92	0.80
12	I	1.06	11.65	20.869	20.721	86.68	0.5288	12.18	1.835	17.79	0.80
13	I	1.06	12.71	20.721	20.573	86.05	0.5288	13.23	1.822	17.67	1.00
14	I	1.06	13.76	20.573	20.425	85.42	0.5288	14.29	1.809	17.55	1.00
15	I	1.06	14.82	20.425	20.276	84.79	0.5288	15.35	1.796	17.42	1.00
16	I	1.06	15.88	20.276	20.128	84.16	0.5288	16.41	1.783	17.30	1.00
17	I	1.06	16.94	20.128	19.980	83.53	0.5288	17.47	1.769	17.18	1.00
18	J	3.00	18.00	19.980	19.560	233.25	1.4947	19.49	4.943	48.00	1.00
19	I	3.00	21.00	19.560	19.140	228.20	1.4946	22.49	4.838	47.01	1.00
20	J	1.00	24.00	19.140	19.000	74.94	0.4994	24.50	1.589	15.45	1.00
						<u>2042</u>					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	1594.12	1109.10	0.00	950.95
Section Modulus (in^3)	144.10	113.14	0.00	
Cross-Section Area (in^2)	26.05	23.08	0.00	
Width-Thickness Ratio	60.00	53.28	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	18.218	18.218	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

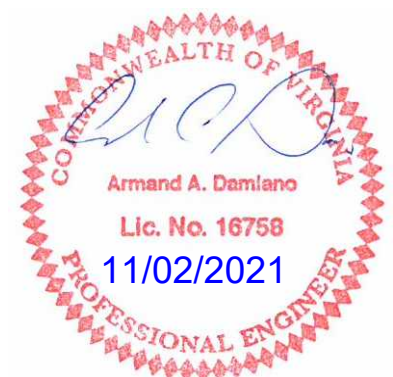
Shaft Deflection From Arm#1 GP I Load (in)	0.995
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

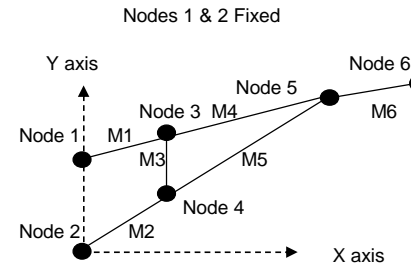
## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	24.97	0.000	24.73	1.100	4.576	9.05
2	0.450	12.62	24.81	0.000	24.57	1.100	4.576	8.99
3	0.450	12.62	24.64	0.000	24.41	1.100	4.576	8.94
4	0.450	12.62	24.48	0.000	24.24	1.100	4.576	8.88
5	0.450	12.62	24.31	0.000	24.08	1.100	4.576	8.82
6	0.450	12.62	24.15	0.000	23.92	1.100	4.576	8.76
7	0.450	12.62	23.98	0.001	23.75	1.100	4.576	8.70
8	0.450	12.62	23.82	0.001	23.59	1.100	4.576	8.64
9	0.450	12.62	23.65	0.001	23.43	1.100	4.576	8.58
10	0.450	12.62	23.49	0.001	23.26	1.100	4.576	8.52
11	0.450	12.62	23.32	0.001	23.10	1.100	4.576	8.46
12	0.450	12.62	23.16	0.001	22.94	1.100	4.576	8.40
13	0.450	15.77	28.73	0.002	22.77	1.100	4.576	8.34
14	0.450	15.77	28.52	0.002	22.61	1.100	4.576	8.28
15	0.450	15.77	28.32	0.003	22.45	1.100	4.576	8.22
16	0.450	15.77	28.11	0.003	22.28	1.100	4.576	8.16
17	0.450	15.77	27.90	0.003	22.12	1.100	4.576	8.10
18	0.450	15.77	77.94	0.011	61.78	1.100	4.576	22.62
19	0.450	15.77	76.29	0.014	60.47	1.100	4.576	22.14
20	0.450	15.77	25.06	0.005	19.86	1.100	4.576	7.27
Fix. #1	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.053	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum. - Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-44.01	-40.6	0	0	0
Node #2	0	0	0	0	-46.58	-42.9	0	0	0
Node #3	100	59.5	0	0	-87	-84.8	0	0	0
Node #4	100	48.8	0	0	-90.64	-88.2	0	0	0
Node #5	200	79	0	0	-123.35	-125	0	0	0
Node #6	288	87	0	0	-93.99	-114.6	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-88.02	1.1	1	-81.07	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-93.14	1.1	1	-85.79	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.95	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-85.28	1.1	1.1	-86.40	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-87.44	1.1	1.1	-88.59	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-73.97	1.1	1.1	-74.94	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-77.10					

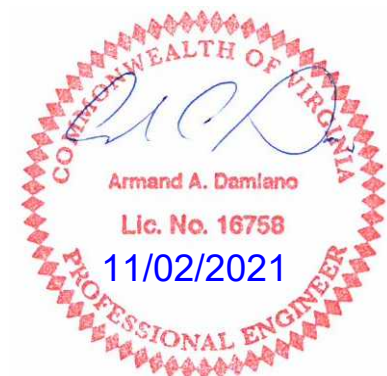
AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2629.3	lbs
P1y	-827.0	lbs
P1z	294.4	lbs
M1x	10996.1	in-lbs
M1y	-41528.6	in-lbs
M1z	-716.1	in-lbs
P2x	2629.3	lbs
P2y	1312.5	lbs
P2z	201.7	lbs
M2x	11346.6	in-lbs
M2y	-33776.2	in-lbs
M2z	-770.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-939	173	26099	-644	0.76
#2	989	109	21500	-1250	0.95
#3	1807	572	11253	-534	0.45
#4	-919	78	10031	-29	0.28
#5	936	91	11105	-380	0.58
#6	3	101	7955	-1	0.24

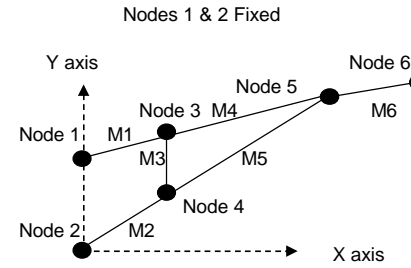
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16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum. - Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-51.2	-20.3	0	0	0
Node #2	0	0	0	0	-54.18	-21.5	0	0	0
Node #3	100	59.5	0	0	-101.41	-42.4	0	0	0
Node #4	100	48.8	0	0	-105.65	-44.1	0	0	0
Node #5	200	79	0	0	-143.49	-62.5	0	0	0
Node #6	288	87	0	0	-124.03	-57.3	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-102.39	1.1	1	-40.53	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-108.35	1.1	1	-42.89	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.98	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-99.21	1.1	1.1	-43.20	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-101.72	1.1	1.1	-44.29	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-86.04	1.1	1.1	-37.47	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-38.55					

AASHTO Gp	3
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-3247.7	lbs
P1y	-1031.5	lbs
P1z	147.2	lbs
M1x	5498.0	in-lbs
M1y	-20764.3	in-lbs
M1z	-1257.5	in-lbs
P2x	3247.7	lbs
P2y	1611.4	lbs
P2z	100.9	lbs
M2x	5673.3	in-lbs
M2y	-16888.1	in-lbs
M2z	-1306.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1160	88	13070	-322	0.36
#2	1221	57	10777	-625	0.69
#3	2226	425	8530	-267	0.39
#4	-1137	47	5068	-15	0.12
#5	1159	52	5600	-190	0.48
#6	4	93	7320	-1	0.23

V09.19.15



16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	4.33	0.00	19.000	18.394	318.0	2.1533	2.15	6.746	6.746	65.62
2	I	4.33	4.33	18.394	17.788	307.5	2.1529	6.48	6.528	6.528	63.56
3	I	4.33	8.66	17.788	17.181	297.0	2.1525	10.81	6.309	6.309	61.50
4	I	4.33	12.99	17.181	16.575	286.5	2.1520	15.14	6.090	6.090	59.44
5	I	4.33	17.32	16.575	15.969	275.9	2.1516	19.47	5.872	5.872	57.38
6	I	4.33	21.65	15.969	15.363	265.4	2.1510	23.80	5.653	5.653	55.32
7	J	3.02	25.98	15.870	15.447	303.3	1.5032	27.48	3.941	3.941	38.56
8	O	3.54	29.00	15.447	14.952	141.4	1.7604	30.76	4.484	4.484	43.93
9	O	3.54	32.54	14.952	14.456	136.7	1.7601	34.30	4.338	4.338	42.55
10	O	3.54	36.08	14.456	13.960	132.1	1.7597	37.84	4.191	4.191	41.17
11	O	3.54	39.62	13.960	13.465	127.4	1.7593	41.38	4.045	4.045	39.79
12	O	3.54	43.16	13.465	12.969	122.7	1.7589	44.92	3.899	3.899	38.42
13	O	3.54	46.70	12.969	12.474	118.0	1.7585	48.46	3.753	3.753	37.04
14	O	3.54	50.24	12.474	11.978	113.3	1.7580	52.00	3.607	3.607	35.66
15	O	3.54	53.78	11.978	11.482	108.6	1.7575	55.54	3.460	3.460	34.28
16	O	3.54	57.32	11.482	10.987	103.9	1.7570	59.08	3.314	3.314	32.90
17	O	3.54	60.86	10.987	10.491	99.2	1.7564	62.62	3.168	3.168	31.53
18	O	3.54	64.40	10.491	9.996	94.5	1.7557	66.16	3.022	3.022	30.15
19	O	3.54	67.94	9.996	9.500	89.9	1.7550	69.70	2.876	2.876	28.77
20	O	3.54	71.48	9.500	9.004	85.2	1.7542	73.23	2.729	2.729	27.39
		<u>75.02</u>				<u>3527</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	65	20.00	8.700	1.000	78.00
Fix. #3	65	32.00	8.700	1.000	78.00
Fix. #4	22.5	41.00	7.500	1.000	22.50
Fix. #5	65	44.00	8.700	1.000	78.00
Fix. #6	22.5	47.00	7.500	1.000	22.50
Fix. #7	65	50.00	8.700	1.000	78.00
Fix. #8	22.5	52.00	7.500	1.000	22.50
Fix. #9	22	54.00	1.000	1.000	9.00
Fix. #10	65	56.00	8.700	1.000	78.00
Fix. #11	22.5	58.00	7.500	1.000	22.50
Fix. #12	105	62.00	13.750	2.000	126.00
Fix. #13	26.7	65.00	10.500	1.000	31.50
Fix. #14	22	66.00	1.000	1.000	9.00
Fix. #15	80	68.00	11.000	1.000	102.00
Fix. #16	26.7	71.00	10.500	1.000	31.50
Fix. #17	80	74.00	11.000	1.000	102.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	102.116	47.882
Cross-Section Area (in^2)	21.931	12.262
Width-Thickness Ratio	50.67	63.48
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	36.300
Allow. Shear Stress (ksi)	18.150	18.150



16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000 Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	106.39	84.33	1.100	4.576	30.87	0	0.450	0.00	0.00	
2	1.00	0.450	15.77	102.94	81.60	1.100	4.576	29.87	0	0.454	0.00	0.00	
3	1.00	0.450	15.77	99.49	78.86	1.100	4.576	28.87	0	0.475	0.00	0.00	
4	1.00	0.450	15.77	96.04	76.13	1.100	4.576	27.87	0	0.497	0.00	0.00	
5	1.00	0.450	15.77	92.59	73.39	1.100	4.576	26.87	0	0.521	0.00	0.00	
6	1.00	0.450	15.77	89.14	70.66	1.100	4.576	25.87	0	0.548	0.00	0.00	
7	1.00	0.450	15.77	82.15	67.92	1.100	4.576	24.87	0	0.575	0.00	0.00	
8	1.00	0.450	15.77	77.71	64.18	1.100	4.576	23.87	0	0.602	0.00	0.00	
9	1.00	0.450	15.77	73.27	60.44	1.100	4.576	22.87	0	0.629	0.00	0.00	
10	1.00	0.450	15.77	68.83	56.70	1.100	4.576	21.87	0	0.656	0.00	0.00	
11	1.00	0.450	15.77	64.39	52.96	1.100	4.576	20.87	0	0.683	0.00	0.00	
12	1.00	0.450	15.77	59.95	49.22	1.100	4.576	19.87	0	0.710	0.00	0.00	
13	1.00	0.450	15.77	55.51	45.48	1.100	4.576	18.87	0	0.737	0.00	0.00	
14	1.00	0.450	15.77	51.07	41.74	1.100	4.576	17.87	0	0.764	0.00	0.00	
15	1.00	0.450	15.77	46.63	38.00	1.100	4.576	16.87	0	0.791	0.00	0.00	
16	1.00	0.450	15.77	42.19	34.26	1.100	4.576	15.87	0	0.818	0.00	0.00	
17	1.00	0.450	15.77	37.75	30.52	1.100	4.576	14.87	0	0.845	0.00	0.00	
18	1.00	0.450	15.77	33.31	26.78	1.100	4.576	13.87	1	0.872	0.00	0.00	
19	1.00	0.450	15.77	28.87	23.04	1.100	4.576	12.87	1	0.899	0.00	0.00	
20	1.00	0.450	15.77	24.43	19.30	1.100	4.576	11.87	1	0.926	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #7	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #12	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	1	1.200	0.00	0.00	0.00
Fix. #13	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #14	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #15	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #16	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #17	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



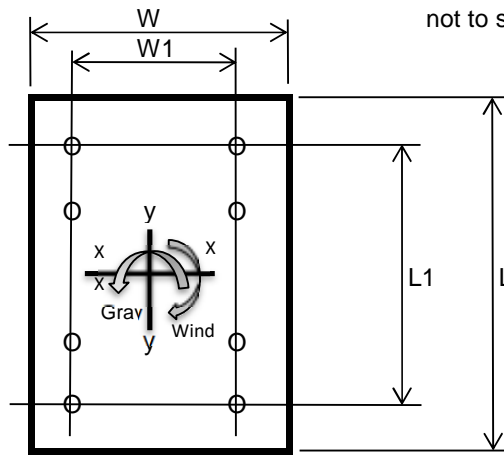
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	4326	6091	-	lbs
Shear (Wind)	6873	3843	-	lbs
Torsion (Arm Rise)	27017	15106	-	ft-lbs
Moment (Gravity)	145635	222371	-	ft-lbs
Moment (Wind)	342355	184645	-	ft-lbs
Nat. Wind Moment	-	-	48528	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	19.00	in
Tube Wall Thick.	0.375	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.75
W	29.5
W1	25.00
L	29.5
L1	25.00
L2 - Dist. between bolts (Typ.)	8.33



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	979.65	979.65	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1763.77	1763.77	in <sup>4</sup>
Bolt Tensile Stress - ft	36.68	37.50	ksi
Bolt Shear Stress - fv	3.06	1.97	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Fv =	44.22	44.22	ksi
Allowable Shear Stress = Ft =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.85	0.86	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	4.13	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.59	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	14.47	22.09	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	34.56	18.64	ksi
Combined applied stress for interaction (SRSS)	37.47	28.90	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	22.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	29.00	in
Cbc - Bolt circle ratio	1.288889	
Dop - Baseplate center hole diameter	17.75	in
Cop - Center hole to shaft diameter ratio	0.788889	
Kf - Fatigue stress concentration factor for finite life	2.72	
Ki - Fatigue stress concentration factor for infinite life	6.44	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.375	in
Dt - Arm base diameter	19.00	in
Ttp - Thickness of baseplate	2.75	in
Dbc - Bolt circle diameter	35.36	in
Cbc - Bolt circle ratio	1.86	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.315789	
Kf - Fatigue stress concentration factor for finite life	1.76	
Ki - Fatigue stress concentration factor for infinite life	3.73	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

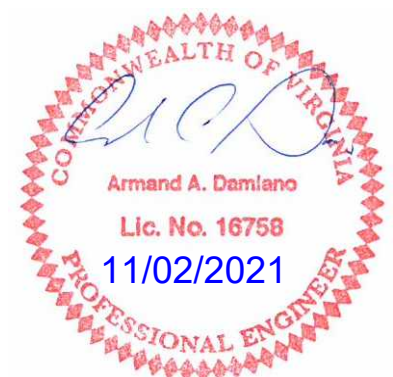
## Lower Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	22.07	in
Shaft Thickness	0.375	in
Total Area	30.273	in <sup>2</sup>
Ix	1605	in <sup>4</sup>
Iy	1798	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	26795	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	8.69	ksi
CSR	0.54	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.33	ksi
CSR	0.33	
Therefore	<b>OK</b>	



16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

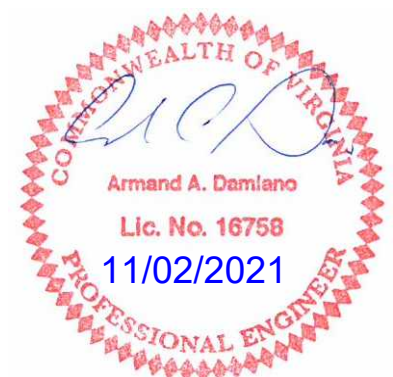
## Upper Hand Hole Stresses

**INPUTS**

Handhole Width	3.00	in
Handhole Height	5.00	in
Distance From Base Plate To Hand Hole Center Line	216	in
Radial Orientation	0	Degrees
Rim Thickness	0.50	in
Rim Depth	3.50	in
Rim Projection	0.375	in
Shaft Diameter (At hand hole location)	19.98	in
Shaft Thickness	0.375	in
Total Area	25.1464	in <sup>2</sup>
Ix	1124	in <sup>4</sup>
Iy	1218	in <sup>4</sup>
Controlling Moment - Galloping	4323	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	1.81	ksi
CSR	0.11	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.47	ksi
CSR	0.07	
Therefore	<b>OK</b>	



16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	4326		4326	145635		145635		395	17115		0.48
Gp II	4326	6873	8121	145635	342355	372044	27017	741	43721	1588	0.92
Gp III	6091	3843	7202	222371	184645	289038	15106	657	33966	888	0.71
Gp IV Natural		1054	1054		48528	48528	4143	97	5703	244	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	2489		2489	57675		57675		406	14455		0.40
Gp II	2489	5878	6384	57675	174805	184074	23107	1042	46132	2896	0.99
Gp III	3804	3174	4954	94096	92625	132036	12476	809	33091	1564	0.70
Gp IV Natural		835	835		23809	23809	3284	137	5967	412	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-





16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	7019		145635	0	145635		269		12128		0.35
Gp II	7019	8891	150725	212163	260252	344216	269	683	21672	14332	0.85
Gp III	9459	5100	84272	260067	273380	185576	363	392	22766	7727	0.60
Gp IV Natural			26795	0	26795				2231		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9975										

<b>Shaft At Arm</b>											
Gp I	5348		145635	0	145635		232		15446		0.44
Gp II	5348	7548	27017	155509	157838	344216	232	654	16740	18254	0.97
Gp III	7207	4233	15106	227490	227991	185576	312	367	24180	9841	0.69
Gp IV Natural			4323	0	4323				458		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9975										



16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	8891 lbs
Bending Moment	273380 ft-lbs
Torsion Moment	344216 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	29 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	35 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	22.50 in

**ANALYSIS - ANCHOR BOLTS**

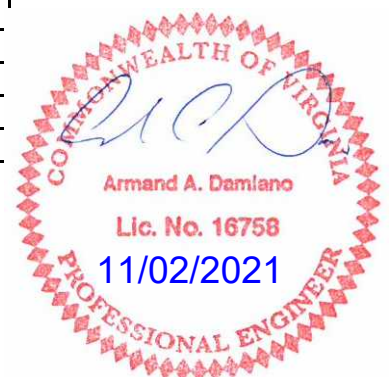
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	2106.48 in <sup>4</sup>
c Dist. (Section 5.17.7)	14.50 in
Bolt Tensile Stress	22.582 ksi
Bolt Direct Shear Stress	0.484 ksi
Bolt Torsion Shear Stress	15.482 ksi
Combined Bolt Stress	
$F_v = .3 F_y * \text{Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y * \text{Allowable Increase Factor}$	36.575 ksi
$f_t =$	22.582 ksi
$f_v =$	15.966 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.96 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	11.183 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	184 in-kip
Section Modulus of Failure Plane	7.45 in <sup>3</sup>
Applied Plate Stress	24.7 ksi
Allowable Plate Stress = $.66 F_y * \text{Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	10.717 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	96 in-kip
Section Modulus of Failure Plane	7.14 in <sup>3</sup>
Applied Plate Stress	13.45 ksi
Allowable Plate Stress = $.66 F_y * \text{Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-7 - VA - 90 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	26795 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	2106.48 in <sup>4</sup>
c Dist. (Section 5.17.7)	14.50 in
Bolt Tensile Stress	2.22 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.32
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	118588 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	8.5 in
T Reduced For Group Action	59294 lbs
Maximum Applied Tensile Load	56455 lbs
Computed Factor-of Safety	1.05 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	56455 lbs
Total Tensile Load	451640 lbs
Concrete Failure Surface Area	4772.08 in <sup>2</sup>
Concrete Shear Strength	522755 psi
Computed Factor-of Safety	1.15 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	56455 lbs
Total Tensile Load	451640 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	43.59 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	<b>10</b> Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

11/02/21

**General**

Wind Vel.- mph	90	No	Roadway - mph	55	<i>Fatigue Importance Factors</i>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	2		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	1		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	21.00	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.3125	0.14	17.50	25.00	18.00	-	3.67	0	55	29000	180
	0.1880	0.14	14.79	47.92	-	2.92	-	0	55	29000	-
Traffic Arm #2	0.2500	0.14	15.58	23.69	18.00	-	3.14	0	55	29000	270
	0.1793	0.14	13.00	39.00	-	2.69	-	0	55	29000	-
Lum Arm #1	0.3750		2.88	24.00	24.00	-	5	0	36	29000	180
Lum Arm #2						-		0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8	Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes
A.B. Bolt Circle	29.00	in	Foundation Diameter	48
Baseplate Dia.	35.00	in	Concrete Cover	4
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000
B.P. Center Hole	15.25	in	Vertical Reinforcing Bar Size #	8
Weld Type	Full Pen.		Rebar Yield Strength fy	60
				ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	8
Bolt Diameter	1.50	in
Flange Plate Length (V)	27.00	in
Flange Plate Width (H)	27.00	in
Spac. Between Bolt (V)	22.50	in
Spac. Between Bolt (H)	22.50	in
Flange Plate Thk.	2.25	in
Flange Plate Yield (Fy)	50.00	ksi
Gusset Thk.	0.500	in
Plate Center Hole	6.00	in
Weld Type	Full Pen.	Full Pen.

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

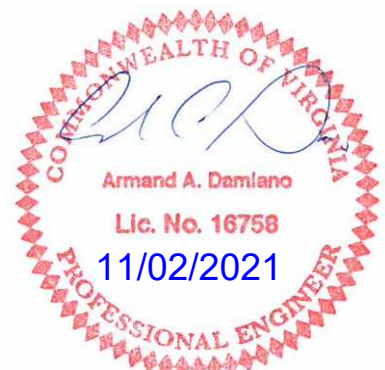
	<i>Shaft At</i>		<i>Arm#1</i>		<i>Arm#2</i>		<i>Lum#1</i>		<i>Lum#2</i>		<i>Tip Deflection (in)</i>	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.30	0.38	0.41	0.41	0.43	0.34					23.97	17.87
GP II CSR	0.87	0.93	0.84	0.97	0.99	0.88	0.95					
GP III CSR	0.62	0.66	0.65	0.71	0.73	0.63	0.69				39.17	30.00
Nat.Wind (psi)	2830	554	5428	5792	6306	5372						

Arm #1 Flange Bolt (Max.) CSR	0.61
Arm #1 Flange Bolt Fatigue CSR	0.45
Arm #1 Flange Plate (Max.) CSR	0.89
Arm #2 Flange Bolt (Max.) CSR	0.44
Arm #2 Flange Bolt Fatigue CSR	0.33
Arm #2 Flange Plate (Max.) CSR	0.70
Handhole at Root (Fatigue) CSR	0.68
Handhole at Toe (Fatigue) CSR	0.42
Minimum Qty of Vertical Reinf. Bars	10

Fatigue Allowable - Shaft to Baseplate	4.5	ksi
Fatigue Allowable - Arm#1 to Flange	7	ksi
Fatigue Allowable - Arm#2 to Flange	7	ksi
Anchor Bolt Max. CSR	0.84	
Anchor Bolt Max. Fatigue Stress Ratio	0.35	
Base Plate Max. CSR	0.91	
Anchorage Capacity S.F.	1.11	
Concrete Pull Out Capacity S.F.	1.22	

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
10967	8146	258432	282283



16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft.)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1	Cobra Head w/Camera	24	2	1			4.54	9	57	1.00
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	12			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	25	13.75	4			2	42	105	1.20
	#4	2.5'x3' Sign	29			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	36	8.7	4			1	26	65	1.20
	#6	Camera	40	1	1			1	3	22	1.20
	#7	2.5'x3' Sign	44			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	47	8.7	4			1	26	65	1.20
	#9	2.5'x3' Sign	55			2.5	3	1	7.5	22.5	1.13
	#10	3 Section Head w/BP	58	8.7	4			1	26	65	1.20
	#11	Camera	62	1	1			1	3	22	1.20
	#12	3'x3.5' Sign	66			3	3.5	1	10.5	26.7	1.13
	#13	4 Section Head w/BP	69	11	5			1	34	80	1.20
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	12.5			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	26	13.75	4			2	42	105	1.20
	#4	2.5'x3' Sign	34			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	37	8.7	4			1	26	65	1.20
	#6	Camera	46	1	1			1	3	22	1.20
	#7	2.5'x3' Sign	45			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	48	8.7	4			1	26	65	1.20
	#9	Camera	57	1	1			1	3	22	1.20
	#10	3'x3.5' Sign	56			3	3.5	1	10.5	26.7	1.13
	#11	4 Section Head w/BP	59	11	5			1	34	80	1.20
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										



16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	21.000	20.852	87.23	0.5288	0.53	1.846	17.90	0.80
2	I	1.06	1.06	20.852	20.704	86.60	0.5288	1.59	1.833	17.78	0.80
3	I	1.06	2.12	20.704	20.555	85.97	0.5288	2.65	1.820	17.65	0.80
4	I	1.06	3.18	20.555	20.407	85.34	0.5288	3.71	1.807	17.53	0.80
5	I	1.06	4.24	20.407	20.259	84.71	0.5288	4.76	1.794	17.41	0.80
6	I	1.06	5.29	20.259	20.111	84.08	0.5288	5.82	1.781	17.28	0.80
7	I	1.06	6.35	20.111	19.962	83.45	0.5288	6.88	1.768	17.16	0.80
8	I	1.06	7.41	19.962	19.814	82.83	0.5288	7.94	1.755	17.04	0.80
9	I	1.06	8.47	19.814	19.666	82.20	0.5287	9.00	1.742	16.91	0.80
10	I	1.06	9.53	19.666	19.518	81.57	0.5287	10.06	1.729	16.79	0.80
11	I	1.06	10.59	19.518	19.369	80.94	0.5287	11.12	1.716	16.67	0.80
12	I	1.06	11.65	19.369	19.221	80.31	0.5287	12.18	1.703	16.54	0.80
13	I	1.06	12.71	19.221	19.073	79.68	0.5287	13.23	1.689	16.42	1.00
14	I	1.06	13.76	19.073	18.925	79.05	0.5287	14.29	1.676	16.30	1.00
15	I	1.06	14.82	18.925	18.776	78.42	0.5287	15.35	1.663	16.17	1.00
16	I	1.06	15.88	18.776	18.628	77.79	0.5287	16.41	1.650	16.05	1.00
17	I	1.06	16.94	18.628	18.480	77.16	0.5287	17.47	1.637	15.93	1.00
18	J	3.00	18.00	18.480	18.060	215.21	1.4943	19.49	4.568	44.46	1.00
19	I	3.00	21.00	18.060	17.640	210.16	1.4941	22.49	4.463	43.47	1.00
20	J	1.00	24.00	17.640	17.500	68.93	0.4993	24.50	1.464	14.27	1.00
						1892					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in <sup>4</sup> )	1291.38	873.51	873.51	739.20
Section Modulus (in <sup>3</sup> )	125.22	96.49	96.49	
Cross-Section Area (in <sup>2</sup> )	24.29	21.32	21.32	
Width-Thickness Ratio	56.00	49.28	49.28	
Compact Limit	68.55	68.55	68.55	
Non-Compact Limit	137.09	137.09	137.09	
Maximum Limit	237.27	237.27	237.27	
Allow. Bending Stress (ksi)	36.300	36.300	36.300	
Allow. Compressive Str (ksi)	16.423	16.423	16.423	
Allow. Shear Stress (ksi)	18.150	18.150	18.150	

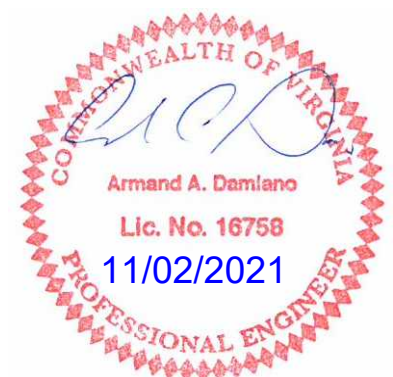
Shaft Deflection From Arm#1 GP I Load (in)	0.751
Shaft Deflection From Arm#2 GP I Load (in)	0.500



16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

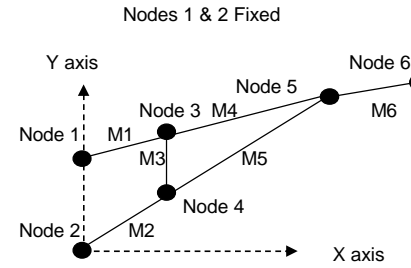
## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	23.30	0.000	23.08	1.100	4.576	8.45
2	0.450	12.62	23.14	0.000	22.92	1.100	4.576	8.39
3	0.450	12.62	22.97	0.000	22.75	1.100	4.576	8.33
4	0.450	12.62	22.81	0.000	22.59	1.100	4.576	8.27
5	0.450	12.62	22.64	0.000	22.43	1.100	4.576	8.21
6	0.450	12.62	22.48	0.000	22.26	1.100	4.576	8.15
7	0.450	12.62	22.31	0.001	22.10	1.100	4.576	8.09
8	0.450	12.62	22.15	0.001	21.94	1.100	4.576	8.03
9	0.450	12.62	21.98	0.001	21.77	1.100	4.576	7.97
10	0.450	12.62	21.82	0.001	21.61	1.100	4.576	7.91
11	0.450	12.62	21.65	0.001	21.45	1.100	4.576	7.85
12	0.450	12.62	21.49	0.002	21.28	1.100	4.576	7.79
13	0.450	15.77	26.64	0.002	21.12	1.100	4.576	7.73
14	0.450	15.77	26.44	0.003	20.95	1.100	4.576	7.67
15	0.450	15.77	26.23	0.003	20.79	1.100	4.576	7.61
16	0.450	15.77	26.02	0.004	20.63	1.100	4.576	7.55
17	0.450	15.77	25.82	0.004	20.46	1.100	4.576	7.49
18	0.450	15.77	72.03	0.013	57.09	1.100	4.576	20.90
19	0.450	15.77	70.37	0.016	55.78	1.100	4.576	20.42
20	0.450	15.77	23.09	0.006	18.30	1.100	4.576	6.70
Fix. #1	1.200	33.65	80.76	0.005	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.005	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.066	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum. - Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-44.01	-40.6	0	0	0
Node #2	0	0	0	0	-46.58	-42.9	0	0	0
Node #3	100	59.5	0	0	-87	-84.8	0	0	0
Node #4	100	48.8	0	0	-90.64	-88.2	0	0	0
Node #5	200	79	0	0	-123.35	-125	0	0	0
Node #6	288	87	0	0	-93.99	-114.6	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-88.02	1.1	1	-81.07	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-93.14	1.1	1	-85.79	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.95	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-85.28	1.1	1.1	-86.40	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-87.44	1.1	1.1	-88.59	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-73.97	1.1	1.1	-74.94	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-77.10					

AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2629.3	lbs
P1y	-827.0	lbs
P1z	294.4	lbs
M1x	10996.1	in-lbs
M1y	-41528.6	in-lbs
M1z	-716.1	in-lbs
P2x	2629.3	lbs
P2y	1312.5	lbs
P2z	201.7	lbs
M2x	11346.6	in-lbs
M2y	-33776.2	in-lbs
M2z	-770.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-939	173	26099	-644	0.76
#2	989	109	21500	-1250	0.95
#3	1807	572	11253	-534	0.45
#4	-919	78	10031	-29	0.28
#5	936	91	11105	-380	0.58
#6	3	101	7955	-1	0.24

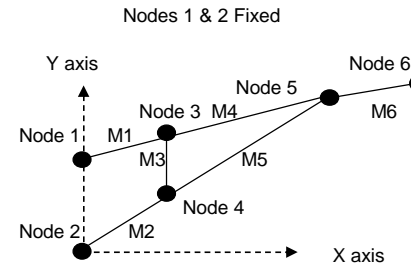
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16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum. - Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-51.2	-20.3	0	0	0
Node #2	0	0	0	0	-54.18	-21.5	0	0	0
Node #3	100	59.5	0	0	-101.41	-42.4	0	0	0
Node #4	100	48.8	0	0	-105.65	-44.1	0	0	0
Node #5	200	79	0	0	-143.49	-62.5	0	0	0
Node #6	288	87	0	0	-124.03	-57.3	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-102.39	1.1	1	-40.53	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-108.35	1.1	1	-42.89	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.98	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-99.21	1.1	1.1	-43.20	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-101.72	1.1	1.1	-44.29	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-86.04	1.1	1.1	-37.47	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-38.55					

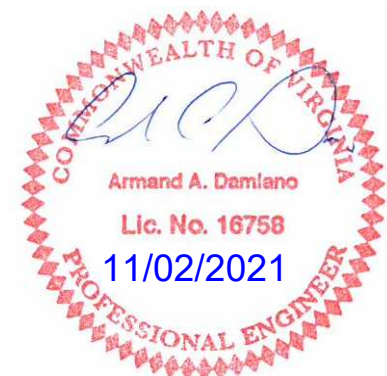
AASHTO Gp	3
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-3247.7	lbs
P1y	-1031.5	lbs
P1z	147.2	lbs
M1x	5498.0	in-lbs
M1y	-20764.3	in-lbs
M1z	-1257.5	in-lbs
P2x	3247.7	lbs
P2y	1611.4	lbs
P2z	100.9	lbs
M2x	5673.3	in-lbs
M2y	-16888.1	in-lbs
M2z	-1306.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1160	88	13070	-322	0.36
#2	1221	57	10777	-625	0.69
#3	2226	425	8530	-267	0.39
#4	-1137	47	5068	-15	0.12
#5	1159	52	5600	-190	0.48
#6	4	93	7320	-1	0.23

V09.19.15



16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	3.68	0.00	17.500	16.985	208.1	1.8308	1.83	5.288	5.288	51.57
2	I	3.68	3.68	16.985	16.470	201.8	1.8306	5.51	5.130	5.130	50.08
3	I	3.68	7.36	16.470	15.954	195.5	1.8303	9.19	4.972	4.972	48.59
4	I	3.68	11.04	15.954	15.439	189.1	1.8299	12.87	4.814	4.814	47.10
5	I	3.68	14.72	15.439	14.924	182.8	1.8296	16.55	4.656	4.656	45.61
6	I	3.68	18.40	14.924	14.409	176.5	1.8292	20.23	4.498	4.498	44.12
7	J	2.92	22.08	14.790	14.381	220.1	1.4532	23.53	3.549	3.549	34.83
8	O	3.46	25.00	14.381	13.897	97.1	1.7209	26.72	4.079	4.079	40.07
9	O	3.46	28.46	13.897	13.412	93.7	1.7205	30.18	3.939	3.939	38.75
10	O	3.46	31.92	13.412	12.927	90.3	1.7202	33.64	3.799	3.799	37.43
11	O	3.46	35.38	12.927	12.443	86.9	1.7197	37.10	3.659	3.659	36.12
12	O	3.46	38.85	12.443	11.958	83.6	1.7193	40.57	3.519	3.519	34.80
13	O	3.46	42.31	11.958	11.474	80.2	1.7188	44.03	3.380	3.380	33.48
14	O	3.46	45.77	11.474	10.989	76.8	1.7183	47.49	3.240	3.240	32.16
15	O	3.46	49.23	10.989	10.504	73.5	1.7178	50.95	3.100	3.100	30.85
16	O	3.46	52.69	10.504	10.020	70.1	1.7171	54.41	2.960	2.960	29.53
17	O	3.46	56.15	10.020	9.535	66.7	1.7165	57.87	2.820	2.820	28.21
18	O	3.46	59.62	9.535	9.050	63.3	1.7157	61.33	2.681	2.681	26.89
19	O	3.46	63.08	9.050	8.566	60.0	1.7149	64.79	2.541	2.541	25.58
20	O	3.46	66.54	8.566	8.081	56.6	1.7140	68.25	2.401	2.401	24.26
		<u>70.00</u>				<u>2373</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	12.00	37.500	1.000	112.50
Fix. #3	105	25.00	13.750	2.000	126.00
Fix. #4	22.5	29.00	7.500	1.000	22.50
Fix. #5	65	36.00	8.700	1.000	78.00
Fix. #6	22	40.00	1.000	1.000	9.00
Fix. #7	22.5	44.00	7.500	1.000	22.50
Fix. #8	65	47.00	8.700	1.000	78.00
Fix. #9	22.5	55.00	7.500	1.000	22.50
Fix. #10	65	58.00	8.700	1.000	78.00
Fix. #11	22	62.00	1.000	1.000	9.00
Fix. #12	26.7	66.00	10.500	1.000	31.50
Fix. #13	80	69.00	11.000	1.000	102.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	72.468	31.467
Cross-Section Area (in^2)	16.865	8.620
Width-Thickness Ratio	56.00	78.67
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	34.389
Allow. Shear Stress (ksi)	18.150	17.040



16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000 Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	83.39	66.10	1.100	4.576	24.20	0	0.484	0.00	0.00	
2	1.00	0.450	15.77	80.89	64.12	1.100	4.576	23.47	0	0.503	0.00	0.00	
3	1.00	0.450	15.77	78.40	62.15	1.100	4.576	22.75	0	0.524	0.00	0.00	
4	1.00	0.450	15.77	75.91	60.17	1.100	4.576	22.03	0	0.546	0.00	0.00	
5	1.00	0.450	15.77	73.42	58.20	1.100	4.576	21.30	0	0.571	0.00	0.00	
6	1.00	0.450	15.77	70.93	56.22	1.100	4.576	20.58	0	0.597	0.00	0.00	
7	1.00	0.450	15.77	55.97	44.36	1.100	4.576	16.24	0	0.601	0.00	0.00	
8	1.00	0.450	15.77	64.32	50.98	1.100	4.576	18.66	0	0.626	0.00	0.00	
9	1.00	0.450	15.77	62.11	49.23	1.100	4.576	18.02	0	0.655	0.00	0.00	
10	1.00	0.450	15.77	59.91	47.49	1.100	4.576	17.38	0	0.686	0.00	0.00	
11	1.00	0.450	15.77	57.70	45.74	1.100	4.576	16.74	0	0.721	0.00	0.00	
12	1.00	0.450	15.77	55.50	43.99	1.100	4.576	16.10	0	0.758	0.00	0.00	
13	1.00	0.450	15.77	53.30	42.24	1.100	4.576	15.46	0	0.799	0.00	0.00	
14	1.00	0.450	15.77	51.09	40.50	1.100	4.576	14.83	0	0.844	0.00	0.00	
15	1.00	0.450	15.77	48.89	38.75	1.100	4.576	14.19	0	0.894	0.00	0.00	
16	1.00	0.450	15.77	46.68	37.00	1.100	4.576	13.55	0	0.949	0.00	0.00	
17	1.00	0.450	15.77	44.48	35.25	1.100	4.576	12.91	1	1.011	0.00	0.00	
18	1.00	0.450	15.77	42.27	33.51	1.100	4.576	12.27	1	1.080	0.00	0.00	
19	1.00	0.450	15.77	40.07	31.76	1.100	4.576	11.63	1	1.100	0.00	0.00	
20	1.00	0.463	16.25	39.02	30.01	1.100	4.576	10.99	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



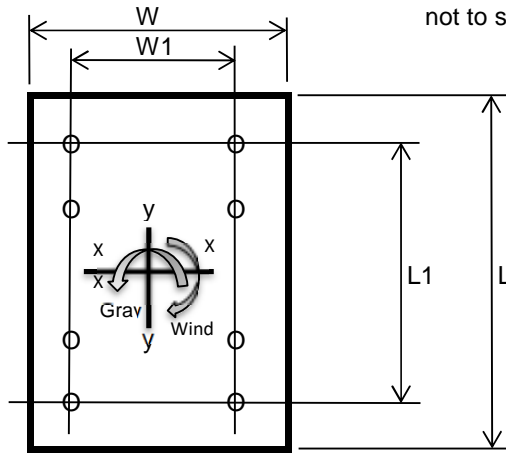
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	3001	4442	-	lbs
Shear (Wind)	6345	3518	-	lbs
Torsion (Arm Rise)	23274	12905	-	ft-lbs
Moment (Gravity)	88146	139512	-	ft-lbs
Moment (Wind)	223585	122410	-	ft-lbs
Nat. Wind Moment	-	-	32774	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	17.50	in
Tube Wall Thick.	0.3125	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	25.90	26.38	ksi
Bolt Shear Stress - fv	2.84	1.76	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.6	0.61	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	3.1	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.45	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	14.17	22.43	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	36.56	20.02	ksi
Combined applied stress for interaction (SRSS)	39.21	30.07	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

Arm #2 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	3.00	0.00	15.580	15.160	121.2	1.4932	1.49	3.843	3.843	37.63
2	I	3.00	3.00	15.160	14.740	117.9	1.4930	4.49	3.738	3.738	36.64
3	I	3.00	6.00	14.740	14.320	114.5	1.4928	7.49	3.633	3.633	35.65
4	I	3.00	9.00	14.320	13.900	111.1	1.4926	10.49	3.528	3.528	34.66
5	I	3.00	12.00	13.900	13.480	107.8	1.4923	13.49	3.423	3.423	33.67
6	I	3.00	15.00	13.480	13.060	104.4	1.4921	16.49	3.318	3.318	32.68
7	I	3.00	18.00	13.060	12.640	101.0	1.4918	19.49	3.213	3.213	31.69
8	J	2.69	21.00	13.000	12.623	152.9	1.3384	22.34	2.872	2.872	28.33
9	O	3.03	23.69	12.623	12.200	70.9	1.5043	25.19	3.130	3.130	30.92
10	O	3.03	26.72	12.200	11.776	68.5	1.5040	28.22	3.023	3.023	29.91
11	O	3.03	29.74	11.776	11.353	66.0	1.5037	31.25	2.916	2.916	28.91
12	O	3.03	32.77	11.353	10.929	63.6	1.5033	34.27	2.809	2.809	27.90
13	O	3.03	35.79	10.929	10.505	61.1	1.5029	37.30	2.702	2.702	26.89
14	O	3.03	38.82	10.505	10.082	58.7	1.5025	40.32	2.596	2.596	25.89
15	O	3.03	41.85	10.082	9.658	56.2	1.5021	43.35	2.489	2.489	24.88
16	O	3.03	44.87	9.658	9.234	53.7	1.5016	46.37	2.382	2.382	23.87
17	O	3.03	47.90	9.234	8.811	51.3	1.5011	49.40	2.275	2.275	22.87
18	O	3.03	50.92	8.811	8.387	48.8	1.5005	52.42	2.168	2.168	21.86
19	O	3.03	53.95	8.387	7.964	46.4	1.4999	55.45	2.061	2.061	20.85
20	O	3.03	56.97	7.964	7.540	43.9	1.4991	58.47	1.955	1.955	19.85
		60.00				1620					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	12.50	37.500	1.000	112.50
Fix. #3	105	26.00	13.750	2.000	126.00
Fix. #4	22.5	34.00	7.500	1.000	22.50
Fix. #5	65	37.00	8.700	1.000	78.00
Fix. #6	22	46.00	1.000	1.000	9.00
Fix. #7	22.5	45.00	7.500	1.000	22.50
Fix. #8	65	48.00	8.700	1.000	78.00
Fix. #9	22	57.00	1.000	1.000	9.00
Fix. #10	26.7	56.00	10.500	1.000	31.50
Fix. #11	80	59.00	11.000	1.000	102.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#2 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	46.120	23.135
Cross-Section Area (in^2)	12.034	7.218
Width-Thickness Ratio	62.32	72.50
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	35.489
Allow. Shear Stress (ksi)	18.150	18.150



16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

Arm #2 Analysis Continued

Sec. Num.	Kz	Truck Induced Gust											Gallop Loads (lbs)
		Group 2			Group 3	Natural Wind Gust			Hght Corr. Factor = 1.00				
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	60.60	48.03	1.100	4.576	17.58	0	0.562	0.00	0.00	
2	1.00	0.450	15.77	58.94	46.72	1.100	4.576	17.10	0	0.582	0.00	0.00	
3	1.00	0.450	15.77	57.28	45.41	1.100	4.576	16.62	0	0.604	0.00	0.00	
4	1.00	0.450	15.77	55.63	44.09	1.100	4.576	16.14	0	0.628	0.00	0.00	
5	1.00	0.450	15.77	53.97	42.78	1.100	4.576	15.66	0	0.653	0.00	0.00	
6	1.00	0.450	15.77	52.32	41.47	1.100	4.576	15.18	0	0.680	0.00	0.00	
7	1.00	0.450	15.77	50.66	40.16	1.100	4.576	14.70	0	0.709	0.00	0.00	
8	1.00	0.450	15.77	45.29	35.90	1.100	4.576	13.14	0	0.711	0.00	0.00	
9	1.00	0.450	15.77	49.35	39.12	1.100	4.576	14.32	0	0.741	0.00	0.00	
10	1.00	0.450	15.77	47.67	37.79	1.100	4.576	13.83	0	0.776	0.00	0.00	
11	1.00	0.450	15.77	45.99	36.45	1.100	4.576	13.34	0	0.813	0.00	0.00	
12	1.00	0.450	15.77	44.30	35.11	1.100	4.576	12.85	0	0.853	0.00	0.00	
13	1.00	0.450	15.77	42.62	33.78	1.100	4.576	12.37	0	0.897	0.00	0.00	
14	1.00	0.450	15.77	40.93	32.44	1.100	4.576	11.88	0	0.946	0.00	0.00	
15	1.00	0.450	15.77	39.25	31.11	1.100	4.576	11.39	0	0.999	0.00	0.00	
16	1.00	0.450	15.77	37.56	29.77	1.100	4.576	10.90	1	1.057	0.00	0.00	
17	1.00	0.450	15.77	35.88	28.44	1.100	4.576	10.41	1	1.100	0.00	0.00	
18	1.00	0.450	15.77	34.19	27.10	1.100	4.576	9.92	1	1.100	0.00	0.00	
19	1.00	0.474	16.63	34.28	25.77	1.100	4.576	9.43	1	1.100	0.00	0.00	
20	1.00	0.508	17.82	34.83	24.43	1.100	4.576	8.94	1	1.100	0.00	0.00	
Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



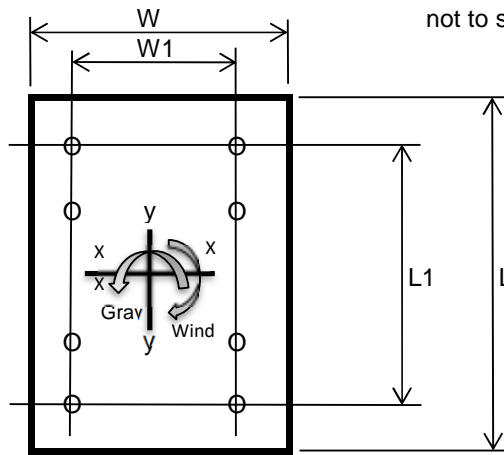
Flange Analysis - Arm #2

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2161	3337	-	lbs
Shear (Wind)	5418	2974	-	lbs
Torsion (Arm Rise)	17035	9351	-	ft-lbs
Moment (Gravity)	58769	96007	-	ft-lbs
Moment (Wind)	169305	91613	-	ft-lbs
Nat. Wind Moment	-	-	24233	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	15.58	in
Tube Wall Thick.	0.25	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	18.86	18.47	ksi
Bolt Shear Stress - fv	2.14	1.32	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.44	0.43	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	2.29	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.33	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	9.97	16.28	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	29.20	15.80	ksi
Combined applied stress for interaction (SRSS)	30.86	22.69	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	21.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	29.00	in
Cbc - Bolt circle ratio	1.380952	
Dop - Baseplate center hole diameter	15.25	in
Cop - Center hole to shaft diameter ratio	0.72619	
Kf - Fatigue stress concentration factor for finite life	2.72	
Ki - Fatigue stress concentration factor for infinite life	6.44	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.3125	in
Dt - Arm base diameter	17.50	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	1.82	
Dop - Baseplate center hole diameter	6.00	in
Cop - Center hole to arm diameter ratio	0.342857	
Kf - Fatigue stress concentration factor for finite life	1.84	
Ki - Fatigue stress concentration factor for infinite life	3.76	
Fatigue Allowable	7	ksi

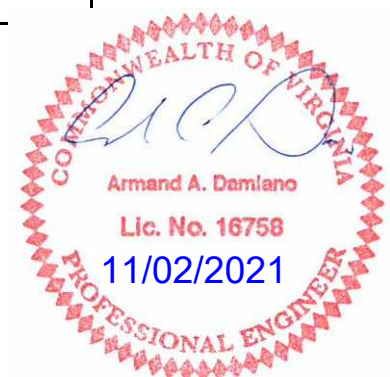
Note: Maximum diagonal distance between bolts used as bolt circle

**ARM 2 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.25	in
Dt - Arm base diameter	15.58	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.042349	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.385109	
Kf - Fatigue stress concentration factor for finite life	1.83	
Ki - Fatigue stress concentration factor for infinite life	3.50	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle





16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

## Lower Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	20.57	in
Shaft Thickness	0.375	in
Total Area	28.4979	in <sup>2</sup>
Ix	1314	in <sup>4</sup>
Iy	1454	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	29533	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	10.89	ksi
CSR	0.68	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.96	ksi
CSR	0.42	
Therefore	<b>OK</b>	



16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

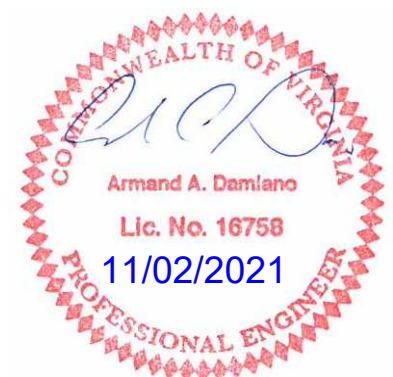
## Upper Hand Hole Stresses

**INPUTS**

Handhole Width	3.00	in
Handhole Height	5.00	in
Distance From Base Plate To Hand Hole Center Line	216	in
Radial Orientation	0	Degrees
Rim Thickness	0.50	in
Rim Depth	3.50	in
Rim Projection	0.375	in
Shaft Diameter (At hand hole location)	18.48	in
Shaft Thickness	0.375	in
Total Area	23.3774	in <sup>2</sup>
Ix	889	in <sup>4</sup>
Iy	961	in <sup>4</sup>
Controlling Moment - Galloping	4451	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	2.18	ksi
CSR	0.14	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.56	ksi
CSR	0.08	
Therefore	<b>OK</b>	



## 16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

## Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					
<b>Arm#1 Base</b>											
Gp I	3001		3001	88146		88146		356	14597		0.41
Gp II	3001	6345	7019	88146	223585	240333	23274	833	39797	1927	0.84
Gp III	4442	3518	5667	139512	122410	185601	12905	673	30734	1069	0.65
Gp IV Natural		956	956		32774	32774	3507	114	5428	291	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-
<b>Arm#1 Joint</b>											
Gp I	1737		1737	36325		36326		404	13853		0.41
Gp II	1737	4255	4596	36325	105504	111583	15607	1067	42553	2976	0.97
Gp III	2769	2338	3624	60449	57281	83278	8575	841	31759	1636	0.71
Gp IV Natural		628	628		15186	15186	2305	146	5792	440	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-
<b>Arm#2 Base</b>											
Gp I	2161		2161	58769		58770		360	15292		0.43
Gp II	2161	5418	5834	58769	169305	179215	17035	970	46630	2217	0.99
Gp III	3337	2974	4470	96007	91613	132705	9351	743	34529	1217	0.73
Gp IV Natural		799	799		24233	24233	2514	133	6306	328	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-
<b>Arm#2 Joint</b>											
Gp I	1273		1273	22969		22969		353	11914		0.34
Gp II	1273	3402	3632	22969	73942	77428	10695	1007	40161	2774	0.88
Gp III	2084	1852	2789	39262	39603	55767	5823	773	28926	1511	0.63
Gp IV Natural		493	493		10356	10356	1552	137	5372	403	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

**Shaft Base**

Gp I	7705		88146	58769	105941		317		10152		0.30
Gp II	7705	8146	145427	213631	258432	282283	317	671	24765	13525	0.87
Gp III	10967	4637	145008	208040	253590	153811	452	382	24301	7370	0.62
Gp IV Natural			24217	16904	29533				2830		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9965										

**Shaft At Arm**

Gp I	6142		88146	58769	105941		288		13175		0.38
Gp II	6142	7006	74343	110631	133290	282283	288	658	16576	17552	0.93
Gp III	8853	3897	104972	151319	184164	153811	415	366	22903	9564	0.66
Gp IV Natural			3673	2513	4451				554		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9965										



**Gusset Box Stress Check  
For Flange Style F2  
Used On Shaft Type F  
Wind Velocity of 90 mph  
Using Governing Load: 70'**

**Input Information**

Gusset Plate Thickness	0.50	in.	
Gusset Yield Strength Fy	50000	psi	A572 Gr 50
Shaft Base Diameter	21.00	in.	
Height To C.L. of Arm Attach.	18.00	ft.	
Shaft Dia. C.L. of Arm Attach.	18.48	in.	Width Between Gussets
Flange Plate Height	27.0	in.	
Flange Plate Width	27.0	in.	
Box Cross-Sectional Area	45.48	sq.in.	

**Applied Loads Onto Flange Box Taken From Pole Analysis - 70'**

Gravity Moment	88,146	ft-lbs
Wind Moment	223,585	ft-lbs
Torsion Moment	23274	ft-lbs
Direct Shear	7019	lbs

**Computing Moments of Inertia**

For Gravity			For Wind		
d	27	in	d	19.48	in
b	19.48	in	b	27	in
d'	26	in	d'	18.48	in
b'	18.48	in	b'	26	in
Inertia	4885.03	in <sup>4</sup>	Inertia	2958.11	in <sup>4</sup>

**Computing Stress**

Gravity = $Mc/I =$	2924	psi	
Wind = $Mc/I =$	8835	psi	
Torsion = $M/[2t(a-b)(b-t)] =$	555	psi	Roark's Table 10.1 #16
Shear = $2.25 * V / A =$	348	psi	

**Allowables**

Bending = $0.66 Fy 1.33 =$	43890	psi
Torsion Limited by b/t ratio	21,945	psi
b/t =	54.0	
$12000 / Fy^{0.5} =$	54.0	

**Result**

**CSR =** 0.31 Which is  $\leq 1$  Therefore OK  
To be conservative bending stresses were added not SRSS



16362-3-5 - VA - 90 MPH - MP-3 Std. Loads-Type F-49'/49' Arms w/Lum  
Weld Analysis

Page S4

**INPUTS**

	<b>Gp II</b>	<b>GpIII</b>		<b>Arm Dimensions</b>		
<b>Applied Loads To Flange Connection</b>						
Vert. Shr	1706	2713	lbs	Diameter (d)	14.0	in
Horz. Shr	4865	2626	lbs	Tube Wall Thk	0.219	in
Torsion Moment	12491	6742	ft-lbs	Plate Thk (D)	2.25	in
Gravity Moment	39946	65204	ft-lbs	Plate Yield (Fy)	50	ksi
Wind Moment	117926	63047	ft-lbs			
<b>Applied Loads To Base Plate Connection</b>				<b>Shaft Dimensions</b>		
Axial	0	0	lbs	Diameter (d)	20.5	in
Shear	0	0	lbs	Tube Wall Thk	<b>0.375</b>	in
Shear	0	0	lbs	Plate Thk (D)	2	in
Bending Moment	0	0	ft-lbs	Plate Yield (Fy)	36	ksi
Bending Moment	0	0	ft-lbs	Arm Attach. Elev.	<b>18.0</b>	ft
Torsion Moment	0	0	ft-lbs			

Additional Load Factor To Apply As Per Signal Plans & Specifications = 1.00

**Electrodes**

**AASHTO Gp II & III Factor** = 1.33

**E70 Electrodes (Used with plates having Fy = 36 ksi)**

$F_v = 0.27 F_u$  (AASHTO Bridge Spec 10.32.2)

$F_v = 0.27 \times 58000 = 15660$  psi

Allowable =  $F_v \times \text{Gp Factor} = 20828$  psi

**E70 Electrodes (Used with plates having Fy = 50 ksi)**

$F_v = 0.27 \times 65000 = 17550$  psi

Allowable =  $F_v \times \text{Gp Factor} = 23342$  psi

Reference: *Design of Welded Structures*, Omer W. Blodgett

Method: Weld As A Line

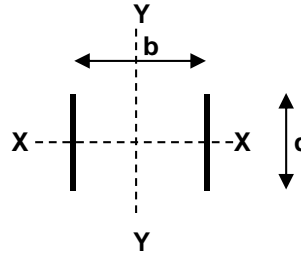


16362-3-5 - VA - 90 MPH - MP-3 Std. Loads-Type F-49'/49' Arms w/Lum  
Weld Analysis - Continued

**ARM CONNECTING PLATES**

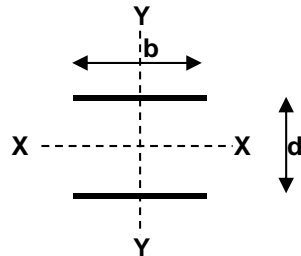
**Side Plates**

Vertical Length (d)	26.50	in
Horz. Dist Between Plates (b)	17.98	in
Thickness	<b>0.5</b>	in
Weld Size	<b>0.375</b>	in
Weld Throat (t <sub>1</sub> )	0.265	in
$A_1 = A_{w1} * t_1 = 2 * d * t_1$	=	14.05 in <sup>2</sup>
$S_{x1} = S_{wx1} * t_1 = (d^2 / 3) * t_1$	=	62.06 in <sup>3</sup>
$S_{y1} = S_{wy1} * t_1 = b * d * t_1$	=	126.32 in <sup>3</sup>
$J_1 = J_{w1} * t_1 = t_1 * d(3b^2 + d^2) / 6$	=	1958.00 in <sup>4</sup>



**Top & Bottom Plates**

Vert. Dist Between Plates (d)	26.50	in
Horz. Length (b)	28.24	in
Thickness	<b>0.5</b>	in
Weld Size	<b>0.375</b>	in
Weld Throat (t <sub>2</sub> )	0.265	in
$A_2 = A_{w2} * t_2 = t_2 * 2 * b$	=	15.0 in <sup>2</sup>
$S_{x2} = S_{wx2} * t_2 = t_2 * b * d$	=	198.4 in <sup>3</sup>
$S_{y2} = S_{wy2} * t_2 = t_2 * (b^2 / 3)$	=	70.5 in <sup>3</sup>
$J_2 = J_{w2} * t_2 = t_2 * (b^3 + 3bd^2) / 6$	=	3624.7 in <sup>4</sup>



**Combined Analysis**

$\sigma_1 = \text{Gravity Mom} / (S_{x1} + S_{x2})$	=	1841.0	Gp II	3004.0	psi
$\sigma_2 = \text{Wind Mom} / (S_{y1} + S_{y2})$	=	7191.0	Gp III	3845.0	psi
$\sigma_2 = [\text{Tor. Mom} * C / (J_1 + J_2)] + [\text{Res. Shr} / (A_1 + A_2)]$	=	608.0		363.0	psi
Res. Weld Stress = $\sigma_r = \text{Sqrt}[(\sigma_1 + \sigma_2)^2 + \sigma_3^2]$	=	9053		6859	psi
Allowable: E70 Electrodes * AASHTO Gp Factor	=	23341.5		23341.5	psi
<b>Actual Weld Stress vs. Allowable</b>		<b>Passes</b>		<b>Passes</b>	



16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	8146 lbs
Bending Moment	258432 ft-lbs
Torsion Moment	282283 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	29 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	35 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	21.00 in

**ANALYSIS - ANCHOR BOLTS**

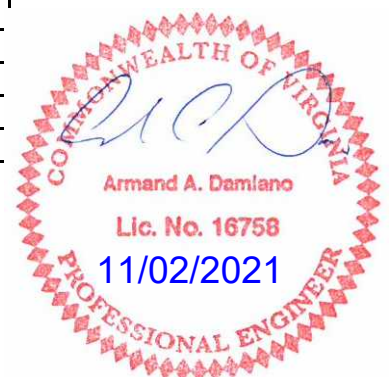
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	2106.48 in <sup>4</sup>
c Dist. (Section 5.17.7)	14.50 in
Bolt Tensile Stress	21.348 ksi
Bolt Direct Shear Stress	0.443 ksi
Bolt Torsion Shear Stress	12.697 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	21.348 ksi
$f_v =$	13.14 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.84 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	11.183 in
Dist. Shaft Face To Bolt Center	4 in
Design Moment	214 in-kip
Section Modulus of Failure Plane	7.45 in <sup>3</sup>
Applied Plate Stress	28.73 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	10.717 in
Dist From Shaft To Nut Face	2.438 in
Design Moment	131 in-kip
Section Modulus of Failure Plane	7.14 in <sup>3</sup>
Applied Plate Stress	18.35 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>





16362-3-8 - VA - 90 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	29533 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	2106.48 in <sup>4</sup>
c Dist. (Section 5.17.7)	14.50 in
Bolt Tensile Stress	2.44 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.35
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

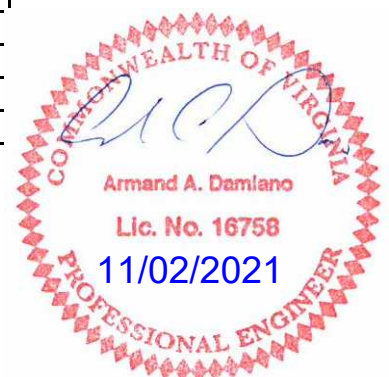
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	118588 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	8.5 in
T Reduced For Group Action	59294 lbs
Maximum Applied Tensile Load	53370 lbs
Computed Factor-of Safety	1.11 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	53370 lbs
Total Tensile Load	426960 lbs
Concrete Failure Surface Area	4772.08 in <sup>2</sup>
Concrete Shear Strength	522755 psi
Computed Factor-of Safety	1.22 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	53370 lbs
Total Tensile Load	426960 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	43.59 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	10 Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-9 - VA - 90 MPH - MP-3 Std. Loads - Type A - 30' Arm

11/02/21

**General**

Wind Vel. - mph	90	No	Roadway - mph	55	<b>Fatigue Importance Factors</b>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.00
Fatigue Cat.	0		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.00
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.00
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	0		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Member E (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.2500	0.14	17.00	19.50	-	-	-	0	55	29000	29000	-
Traffic Arm #1	0.1793	0.14	12.00	30.00	18.00	-	1.57	0	55	29000	29000	180
Traffic Arm #2								0	55	29000	29000	90
Lum Arm #1								0	36	29000	29000	180
Lum Arm #2								0	36	29000	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	6	Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	Double Top Nuts	Yes	
A.B. Bolt Circle	24.00	Foundation Diameter	48	in
Baseplate Dia.	30.00	Concrete Cover	4	in
Baseplate Thk.	2.00	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	12.50	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.	Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50	in
Flange Plate Length (V)	24.00	in
Flange Plate Width (H)	24.00	in
Spac. Between Bolt (V)	19.50	in
Spac. Between Bolt (H)	19.50	in
Flange Plate Thk.	2.00	in
Flange Plate Yield (Fy)	50	ksi
Gusset Thk.	0.375	in
Plate Center Hole	6.00	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.10	0.13	0.25								3.47	0.00
GP II CSR	0.48	0.24	0.74									
GP III CSR	0.28	0.21	0.50								6.19	
Nat.Wind (psi)	0	0										

Arm #1 Flange Bolt (Max.) CSR	0.16
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.34
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.00
Handhole at Toe (Fatigue) CSR	0.00
Minimum Qty of Vertical Reinf. Bars	4

Fatigue Allowable - Shaft to Baseplate	
Fatigue Allowable - Arm#1 to Flange	
Fatigue Allowable - Arm#2 to Flange	
Anchor Bolt Max. CSR	0.38
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.39
Anchorage Capacity S.F.	2.18
Concrete Pull Out Capacity S.F.	2.50

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
2949	4714	87693	55530



16362-3-9 - VA - 90 MPH - MP-3 Std. Loads - Type A - 30' Arm

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.2
	#2	Ped Head	10.5	2.4	1			1	6	30	1.2
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.2
	#4										
Lum #1	#1										
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	12'x2.5' Sign	7			12	2.5	1	30	66	1.20
	#3	Camera	10	1	1			1	3	22	1.20
	#4	2.5'x3' Sign	15			2.5	3	1	7.5	22.5	1.13
	#5	5 Section Head w/BP	19	13.75	4			2	42	105	1.20
	#6	Camera	21	1	1			1	3	22	1.20
	#7	3'x3.5' Sign	26			3	3.5	1	10.5	26.7	1.13
	#8	4 Section Head w/BP	29	11	5			1	34	80	1.20
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
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	#16										
	#17										
	#18										
	#19										
	#20										



16362-3-9 - VA - 90 MPH - MP-3 Std. Loads - Type A - 30' Arm

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	17.000	16.852	47.19	0.5286	0.53	1.493	14.57	0.80
2	I	1.06	1.06	16.852	16.704	46.77	0.5286	1.59	1.480	14.45	0.80
3	I	1.06	2.12	16.704	16.555	46.35	0.5286	2.65	1.467	14.33	0.80
4	I	1.06	3.18	16.555	16.407	45.93	0.5286	3.71	1.454	14.20	0.80
5	I	1.06	4.24	16.407	16.259	45.51	0.5286	4.76	1.441	14.08	0.80
6	I	1.06	5.29	16.259	16.111	45.09	0.5286	5.82	1.428	13.96	0.80
7	I	1.06	6.35	16.111	15.962	44.67	0.5286	6.88	1.415	13.83	0.80
8	I	1.06	7.41	15.962	15.814	44.25	0.5286	7.94	1.402	13.71	0.80
9	I	1.06	8.47	15.814	15.666	43.83	0.5286	9.00	1.389	13.59	0.80
10	I	1.06	9.53	15.666	15.518	43.41	0.5286	10.06	1.376	13.46	0.80
11	I	1.06	10.59	15.518	15.369	42.99	0.5286	11.12	1.363	13.34	0.80
12	I	1.06	11.65	15.369	15.221	42.57	0.5286	12.18	1.350	13.22	0.80
13	I	1.06	12.71	15.221	15.073	42.15	0.5285	13.23	1.337	13.10	1.00
14	I	1.06	13.76	15.073	14.925	41.73	0.5285	14.29	1.323	12.97	1.00
15	I	1.06	14.82	14.925	14.776	41.32	0.5285	15.35	1.310	12.85	1.00
16	I	1.06	15.88	14.776	14.628	40.90	0.5285	16.41	1.297	12.73	1.00
17	I	1.06	16.94	14.628	14.480	40.48	0.5285	17.47	1.284	12.60	1.00
18	J	0.50	18.00	14.480	14.410	18.97	0.2498	18.25	0.602	5.91	1.00
19	I	0.50	18.50	14.410	14.340	18.87	0.2498	18.75	0.599	5.88	1.00
20	I	0.50	19.00	14.340	14.270	18.78	0.2498	19.25	0.596	5.85	1.00
						802					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	461.13	282.74	0.00	270.41
Section Modulus (in^3)	55.06	39.74	0.00	
Cross-Section Area (in^2)	13.15	11.17	0.00	
Width-Thickness Ratio	68.00	57.92	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	17.484	17.484	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

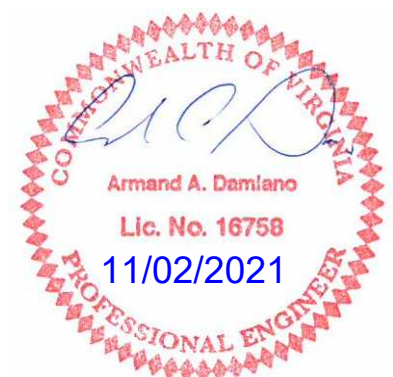
Shaft Deflection From Arm#1 GP I Load (in)	0.354
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-9 - VA - 90 MPH - MP-3 Std. Loads - Type A - 30' Arm

## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	18.85	0.000	18.67	1.100	0.000	0.00
2	0.450	12.62	18.68	0.000	18.50	1.100	0.000	0.00
3	0.450	12.62	18.52	0.000	18.34	1.100	0.000	0.00
4	0.450	12.62	18.35	0.000	18.18	1.100	0.000	0.00
5	0.450	12.62	18.19	0.001	18.01	1.100	0.000	0.00
6	0.450	12.62	18.02	0.001	17.85	1.100	0.000	0.00
7	0.450	12.62	17.86	0.001	17.69	1.100	0.000	0.00
8	0.450	12.62	17.69	0.001	17.52	1.100	0.000	0.00
9	0.450	12.62	17.53	0.002	17.36	1.100	0.000	0.00
10	0.450	12.62	17.36	0.002	17.20	1.100	0.000	0.00
11	0.450	12.62	17.20	0.002	17.03	1.100	0.000	0.00
12	0.450	12.62	17.03	0.003	16.87	1.100	0.000	0.00
13	0.450	15.77	21.08	0.004	16.71	1.100	0.000	0.00
14	0.450	15.77	20.87	0.005	16.54	1.100	0.000	0.00
15	0.450	15.77	20.66	0.005	16.38	1.100	0.000	0.00
16	0.450	15.77	20.46	0.006	16.22	1.100	0.000	0.00
17	0.450	15.77	20.25	0.006	16.05	1.100	0.000	0.00
18	0.450	15.77	9.49	0.003	7.52	1.100	0.000	0.00
19	0.450	15.77	9.45	0.003	7.49	1.100	0.000	0.00
20	0.450	15.77	9.40	0.003	7.45	1.100	0.000	0.00
Fix. #1	1.200	33.65	80.76	0.010	40.38	1.200	0.000	0.00
Fix. #2	1.200	33.65	80.76	0.010	40.38	1.200	0.000	0.00
Fix. #3	1.200	42.06	578.33	0.137	289.16	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-9 - VA - 90 MPH - MP-3 Std. Loads - Type A - 30' Arm

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	1.50	0.00	12.000	11.790	33.7	0.7478	0.75	1.487	1.487	14.72
2	I	1.50	1.50	11.790	11.580	33.1	0.7478	2.25	1.461	1.461	14.47
3	I	1.50	3.00	11.580	11.370	32.5	0.7477	3.75	1.434	1.434	14.23
4	I	1.50	4.50	11.370	11.160	31.9	0.7477	5.25	1.408	1.408	13.98
5	I	1.50	6.00	11.160	10.950	31.3	0.7476	6.75	1.382	1.382	13.73
6	I	1.50	7.50	10.950	10.740	30.7	0.7476	8.25	1.356	1.356	13.48
7	I	1.50	9.00	10.740	10.530	30.1	0.7475	9.75	1.329	1.329	13.24
8	I	1.50	10.50	10.530	10.320	29.5	0.7475	11.25	1.303	1.303	12.99
9	I	1.50	12.00	10.320	10.110	28.9	0.7474	12.75	1.277	1.277	12.74
10	I	1.50	13.50	10.110	9.900	28.2	0.7474	14.25	1.251	1.251	12.49
11	I	1.50	15.00	9.900	9.690	27.6	0.7473	15.75	1.224	1.224	12.25
12	I	1.50	16.50	9.690	9.480	27.0	0.7473	17.25	1.198	1.198	12.00
13	I	1.50	18.00	9.480	9.270	26.4	0.7472	18.75	1.172	1.172	11.75
14	I	1.50	19.50	9.270	9.060	25.8	0.7471	20.25	1.146	1.146	11.50
15	I	1.50	21.00	9.060	8.850	25.2	0.7471	21.75	1.119	1.119	11.26
16	I	1.50	22.50	8.850	8.640	24.6	0.7470	23.25	1.093	1.093	11.01
17	I	1.50	24.00	8.640	8.430	24.0	0.7469	24.75	1.067	1.067	10.76
18	I	1.50	25.50	8.430	8.220	23.4	0.7468	26.25	1.041	1.041	10.51
19	I	1.50	27.00	8.220	8.010	22.8	0.7468	27.75	1.014	1.014	10.27
20	I	1.50	28.50	8.010	7.800	22.2	0.7467	29.25	0.988	0.988	10.02
		<u>30.00</u>				<u>559</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	66	7.00	30.000	1.000	90.00
Fix. #3	22	10.00	1.000	1.000	9.00
Fix. #4	22.5	15.00	7.500	1.000	22.50
Fix. #5	105	19.00	13.750	2.000	126.00
Fix. #6	22	21.00	1.000	1.000	9.00
Fix. #7	26.7	26.00	10.500	1.000	31.50
Fix. #8	80	29.00	11.000	1.000	102.00
Fix. #9	0	0.00	0.000	0.000	0.00
Fix. #10	0	0.00	0.000	0.000	0.00
Fix. #11	0	0.00	0.000	0.000	0.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	19.667	0.000
Cross-Section Area (in^2)	6.655	0.000
Width-Thickness Ratio	66.93	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	36.300	0.000
Allow. Shear Stress (ksi)	18.150	0.000



16362-3-9 - VA - 90 MPH - MP-3 Std. Loads - Type A - 30' Arm

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	
1	1.00	0.450	15.77	23.45	18.59	1.100	0.000	0.00	0	0.784	0.00	0.00	0.00
2	1.00	0.450	15.77	23.03	18.26	1.100	0.000	0.00	0	0.802	0.00	0.00	0.00
3	1.00	0.450	15.77	22.62	17.93	1.100	0.000	0.00	0	0.821	0.00	0.00	0.00
4	1.00	0.450	15.77	22.21	17.60	1.100	0.000	0.00	0	0.841	0.00	0.00	0.00
5	1.00	0.450	15.77	21.79	17.27	1.100	0.000	0.00	0	0.862	0.00	0.00	0.00
6	1.00	0.450	15.77	21.38	16.95	1.100	0.000	0.00	0	0.884	0.00	0.00	0.00
7	1.00	0.450	15.77	20.96	16.62	1.100	0.000	0.00	0	0.906	0.00	0.00	0.00
8	1.00	0.450	15.77	20.55	16.29	1.100	0.000	0.00	0	0.930	0.00	0.00	0.00
9	1.00	0.450	15.77	20.14	15.96	1.100	0.000	0.00	0	0.955	0.00	0.00	0.00
10	1.00	0.450	15.77	19.72	15.63	1.100	0.000	0.00	0	0.981	0.00	0.00	0.00
11	1.00	0.450	15.77	19.31	15.30	1.100	0.000	0.00	1	1.009	0.00	0.00	0.00
12	1.00	0.450	15.77	18.89	14.98	1.100	0.000	0.00	1	1.037	0.00	0.00	0.00
13	1.00	0.450	15.77	18.48	14.65	1.100	0.000	0.00	1	1.068	0.00	0.00	0.00
14	1.00	0.450	15.77	18.07	14.32	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
15	1.00	0.450	15.77	17.65	13.99	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
16	1.00	0.450	15.77	17.24	13.66	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
17	1.00	0.450	15.77	16.82	13.34	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
18	1.00	0.463	16.24	16.90	13.01	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
19	1.00	0.479	16.79	17.03	12.68	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
20	1.00	0.496	17.37	17.16	12.35	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	42.03	1260.90	630.45	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	578.33	289.16	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.132	39.66	416.43	208.22	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	462.66	231.33	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #10	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #11	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



16362-3-9 - VA - 90 MPH - MP-3 Std. Loads - Type A - 30' Arm

Flange Analysis - Arm #1

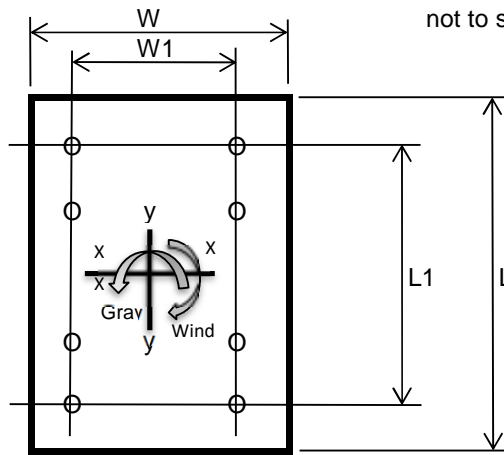
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Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	925	1572	-	lbs
Shear (Wind)	3536	1881	-	lbs
Torsion (Arm Rise)	5559	2957	-	ft-lbs
Moment (Gravity)	14359	25276	-	ft-lbs
Moment (Wind)	55530	29313	-	ft-lbs
Nat. Wind Moment	-	-	0	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	12.00	in
Tube Wall Thick.	0.1793	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.00
W	24
W1	19.50
L	24
L1	19.50
L2 - Dist. between bolts (Typ.)	6.50



Worst Bolt Load (Corner Bolt P1)

	Results GpII	Results GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	596.99	596.99	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1073.57	1073.57	in <sup>4</sup>
Bolt Tensile Stress - ft	6.68	5.90	ksi
Bolt Shear Stress - fv	0.93	0.56	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.16	0.14	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	0	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0	<b>OK</b>	

Plate Analysis

Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	3.63	6.38	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	14.26	7.53	ksi
Combined applied stress for interaction (SRSS)	14.71	9.87	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	





16362-3-9 - VA - 90 MPH - MP-3 Std. Loads - Type A - 30' Arm

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

<b>Arm#1 Base</b>											
Gp I	925		925	14359		14360		278	8762		0.25
Gp II	925	3536	3655	14359	55530	57357	5559	1099	34997	1696	0.74
Gp III	1572	1881	2451	25276	29313	38707	2957	737	23617	903	0.50
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Arm#1 Joint</b>											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Arm#2 Base</b>											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Arm#2 Joint</b>											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Lum#1 Base</b>											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

<b>Lum#2 Base</b>											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-9 - VA - 90 MPH - MP-3 Std. Loads - Type A - 30' Arm

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

**Shaft Base**

Gp I	1892		14359	0	14359		144		3129		0.10
Gp II	1892	4714	28201	83035	87693	55530	144	718	19112	6051	0.48
Gp III	2949	2619	32638	45000	55590	29313	224	399	12115	3194	0.28
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9980										

**Shaft At Arm**

Gp I	982		14359	0	14359		88		4336		0.13
Gp II	982	3564	5559	14381	15418	55530	88	639	4656	8384	0.24
Gp III	1628	1903	2957	25293	25465	29313	146	341	7690	4426	0.21
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9980										



16362-3-9 - VA - 90 MPH - MP-3 Std. Loads - Type A - 30' Arm

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	4714 lbs
Bending Moment	87693 ft-lbs
Torsion Moment	55530 ft-lbs
Num. Anchor Bolts	6
Bolt Circle	24 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	30 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	17.00 in

**ANALYSIS - ANCHOR BOLTS**

Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1082.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	11.661 ksi
Bolt Direct Shear Stress	0.342 ksi
Bolt Torsion Shear Stress	4.024 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	11.661 ksi
$f_v =$	4.366 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.38 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	12.701 in
Dist. Shaft Face To Bolt Center	3.5 in
Design Moment	103 in-kip
Section Modulus of Failure Plane	8.46 in <sup>3</sup>
Applied Plate Stress	12.18 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	12.052 in
Dist From Shaft To Nut Face	1.938 in
Design Moment	57 in-kip
Section Modulus of Failure Plane	8.03 in <sup>3</sup>
Applied Plate Stress	7.1 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-9 - VA - 90 MPH - MP-3 Std. Loads - Type A - 30' Arm

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1082.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	0 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

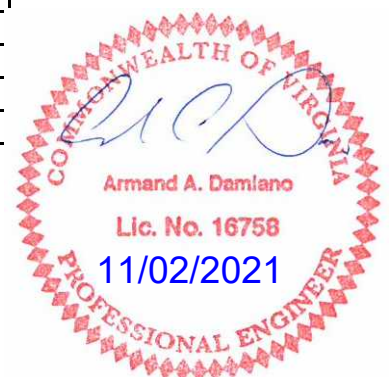
Anchor Bolt Length	60.0 in
Anchor Bolt Max. Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	127540 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	11 in
T Reduced For Group Action	63770 lbs
Maximum Applied Tensile Load	29153 lbs
Computed Factor-of Safety	2.18 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	29153 lbs
Total Tensile Load	174918 lbs
Concrete Failure Surface Area	4002.39 in <sup>2</sup>
Concrete Shear Strength	438440 psi
Computed Factor-of Safety	2.5 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	29153 lbs
Total Tensile Load	174918 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	45.36 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	4 Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-10 - VA - 90 MPH - MP-3 Std. Loads - Type A - 40' Arm

11/02/21

**General**

Wind Vel.- mph	90	No	Roadway - mph	55	<b>Fatigue Importance Factors</b>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.00
Fatigue Cat.	0		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.00
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.00
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	0		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Member E (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.2500	0.14	17.00	19.50	-	-	-	0	55	29000	29000	-
Traffic Arm #1	0.1793	0.14	13.00	40.00	18.00	-	2.10	0	55	29000	29000	180
Traffic Arm #2					-	-		0	55	29000	29000	90
Lum Arm #1					-	-		0	36	29000	29000	180
Lum Arm #2					-	-		0	36	29000	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	6	Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes
A.B. Bolt Circle	24.00	in	Foundation Diameter	48
Baseplate Dia.	30.00	in	Concrete Cover	4
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000
B.P. Center Hole	12.50	in	Vertical Reinforcing Bar Size #	8
Weld Type	Full Pen.		Rebar Yield Strength fy	60
				ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50	in
Flange Plate Length (V)	24.00	in
Flange Plate Width (H)	24.00	in
Spac. Between Bolt (V)	19.50	in
Spac. Between Bolt (H)	19.50	in
Flange Plate Thk.	2.00	in
Flange Plate Yield (Fy)	50	ksi
Gusset Thk.	0.375	in
Plate Center Hole	6.00	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.15	0.21	0.35								8.21	0.00
GP II CSR	0.64	0.47	0.97									
GP III CSR	0.39	0.36	0.68								14.33	
Nat.Wind (psi)	0	0										

Arm #1 Flange Bolt (Max.) CSR	0.24
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.49
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.00
Handhole at Toe (Fatigue) CSR	0.00
Minimum Qty of Vertical Reinf. Bars	5

Fatigue Allowable - Shaft to Baseplate	
Fatigue Allowable - Arm#1 to Flange	
Fatigue Allowable - Arm#2 to Flange	
Anchor Bolt Max. CSR	0.48
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.45
Anchorage Capacity S.F.	1.85
Concrete Pull Out Capacity S.F.	2.12

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
3393	5241	103394	82951



16362-3-10 - VA - 90 MPH - MP-3 Std. Loads - Type A - 40' Arm

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1										
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	12'x2.5' Sign	8			12	2.5	1	30	66	1.20
	#3	5 Section Head w/BP	17	13.75	4			2	42	105	1.20
	#4		Camera	20	1	1			1	3	22
	#5	2.5'x3' Sign	25			2.5	3	1	7.5	22.5	1.13
	#6	3 Section Head w/BP	28	8.7	4			1	26	65	1.20
	#7		Camera	30	1	1			1	3	22
	#8	3'x3.5' Sign	36			3	3.5	1	10.5	26.7	1.13
	#9	4 Section Head w/BP	39	11	5			1	34	80	1.20
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										



16362-3-10 - VA - 90 MPH - MP-3 Std. Loads - Type A - 40' Arm

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	17.000	16.852	47.19	0.5286	0.53	1.493	14.57	0.80
2	I	1.06	1.06	16.852	16.704	46.77	0.5286	1.59	1.480	14.45	0.80
3	I	1.06	2.12	16.704	16.555	46.35	0.5286	2.65	1.467	14.33	0.80
4	I	1.06	3.18	16.555	16.407	45.93	0.5286	3.71	1.454	14.20	0.80
5	I	1.06	4.24	16.407	16.259	45.51	0.5286	4.76	1.441	14.08	0.80
6	I	1.06	5.29	16.259	16.111	45.09	0.5286	5.82	1.428	13.96	0.80
7	I	1.06	6.35	16.111	15.962	44.67	0.5286	6.88	1.415	13.83	0.80
8	I	1.06	7.41	15.962	15.814	44.25	0.5286	7.94	1.402	13.71	0.80
9	I	1.06	8.47	15.814	15.666	43.83	0.5286	9.00	1.389	13.59	0.80
10	I	1.06	9.53	15.666	15.518	43.41	0.5286	10.06	1.376	13.46	0.80
11	I	1.06	10.59	15.518	15.369	42.99	0.5286	11.12	1.363	13.34	0.80
12	I	1.06	11.65	15.369	15.221	42.57	0.5286	12.18	1.350	13.22	0.80
13	I	1.06	12.71	15.221	15.073	42.15	0.5285	13.23	1.337	13.10	1.00
14	I	1.06	13.76	15.073	14.925	41.73	0.5285	14.29	1.323	12.97	1.00
15	I	1.06	14.82	14.925	14.776	41.32	0.5285	15.35	1.310	12.85	1.00
16	I	1.06	15.88	14.776	14.628	40.90	0.5285	16.41	1.297	12.73	1.00
17	I	1.06	16.94	14.628	14.480	40.48	0.5285	17.47	1.284	12.60	1.00
18	J	0.50	18.00	14.480	14.410	18.97	0.2498	18.25	0.602	5.91	1.00
19	I	0.50	18.50	14.410	14.340	18.87	0.2498	18.75	0.599	5.88	1.00
20	I	0.50	19.00	14.340	14.270	18.78	0.2498	19.25	0.596	5.85	1.00
						802					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	461.13	282.74	0.00	270.41
Section Modulus (in^3)	55.06	39.74	0.00	
Cross-Section Area (in^2)	13.15	11.17	0.00	
Width-Thickness Ratio	68.00	57.92	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	17.484	17.484	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.589
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-10 - VA - 90 MPH - MP-3 Std. Loads - Type A - 40' Arm

## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	18.85	0.000	18.67	1.100	0.000	0.00
2	0.450	12.62	18.68	0.000	18.50	1.100	0.000	0.00
3	0.450	12.62	18.52	0.000	18.34	1.100	0.000	0.00
4	0.450	12.62	18.35	0.000	18.18	1.100	0.000	0.00
5	0.450	12.62	18.19	0.001	18.01	1.100	0.000	0.00
6	0.450	12.62	18.02	0.001	17.85	1.100	0.000	0.00
7	0.450	12.62	17.86	0.001	17.69	1.100	0.000	0.00
8	0.450	12.62	17.69	0.001	17.52	1.100	0.000	0.00
9	0.450	12.62	17.53	0.002	17.36	1.100	0.000	0.00
10	0.450	12.62	17.36	0.002	17.20	1.100	0.000	0.00
11	0.450	12.62	17.20	0.002	17.03	1.100	0.000	0.00
12	0.450	12.62	17.03	0.003	16.87	1.100	0.000	0.00
13	0.450	15.77	21.08	0.004	16.71	1.100	0.000	0.00
14	0.450	15.77	20.87	0.005	16.54	1.100	0.000	0.00
15	0.450	15.77	20.66	0.005	16.38	1.100	0.000	0.00
16	0.450	15.77	20.46	0.006	16.22	1.100	0.000	0.00
17	0.450	15.77	20.25	0.006	16.05	1.100	0.000	0.00
18	0.450	15.77	9.49	0.003	7.52	1.100	0.000	0.00
19	0.450	15.77	9.45	0.003	7.49	1.100	0.000	0.00
20	0.450	15.77	9.40	0.003	7.45	1.100	0.000	0.00
Fix. #1	1.200	33.65	80.76	0.010	40.38	1.200	0.000	0.00
Fix. #2	1.200	33.65	80.76	0.010	40.38	1.200	0.000	0.00
Fix. #3	1.200	42.06	578.33	0.137	289.16	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00





16362-3-10 - VA - 90 MPH - MP-3 Std. Loads - Type A - 40' Arm

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	2.00	0.00	13.000	12.720	48.6	0.9964	1.00	2.143	2.143	21.14
2	I	2.00	2.00	12.720	12.440	47.5	0.9963	3.00	2.097	2.097	20.70
3	I	2.00	4.00	12.440	12.160	46.5	0.9962	5.00	2.050	2.050	20.26
4	I	2.00	6.00	12.160	11.880	45.4	0.9961	7.00	2.003	2.003	19.82
5	I	2.00	8.00	11.880	11.600	44.3	0.9960	9.00	1.957	1.957	19.38
6	I	2.00	10.00	11.600	11.320	43.2	0.9959	11.00	1.910	1.910	18.94
7	I	2.00	12.00	11.320	11.040	42.2	0.9958	13.00	1.863	1.863	18.50
8	I	2.00	14.00	11.040	10.760	41.1	0.9957	15.00	1.817	1.817	18.06
9	I	2.00	16.00	10.760	10.480	40.0	0.9956	17.00	1.770	1.770	17.62
10	I	2.00	18.00	10.480	10.200	39.0	0.9955	19.00	1.723	1.723	17.18
11	I	2.00	20.00	10.200	9.920	37.9	0.9954	21.00	1.677	1.677	16.74
12	I	2.00	22.00	9.920	9.640	36.8	0.9952	23.00	1.630	1.630	16.30
13	I	2.00	24.00	9.640	9.360	35.7	0.9951	25.00	1.583	1.583	15.86
14	I	2.00	26.00	9.360	9.080	34.7	0.9949	26.99	1.537	1.537	15.43
15	I	2.00	28.00	9.080	8.800	33.6	0.9948	28.99	1.490	1.490	14.99
16	I	2.00	30.00	8.800	8.520	32.5	0.9946	30.99	1.443	1.443	14.55
17	I	2.00	32.00	8.520	8.240	31.4	0.9944	32.99	1.397	1.397	14.11
18	I	2.00	34.00	8.240	7.960	30.4	0.9942	34.99	1.350	1.350	13.67
19	I	2.00	36.00	7.960	7.680	29.3	0.9940	36.99	1.303	1.303	13.23
20	I	2.00	38.00	7.680	7.400	28.2	0.9938	38.99	1.257	1.257	12.79
		<u>40.00</u>				<u>768</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	66	8.00	30.000	1.000	90.00
Fix. #3	105	17.00	13.750	2.000	126.00
Fix. #4	22	20.00	1.000	1.000	9.00
Fix. #5	22.5	25.00	7.500	1.000	22.50
Fix. #6	65	28.00	8.700	1.000	78.00
Fix. #7	22	30.00	1.000	1.000	9.00
Fix. #8	26.7	36.00	10.500	1.000	31.50
Fix. #9	80	39.00	11.000	1.000	102.00
Fix. #10	0	0.00	0.000	0.000	0.00
Fix. #11	0	0.00	0.000	0.000	0.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	23.135	0.000
Cross-Section Area (in^2)	7.218	0.000
Width-Thickness Ratio	72.50	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	35.489	0.000
Allow. Shear Stress (ksi)	18.150	0.000



16362-3-10 - VA - 90 MPH - MP-3 Std. Loads - Type A - 40' Arm

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	
1	1.00	0.450	15.77	33.80	26.79	1.100	0.000	0.00	0	0.708	0.00	0.00	0.00
2	1.00	0.450	15.77	33.06	26.21	1.100	0.000	0.00	0	0.729	0.00	0.00	0.00
3	1.00	0.450	15.77	32.33	25.63	1.100	0.000	0.00	0	0.750	0.00	0.00	0.00
4	1.00	0.450	15.77	31.59	25.04	1.100	0.000	0.00	0	0.773	0.00	0.00	0.00
5	1.00	0.450	15.77	30.86	24.46	1.100	0.000	0.00	0	0.797	0.00	0.00	0.00
6	1.00	0.450	15.77	30.12	23.88	1.100	0.000	0.00	0	0.822	0.00	0.00	0.00
7	1.00	0.450	15.77	29.38	23.29	1.100	0.000	0.00	0	0.849	0.00	0.00	0.00
8	1.00	0.450	15.77	28.65	22.71	1.100	0.000	0.00	0	0.878	0.00	0.00	0.00
9	1.00	0.450	15.77	27.91	22.13	1.100	0.000	0.00	0	0.908	0.00	0.00	0.00
10	1.00	0.450	15.77	27.18	21.54	1.100	0.000	0.00	0	0.940	0.00	0.00	0.00
11	1.00	0.450	15.77	26.44	20.96	1.100	0.000	0.00	0	0.974	0.00	0.00	0.00
12	1.00	0.450	15.77	25.71	20.38	1.100	0.000	0.00	0	1.011	0.00	0.00	0.00
13	1.00	0.450	15.77	24.97	19.79	1.100	0.000	0.00	1	1.050	0.00	0.00	0.00
14	1.00	0.450	15.77	24.23	19.21	1.100	0.000	0.00	1	1.091	0.00	0.00	0.00
15	1.00	0.450	15.77	23.50	18.63	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
16	1.00	0.450	15.77	22.76	18.04	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
17	1.00	0.459	16.1	22.49	17.46	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
18	1.00	0.480	16.83	22.72	16.88	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
19	1.00	0.503	17.62	22.96	16.29	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
20	1.00	0.527	18.47	23.21	15.71	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	42.03	1260.90	630.45	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #5	1.00	1.134	39.74	298.05	149.03	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	365.92	182.96	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.132	39.66	416.43	208.22	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	462.66	231.33	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #11	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



16362-3-10 - VA - 90 MPH - MP-3 Std. Loads - Type A - 40' Arm  
Flange Analysis - Arm #1

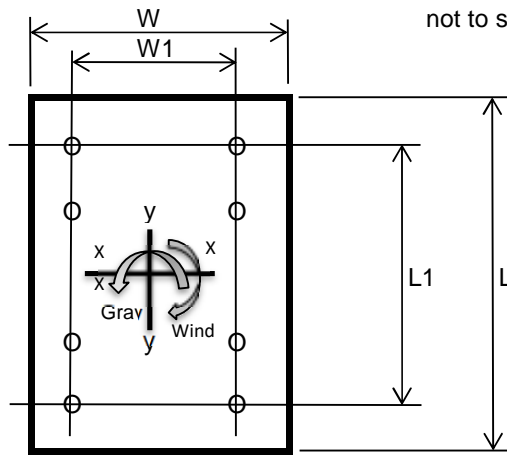
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Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1199	2016	-	lbs
Shear (Wind)	4052	2179	-	lbs
Torsion (Arm Rise)	8494	4568	-	ft-lbs
Moment (Gravity)	23899	41305	-	ft-lbs
Moment (Wind)	82951	44183	-	ft-lbs
Nat. Wind Moment	-	-	0	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	13.00	in
Tube Wall Thick.	0.1793	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.00
W	24
W1	19.50
L	24
L1	19.50
L2 - Dist. between bolts (Typ.)	6.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	596.99	596.99	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1073.57	1073.57	in <sup>4</sup>
Bolt Tensile Stress - ft	10.19	9.42	ksi
Bolt Shear Stress - fv	1.3	0.79	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.24	0.22	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	0	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	5.87	10.15	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	20.74	11.05	ksi
Combined applied stress for interaction (SRSS)	21.55	15.00	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-10 - VA - 90 MPH - MP-3 Std. Loads - Type A - 40' Arm

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear	Shear	Bending	Torsion	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	1199		1199	23899		23900		333	12397		0.35
Gp II	1199	4052	4227	23899	82951	86326	8494	1172	44777	2203	0.97
Gp III	2016	2179	2969	41305	44183	60484	4568	823	31373	1185	0.68
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

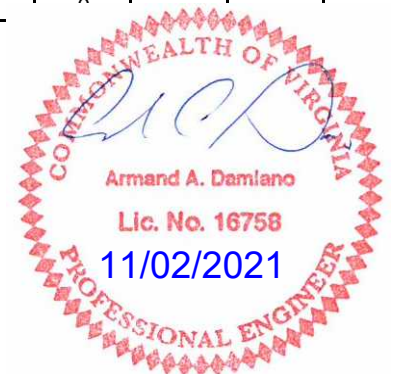
Arm#1 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#1 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#2 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-10 - VA - 90 MPH - MP-3 Std. Loads - Type A - 40' Arm

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	2166		23899	0	23899		165		5209		0.15
Gp II	2166	5241	40186	95265	103394	82951	165	798	22534	9039	0.64
Gp III	3393	2924	43794	58255	72880	44183	258	445	15884	4815	0.39
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9976										

<b>Shaft At Arm</b>											
Gp I	1256		23899	0	23899		112		7217		0.21
Gp II	1256	4081	8494	23920	25383	82951	112	731	7665	12524	0.47
Gp III	2072	2202	4568	41322	41574	44183	186	395	12554	6671	0.36
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9976										



16362-3-10 - VA - 90 MPH - MP-3 Std. Loads - Type A - 40' Arm

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	5241 lbs
Bending Moment	103394 ft-lbs
Torsion Moment	82951 ft-lbs
Num. Anchor Bolts	6
Bolt Circle	24 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	30 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	17.00 in

**ANALYSIS - ANCHOR BOLTS**

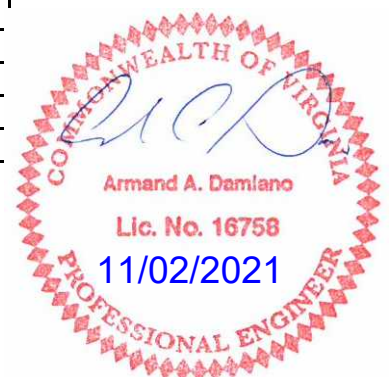
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1082.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	13.748 ksi
Bolt Direct Shear Stress	0.38 ksi
Bolt Torsion Shear Stress	6.011 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	13.748 ksi
$f_v =$	6.391 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.48 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	12.701 in
Dist. Shaft Face To Bolt Center	3.5 in
Design Moment	121 in-kip
Section Modulus of Failure Plane	8.46 in <sup>3</sup>
Applied Plate Stress	14.31 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	12.052 in
Dist From Shaft To Nut Face	1.938 in
Design Moment	67 in-kip
Section Modulus of Failure Plane	8.03 in <sup>3</sup>
Applied Plate Stress	8.35 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-10 - VA - 90 MPH - MP-3 Std. Loads - Type A - 40' Arm

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1082.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	0 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

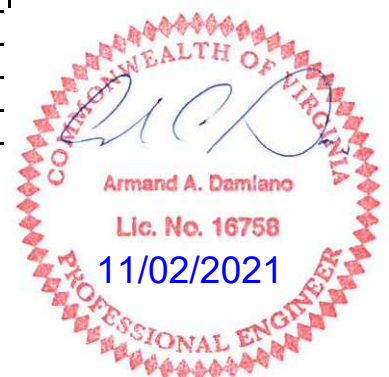
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	127540 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	11 in
T Reduced For Group Action	63770 lbs
Maximum Applied Tensile Load	34370 lbs
Computed Factor-of Safety	1.85 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	34370 lbs
Total Tensile Load	206220 lbs
Concrete Failure Surface Area	4002.39 in <sup>2</sup>
Concrete Shear Strength	438440 psi
Computed Factor-of Safety	2.12 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	34370 lbs
Total Tensile Load	206220 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	45.36 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	5 Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-11 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

11/02/21

**General**

Wind Vel. - mph	90	No	Roadway - mph	55	<b>Fatigue Importance Factors</b>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	0		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.00	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	0.14	15.58	23.69	18.00	-	3.14	0	55	29000	180
	0.1793	0.14	13.00	39.00	-	2.69		0	55	29000	
Traffic Arm #2								0	55	29000	90
								0	55	29000	
Lum Arm #1								0	36	29000	180
Lum Arm #2								0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8		Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes	
A.B. Bolt Circle	26.00	in	Foundation Diameter	48	in
Baseplate Dia.	32.00	in	Concrete Cover	4	in
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	15.25	in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.		Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1		Arm #2	
Flange Bolt Qty.	8		NA	
Bolt Diameter	1.50	in		in
Flange Plate Length (V)	27.00	in		in
Flange Plate Width (H)	27.00	in		in
Spac. Between Bolt (V)	22.50	in		in
Spac. Between Bolt (H)	22.50	in		in
Flange Plate Thk.	2.25	in		in
Flange Plate Yield (Fy)	50	ksi		ksi
Gusset Thk.	0.500	in		in
Plate Center Hole	6.00	in		in
Weld Type	Full Pen.			

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.18	0.23	0.43	0.34							18.49	0.00
GP II CSR	0.50	0.45	0.99	0.88								
GP III CSR	0.35	0.36	0.73	0.63							31.01	
Nat.Wind (psi)	2064	351	6306	5372								

Arm #1 Flange Bolt (Max.) CSR	0.44
Arm #1 Flange Bolt Fatigue CSR	0.33
Arm #1 Flange Plate (Max.) CSR	0.70
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.49
Handhole at Toe (Fatigue) CSR	0.31
Minimum Qty of Vertical Reinf. Bars	6

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.56
Anchor Bolt Max. Fatigue Stress Ratio	0.26
Base Plate Max. CSR	0.51
Anchorage Capacity S.F.	1.76
Concrete Pull Out Capacity S.F.	1.67

**Ground Line Reactions**

	Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
	5386	6702	152751	169305





16362-3-11 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1										
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	12.5			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	26	13.75	4			2	42	105	1.20
	#4		2.5'x3' Sign	34			2.5	3	1	7.5	22.5
	#5	3 Section Head w/BP	37	8.7	4			1	26	65	1.20
	#6		Camera	46	1	1			1	3	22
	#7	2.5'x3' Sign	45			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	48	8.7	4			1	26	65	1.20
	#9		Camera	57	1	1			1	3	22
	#10	3'x3.5' Sign	56			3	3.5	1	10.5	26.7	1.13
	#11	4 Section Head w/BP	59	11	5			1	34	80	1.20
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										



16362-3-11 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.000	19.852	82.99	0.5288	0.53	1.758	17.07	0.80
2	I	1.06	1.06	19.852	19.704	82.36	0.5288	1.59	1.745	16.95	0.80
3	I	1.06	2.12	19.704	19.555	81.73	0.5287	2.65	1.732	16.82	0.80
4	I	1.06	3.18	19.555	19.407	81.10	0.5287	3.71	1.719	16.70	0.80
5	I	1.06	4.24	19.407	19.259	80.47	0.5287	4.76	1.706	16.58	0.80
6	I	1.06	5.29	19.259	19.111	79.84	0.5287	5.82	1.693	16.45	0.80
7	I	1.06	6.35	19.111	18.962	79.21	0.5287	6.88	1.680	16.33	0.80
8	I	1.06	7.41	18.962	18.814	78.58	0.5287	7.94	1.667	16.21	0.80
9	I	1.06	8.47	18.814	18.666	77.95	0.5287	9.00	1.654	16.08	0.80
10	I	1.06	9.53	18.666	18.518	77.32	0.5287	10.06	1.640	15.96	0.80
11	I	1.06	10.59	18.518	18.369	76.69	0.5287	11.12	1.627	15.84	0.80
12	I	1.06	11.65	18.369	18.221	76.06	0.5287	12.18	1.614	15.71	0.80
13	I	1.06	12.71	18.221	18.073	75.43	0.5287	13.23	1.601	15.59	1.00
14	I	1.06	13.76	18.073	17.925	74.81	0.5287	14.29	1.588	15.47	1.00
15	I	1.06	14.82	17.925	17.776	74.18	0.5287	15.35	1.575	15.34	1.00
16	I	1.06	15.88	17.776	17.628	73.55	0.5287	16.41	1.562	15.22	1.00
17	I	1.06	16.94	17.628	17.480	72.92	0.5287	17.47	1.549	15.10	1.00
18	J	0.50	18.00	17.480	17.410	34.21	0.2498	18.25	0.727	7.09	1.00
19	I	0.50	18.50	17.410	17.340	34.07	0.2498	18.75	0.724	7.06	1.00
20	I	0.50	19.00	17.340	17.270	33.93	0.2498	19.25	0.721	7.03	1.00
						1428					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	1112.50	736.61	0.00	709.82
Section Modulus (in^3)	113.38	86.13	0.00	
Cross-Section Area (in^2)	23.11	20.14	0.00	
Width-Thickness Ratio	53.33	46.61	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	20.948	20.948	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.585
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-11 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.19	0.000	21.98	1.100	4.576	8.05
2	0.450	12.62	22.02	0.000	21.81	1.100	4.576	7.99
3	0.450	12.62	21.86	0.000	21.65	1.100	4.576	7.93
4	0.450	12.62	21.69	0.000	21.49	1.100	4.576	7.87
5	0.450	12.62	21.53	0.000	21.32	1.100	4.576	7.81
6	0.450	12.62	21.36	0.000	21.16	1.100	4.576	7.75
7	0.450	12.62	21.20	0.000	21.00	1.100	4.576	7.69
8	0.450	12.62	21.03	0.001	20.83	1.100	4.576	7.63
9	0.450	12.62	20.87	0.001	20.67	1.100	4.576	7.57
10	0.450	12.62	20.70	0.001	20.51	1.100	4.576	7.51
11	0.450	12.62	20.54	0.001	20.34	1.100	4.576	7.45
12	0.450	12.62	20.37	0.001	20.18	1.100	4.576	7.39
13	0.450	15.77	25.25	0.002	20.02	1.100	4.576	7.33
14	0.450	15.77	25.04	0.002	19.85	1.100	4.576	7.27
15	0.450	15.77	24.84	0.002	19.69	1.100	4.576	7.21
16	0.450	15.77	24.63	0.003	19.52	1.100	4.576	7.15
17	0.450	15.77	24.43	0.003	19.36	1.100	4.576	7.09
18	0.450	15.77	11.46	0.002	9.09	1.100	4.576	3.33
19	0.450	15.77	11.42	0.002	9.05	1.100	4.576	3.31
20	0.450	15.77	11.37	0.002	9.01	1.100	4.576	3.30
Fix. #1	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.056	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-11 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	3.00	0.00	15.580	15.160	121.2	1.4932	1.49	3.843	3.843	37.63
2	I	3.00	3.00	15.160	14.740	117.9	1.4930	4.49	3.738	3.738	36.64
3	I	3.00	6.00	14.740	14.320	114.5	1.4928	7.49	3.633	3.633	35.65
4	I	3.00	9.00	14.320	13.900	111.1	1.4926	10.49	3.528	3.528	34.66
5	I	3.00	12.00	13.900	13.480	107.8	1.4923	13.49	3.423	3.423	33.67
6	I	3.00	15.00	13.480	13.060	104.4	1.4921	16.49	3.318	3.318	32.68
7	I	3.00	18.00	13.060	12.640	101.0	1.4918	19.49	3.213	3.213	31.69
8	J	2.69	21.00	13.000	12.623	152.9	1.3384	22.34	2.872	2.872	28.33
9	O	3.03	23.69	12.623	12.200	70.9	1.5043	25.19	3.130	3.130	30.92
10	O	3.03	26.72	12.200	11.776	68.5	1.5040	28.22	3.023	3.023	29.91
11	O	3.03	29.74	11.776	11.353	66.0	1.5037	31.25	2.916	2.916	28.91
12	O	3.03	32.77	11.353	10.929	63.6	1.5033	34.27	2.809	2.809	27.90
13	O	3.03	35.79	10.929	10.505	61.1	1.5029	37.30	2.702	2.702	26.89
14	O	3.03	38.82	10.505	10.082	58.7	1.5025	40.32	2.596	2.596	25.89
15	O	3.03	41.85	10.082	9.658	56.2	1.5021	43.35	2.489	2.489	24.88
16	O	3.03	44.87	9.658	9.234	53.7	1.5016	46.37	2.382	2.382	23.87
17	O	3.03	47.90	9.234	8.811	51.3	1.5011	49.40	2.275	2.275	22.87
18	O	3.03	50.92	8.811	8.387	48.8	1.5005	52.42	2.168	2.168	21.86
19	O	3.03	53.95	8.387	7.964	46.4	1.4999	55.45	2.061	2.061	20.85
20	O	3.03	56.97	7.964	7.540	43.9	1.4991	58.47	1.955	1.955	19.85
		<u>60.00</u>				<u>1620</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	12.50	37.500	1.000	112.50
Fix. #3	105	26.00	13.750	2.000	126.00
Fix. #4	22.5	34.00	7.500	1.000	22.50
Fix. #5	65	37.00	8.700	1.000	78.00
Fix. #6	22	46.00	1.000	1.000	9.00
Fix. #7	22.5	45.00	7.500	1.000	22.50
Fix. #8	65	48.00	8.700	1.000	78.00
Fix. #9	22	57.00	1.000	1.000	9.00
Fix. #10	26.7	56.00	10.500	1.000	31.50
Fix. #11	80	59.00	11.000	1.000	102.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	46.120	23.135
Cross-Section Area (in^2)	12.034	7.218
Width-Thickness Ratio	62.32	72.50
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	35.489
Allow. Shear Stress (ksi)	18.150	18.150



16362-3-11 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000 Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	60.60	48.03	1.100	4.576	17.58	0	0.562	0.00	0.00	
2	1.00	0.450	15.77	58.94	46.72	1.100	4.576	17.10	0	0.582	0.00	0.00	
3	1.00	0.450	15.77	57.28	45.41	1.100	4.576	16.62	0	0.604	0.00	0.00	
4	1.00	0.450	15.77	55.63	44.09	1.100	4.576	16.14	0	0.628	0.00	0.00	
5	1.00	0.450	15.77	53.97	42.78	1.100	4.576	15.66	0	0.653	0.00	0.00	
6	1.00	0.450	15.77	52.32	41.47	1.100	4.576	15.18	0	0.680	0.00	0.00	
7	1.00	0.450	15.77	50.66	40.16	1.100	4.576	14.70	0	0.709	0.00	0.00	
8	1.00	0.450	15.77	45.29	35.90	1.100	4.576	13.14	0	0.711	0.00	0.00	
9	1.00	0.450	15.77	49.35	39.12	1.100	4.576	14.32	0	0.741	0.00	0.00	
10	1.00	0.450	15.77	47.67	37.79	1.100	4.576	13.83	0	0.776	0.00	0.00	
11	1.00	0.450	15.77	45.99	36.45	1.100	4.576	13.34	0	0.813	0.00	0.00	
12	1.00	0.450	15.77	44.30	35.11	1.100	4.576	12.85	0	0.853	0.00	0.00	
13	1.00	0.450	15.77	42.62	33.78	1.100	4.576	12.37	0	0.897	0.00	0.00	
14	1.00	0.450	15.77	40.93	32.44	1.100	4.576	11.88	0	0.946	0.00	0.00	
15	1.00	0.450	15.77	39.25	31.11	1.100	4.576	11.39	0	0.999	0.00	0.00	
16	1.00	0.450	15.77	37.56	29.77	1.100	4.576	10.90	1	1.057	0.00	0.00	
17	1.00	0.450	15.77	35.88	28.44	1.100	4.576	10.41	1	1.100	0.00	0.00	
18	1.00	0.450	15.77	34.19	27.10	1.100	4.576	9.92	1	1.100	0.00	0.00	
19	1.00	0.474	16.63	34.28	25.77	1.100	4.576	9.43	1	1.100	0.00	0.00	
20	1.00	0.508	17.82	34.83	24.43	1.100	4.576	8.94	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



16362-3-11 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 60' Arm  
Flange Analysis - Arm #1

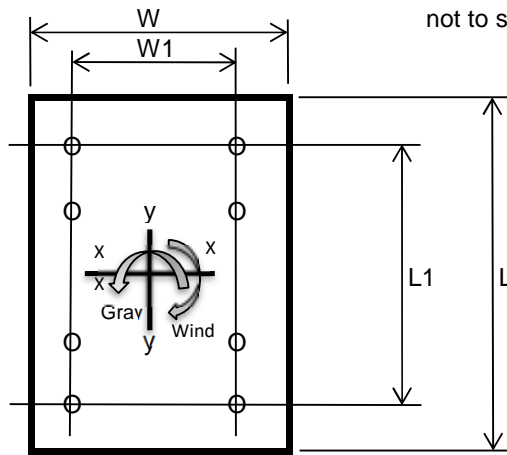
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Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2161	3337	-	lbs
Shear (Wind)	5418	2974	-	lbs
Torsion (Arm Rise)	17035	9351	-	ft-lbs
Moment (Gravity)	58769	96007	-	ft-lbs
Moment (Wind)	169305	91613	-	ft-lbs
Nat. Wind Moment	-	-	24233	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	15.58	in
Tube Wall Thick.	0.25	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	18.86	18.47	ksi
Bolt Shear Stress - fv	2.14	1.32	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Fv =	44.22	44.22	ksi
Allowable Shear Stress = Ft =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.44	0.43	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	2.29	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.33	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	9.97	16.28	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	29.20	15.80	ksi
Combined applied stress for interaction (SRSS)	30.86	22.69	ksi
Allow. Plate Stress = $0.66 \cdot F_y \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-11 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.3	
Dop - Baseplate center hole diameter	15.25	in
Cop - Center hole to shaft diameter ratio	0.7625	
Kf - Fatigue stress concentration factor for finite life	2.49	
Ki - Fatigue stress concentration factor for infinite life	5.82	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.25	in
Dt - Arm base diameter	15.58	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.04	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.385109	
Kf - Fatigue stress concentration factor for finite life	1.83	
Ki - Fatigue stress concentration factor for infinite life	3.50	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



## 16362-3-11 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

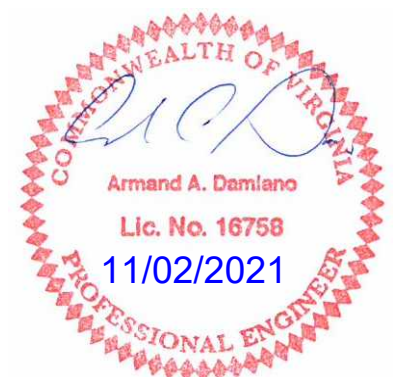
## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	19.57	in
Shaft Thickness	0.375	in
Total Area	27.3136	in <sup>2</sup>
Ix	1143	in <sup>4</sup>
Iy	1250	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	19503	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	7.86	ksi
CSR	0.49	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.17	ksi
CSR	0.31	
Therefore	<b>OK</b>	





16362-3-11 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	2161		2161	58769		58770		360	15292		0.43
Gp II	2161	5418	5834	58769	169305	179215	17035	970	46630	2217	0.99
Gp III	3337	2974	4470	96007	91613	132705	9351	743	34529	1217	0.73
Gp IV Natural		799	799		24233	24233	2514	133	6306	328	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	1273		1273	22969		22969		353	11914		0.34
Gp II	1273	3402	3632	22969	73942	77428	10695	1007	40161	2774	0.88
Gp III	2084	1852	2789	39262	39603	55767	5823	773	28926	1511	0.63
Gp IV Natural		493	493		10356	10356	1552	137	5372	403	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#1 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#2 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-11 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	3753		58769	0	58769		162		6220		0.18
Gp II	3753	6702	81682	129077	152751	169305	162	581	16168	8960	0.50
Gp III	5386	3796	62887	117371	133157	91613	233	329	14094	4848	0.35
Gp IV Natural			19503	0	19503				2064		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9982										

<b>Shaft At Arm</b>											
Gp I	2263		58769	0	58769		112		8188		0.23
Gp II	2263	5452	17035	58795	61213	169305	112	542	8529	11794	0.45
Gp III	3439	3001	9351	96028	96482	91613	171	299	13443	6382	0.36
Gp IV Natural			2521	0	2521				351		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9982										



16362-3-11 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	6702 lbs
Bending Moment	152751 ft-lbs
Torsion Moment	169305 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.00 in

**ANALYSIS - ANCHOR BOLTS**

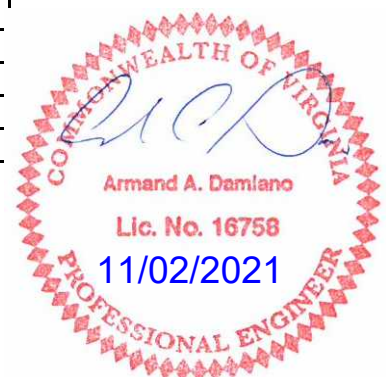
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	14.067 ksi
Bolt Direct Shear Stress	0.365 ksi
Bolt Torsion Shear Stress	8.494 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	14.067 ksi
$f_v =$	8.859 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.56 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3 in
Design Moment	106 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	16.02 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.438 in
Design Moment	51 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	8.09 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-11 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	19503 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	1.8 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.26
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

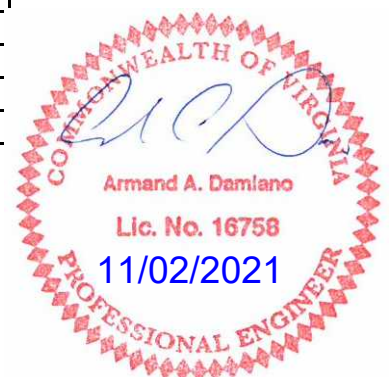
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	35168 lbs
Computed Factor-of Safety	1.76 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	35168 lbs
Total Tensile Load	281344 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.67 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	35168 lbs
Total Tensile Load	281344 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	6 Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-12 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

11/02/21

**General**

Wind Vel.- mph	90	No	Roadway - mph	55	<b>Fatigue Importance Factors</b>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	0		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Member E (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.00	19.50	-	-	-	0	55	29000	29000	-
Traffic Arm #1	0.3125	0.14	16.28	28.69	18.00	-	3.41	0	55	29000	29000	180
	0.1793	0.14	13.00	39.00	-	2.69		0	55	29000	29000	
Traffic Arm #2								0	55	29000	29000	90
								0	55	29000	29000	
Lum Arm #1								0	36	29000	29000	180
Lum Arm #2								0	36	29000	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8		Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes	
A.B. Bolt Circle	26.00	in	Foundation Diameter	48	in
Baseplate Dia.	32.00	in	Concrete Cover	4	in
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	15.25	in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.		Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50 in	in
Flange Plate Length (V)	27.00 in	in
Flange Plate Width (H)	27.00 in	in
Spac. Between Bolt (V)	22.50 in	in
Spac. Between Bolt (H)	22.50 in	in
Flange Plate Thk.	2.25 in	in
Flange Plate Yield (Fy)	50.00 ksi	ksi
Gusset Thk.	0.500 in	in
Plate Center Hole	6.00 in	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.23	0.29	0.40	0.33							20.89	0.00
GP II CSR	0.61	0.58	0.85	0.86								
GP III CSR	0.42	0.45	0.64	0.61							34.46	
Nat.Wind (psi)	2334	432	5394	5252								

Arm #1 Flange Bolt (Max.) CSR	0.52
Arm #1 Flange Bolt Fatigue CSR	0.38
Arm #1 Flange Plate (Max.) CSR	0.80
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.56
Handhole at Toe (Fatigue) CSR	0.35
Minimum Qty of Vertical Reinf. Bars	7

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.65
Anchor Bolt Max. Fatigue Stress Ratio	0.30
Base Plate Max. CSR	0.59
Anchorage Capacity S.F.	1.51
Concrete Pull Out Capacity S.F.	1.44

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
6111	7486	177912	195021



16362-3-12 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1										
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	9.5			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	20	13.75	4			2	42	105	1.20
	#4	2.5'x3' Sign	24			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	31	8.7	4			1	26	65	1.20
	#6	Camera	35	1	1			1	3	22	1.20
	#7	2.5'x3' Sign	39			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	42	8.7	4			1	26	65	1.20
	#9	2.5'x3' Sign	50			2.5	3	1	7.5	22.5	1.13
	#10	3 Section Head w/BP	53	8.7	4			1	26	65	1.20
	#11	Camera	57	1	1			1	3	22	1.20
	#12	3'x3.5' Sign	61			3	3.5	1	10.5	26.7	1.13
	#13	4 Section Head w/BP	64	11	5			1	34	80	1.20
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										



16362-3-12 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.000	19.852	82.99	0.5288	0.53	1.758	17.07	0.80
2	I	1.06	1.06	19.852	19.704	82.36	0.5288	1.59	1.745	16.95	0.80
3	I	1.06	2.12	19.704	19.555	81.73	0.5287	2.65	1.732	16.82	0.80
4	I	1.06	3.18	19.555	19.407	81.10	0.5287	3.71	1.719	16.70	0.80
5	I	1.06	4.24	19.407	19.259	80.47	0.5287	4.76	1.706	16.58	0.80
6	I	1.06	5.29	19.259	19.111	79.84	0.5287	5.82	1.693	16.45	0.80
7	I	1.06	6.35	19.111	18.962	79.21	0.5287	6.88	1.680	16.33	0.80
8	I	1.06	7.41	18.962	18.814	78.58	0.5287	7.94	1.667	16.21	0.80
9	I	1.06	8.47	18.814	18.666	77.95	0.5287	9.00	1.654	16.08	0.80
10	I	1.06	9.53	18.666	18.518	77.32	0.5287	10.06	1.640	15.96	0.80
11	I	1.06	10.59	18.518	18.369	76.69	0.5287	11.12	1.627	15.84	0.80
12	I	1.06	11.65	18.369	18.221	76.06	0.5287	12.18	1.614	15.71	0.80
13	I	1.06	12.71	18.221	18.073	75.43	0.5287	13.23	1.601	15.59	1.00
14	I	1.06	13.76	18.073	17.925	74.81	0.5287	14.29	1.588	15.47	1.00
15	I	1.06	14.82	17.925	17.776	74.18	0.5287	15.35	1.575	15.34	1.00
16	I	1.06	15.88	17.776	17.628	73.55	0.5287	16.41	1.562	15.22	1.00
17	I	1.06	16.94	17.628	17.480	72.92	0.5287	17.47	1.549	15.10	1.00
18	J	0.50	18.00	17.480	17.410	34.21	0.2498	18.25	0.727	7.09	1.00
19	I	0.50	18.50	17.410	17.340	34.07	0.2498	18.75	0.724	7.06	1.00
20	I	0.50	19.00	17.340	17.270	33.93	0.2498	19.25	0.721	7.03	1.00
						1428					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	1112.50	736.61	0.00	709.82
Section Modulus (in^3)	113.38	86.13	0.00	
Cross-Section Area (in^2)	23.11	20.14	0.00	
Width-Thickness Ratio	53.33	46.61	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	20.948	20.948	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.735
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-12 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.19	0.000	21.98	1.100	4.576	8.05
2	0.450	12.62	22.02	0.000	21.81	1.100	4.576	7.99
3	0.450	12.62	21.86	0.000	21.65	1.100	4.576	7.93
4	0.450	12.62	21.69	0.000	21.49	1.100	4.576	7.87
5	0.450	12.62	21.53	0.000	21.32	1.100	4.576	7.81
6	0.450	12.62	21.36	0.000	21.16	1.100	4.576	7.75
7	0.450	12.62	21.20	0.000	21.00	1.100	4.576	7.69
8	0.450	12.62	21.03	0.001	20.83	1.100	4.576	7.63
9	0.450	12.62	20.87	0.001	20.67	1.100	4.576	7.57
10	0.450	12.62	20.70	0.001	20.51	1.100	4.576	7.51
11	0.450	12.62	20.54	0.001	20.34	1.100	4.576	7.45
12	0.450	12.62	20.37	0.001	20.18	1.100	4.576	7.39
13	0.450	15.77	25.25	0.002	20.02	1.100	4.576	7.33
14	0.450	15.77	25.04	0.002	19.85	1.100	4.576	7.27
15	0.450	15.77	24.84	0.002	19.69	1.100	4.576	7.21
16	0.450	15.77	24.63	0.003	19.52	1.100	4.576	7.15
17	0.450	15.77	24.43	0.003	19.36	1.100	4.576	7.09
18	0.450	15.77	11.46	0.002	9.09	1.100	4.576	3.33
19	0.450	15.77	11.42	0.002	9.05	1.100	4.576	3.31
20	0.450	15.77	11.37	0.002	9.01	1.100	4.576	3.30
Fix. #1	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.056	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00





16362-3-12 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	3.25	0.00	16.280	15.825	170.9	1.6173	1.62	4.348	4.348	42.51
2	I	3.25	3.25	15.825	15.370	166.0	1.6171	4.87	4.224	4.224	41.34
3	I	3.25	6.50	15.370	14.915	161.0	1.6169	8.12	4.101	4.101	40.18
4	I	3.25	9.75	14.915	14.460	156.1	1.6166	11.37	3.978	3.978	39.02
5	I	3.25	13.00	14.460	14.005	151.1	1.6163	14.62	3.855	3.855	37.86
6	I	3.25	16.25	14.005	13.550	146.2	1.6161	17.87	3.731	3.731	36.70
7	I	3.25	19.50	13.550	13.095	141.3	1.6158	21.12	3.608	3.608	35.54
8	I	3.25	22.75	13.095	12.640	136.3	1.6154	24.37	3.485	3.485	34.38
9	J	2.69	26.00	13.000	12.623	174.2	1.3384	27.34	2.872	2.872	28.33
10	O	3.30	28.69	12.623	12.161	77.3	1.6402	30.33	3.409	3.409	33.68
11	O	3.30	31.99	12.161	11.699	74.3	1.6398	33.63	3.282	3.282	32.48
12	O	3.30	35.29	11.699	11.237	71.4	1.6394	36.93	3.155	3.155	31.29
13	O	3.30	38.59	11.237	10.775	68.5	1.6389	40.23	3.027	3.027	30.09
14	O	3.30	41.89	10.775	10.313	65.6	1.6384	43.53	2.900	2.900	28.89
15	O	3.30	45.19	10.313	9.851	62.7	1.6378	46.83	2.773	2.773	27.69
16	O	3.30	48.50	9.851	9.389	59.7	1.6372	50.13	2.646	2.646	26.49
17	O	3.30	51.80	9.389	8.926	56.8	1.6366	53.43	2.519	2.519	25.30
18	O	3.30	55.10	8.926	8.464	53.9	1.6358	56.73	2.392	2.392	24.10
19	O	3.30	58.40	8.464	8.002	51.0	1.6350	60.03	2.265	2.265	22.90
20	O	3.30	61.70	8.002	7.540	48.0	1.6341	63.33	2.138	2.138	21.70
		<u>65.00</u>				<u>2092</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	9.50	37.500	1.000	112.50
Fix. #3	105	20.00	13.750	2.000	126.00
Fix. #4	22.5	24.00	7.500	1.000	22.50
Fix. #5	65	31.00	8.700	1.000	78.00
Fix. #6	22	35.00	1.000	1.000	9.00
Fix. #7	22.5	39.00	7.500	1.000	22.50
Fix. #8	65	42.00	8.700	1.000	78.00
Fix. #9	22.5	50.00	7.500	1.000	22.50
Fix. #10	65	53.00	8.700	1.000	78.00
Fix. #11	22	57.00	1.000	1.000	9.00
Fix. #12	26.7	61.00	10.500	1.000	31.50
Fix. #13	80	64.00	11.000	1.000	102.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	62.545	23.135
Cross-Section Area (in^2)	15.668	7.218
Width-Thickness Ratio	52.10	72.50
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	35.489
Allow. Shear Stress (ksi)	18.150	18.150



16362-3-12 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

Arm #1 Analysis Continued

Sec. Num.	Kz	Truck Induced Gust											
		Group 2			Group 3	Natural Wind Gust			Hght Corr. Factor = 1.000				Gallop
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	Loads (lbs)
1	1.00	0.450	15.77	68.56	54.34	1.100	4.576	19.89	0	0.531	0.00	0.00	
2	1.00	0.450	15.77	66.62	52.80	1.100	4.576	19.33	0	0.551	0.00	0.00	
3	1.00	0.450	15.77	64.67	51.26	1.100	4.576	18.77	0	0.572	0.00	0.00	
4	1.00	0.450	15.77	62.73	49.72	1.100	4.576	18.20	0	0.596	0.00	0.00	
5	1.00	0.450	15.77	60.79	48.18	1.100	4.576	17.64	0	0.621	0.00	0.00	
6	1.00	0.450	15.77	58.84	46.64	1.100	4.576	17.07	0	0.647	0.00	0.00	
7	1.00	0.450	15.77	56.90	45.10	1.100	4.576	16.51	0	0.676	0.00	0.00	
8	1.00	0.450	15.77	54.96	43.56	1.100	4.576	15.95	0	0.707	0.00	0.00	
9	1.00	0.450	15.77	45.29	35.90	1.100	4.576	13.14	0	0.711	0.00	0.00	
10	1.00	0.450	15.77	53.76	42.61	1.100	4.576	15.60	0	0.743	0.00	0.00	
11	1.00	0.450	15.77	51.75	41.02	1.100	4.576	15.02	0	0.781	0.00	0.00	
12	1.00	0.450	15.77	49.75	39.43	1.100	4.576	14.44	0	0.822	0.00	0.00	
13	1.00	0.450	15.77	47.74	37.84	1.100	4.576	13.85	0	0.867	0.00	0.00	
14	1.00	0.450	15.77	45.74	36.25	1.100	4.576	13.27	0	0.916	0.00	0.00	
15	1.00	0.450	15.77	43.73	34.67	1.100	4.576	12.69	0	0.971	0.00	0.00	
16	1.00	0.450	15.77	41.73	33.08	1.100	4.576	12.11	0	1.033	0.00	0.00	
17	1.00	0.450	15.77	39.72	31.49	1.100	4.576	11.53	1	1.101	0.00	0.00	
18	1.00	0.450	15.77	37.72	29.90	1.100	4.576	10.95	1	1.100	0.00	0.00	
19	1.00	0.470	16.48	37.32	28.31	1.100	4.576	10.36	1	1.100	0.00	0.00	
20	1.00	0.507	17.76	37.96	26.72	1.100	4.576	9.78	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



16362-3-12 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 65' Arm  
Flange Analysis - Arm #1

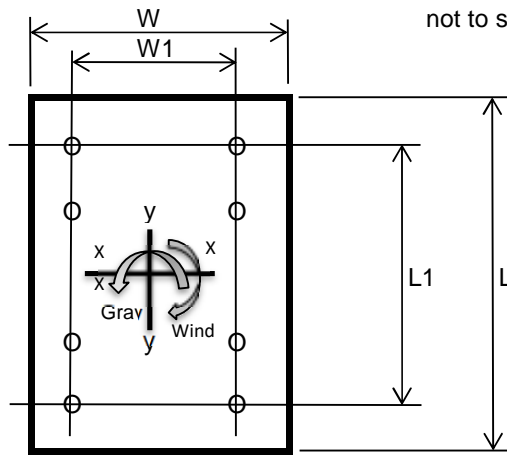
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Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2721	4062	-	lbs
Shear (Wind)	6187	3389	-	lbs
Torsion (Arm Rise)	21073	11544	-	ft-lbs
Moment (Gravity)	73801	117516	-	ft-lbs
Moment (Wind)	195021	105871	-	ft-lbs
Nat. Wind Moment	-	-	28111	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	16.28	in
Tube Wall Thick.	0.3125	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	22.29	22.34	ksi
Bolt Shear Stress - fv	2.61	1.6	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.52	0.52	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	2.66	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.38	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	12.23	19.47	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	32.86	17.84	ksi
Combined applied stress for interaction (SRSS)	35.06	26.41	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-12 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

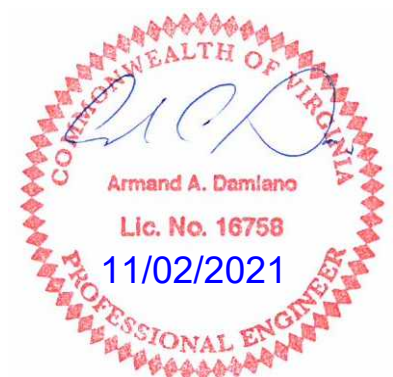
Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.3	
Dop - Baseplate center hole diameter	15.25	in
Cop - Center hole to shaft diameter ratio	0.7625	
Kf - Fatigue stress concentration factor for finite life	2.49	
Ki - Fatigue stress concentration factor for infinite life	5.82	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.3125	in
Dt - Arm base diameter	16.28	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	1.95	
Dop - Baseplate center hole diameter	6.00	in
Cop - Center hole to arm diameter ratio	0.36855	
Kf - Fatigue stress concentration factor for finite life	1.89	
Ki - Fatigue stress concentration factor for infinite life	3.90	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



## 16362-3-12 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	19.57	in
Shaft Thickness	0.375	in
Total Area	27.3136	in <sup>2</sup>
Ix	1143	in <sup>4</sup>
Iy	1250	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	22050	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	8.89	ksi
CSR	0.56	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.45	ksi
CSR	0.35	
Therefore	<b>OK</b>	



16362-3-12 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	2721		2721	73801		73801		348	14160		0.40
Gp II	2721	6187	6759	73801	195021	208518	21073	863	40007	2022	0.85
Gp III	4062	3389	5291	117516	105871	158173	11544	676	30348	1108	0.64
Gp IV Natural		909	909		28111	28111	3095	117	5394	297	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	1254		1254	22336		22336		348	11586		0.33
Gp II	1254	3189	3428	22336	71999	75384	10863	950	39101	2818	0.86
Gp III	2018	1746	2668	38199	38630	54328	5947	740	28180	1543	0.61
Gp IV Natural		468	468		10125	10125	1595	130	5252	414	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#1 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#2 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-12 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	4313		73801	0	73801		187		7811		0.23
Gp II	4313	7486	100288	146952	177912	195021	187	648	18831	10321	0.61
Gp III	6111	4220	72549	140811	158402	105871	264	366	16766	5603	0.42
Gp IV Natural			22050	0	22050				2334		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9978										

<b>Shaft At Arm</b>											
Gp I	2823		73801	0	73801		140		10282		0.29
Gp II	2823	6221	21073	73826	76775	195021	140	618	10697	13586	0.58
Gp III	4164	3416	11544	117536	118102	105871	207	340	16455	7375	0.45
Gp IV Natural			3102	0	3102				432		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9978										



16362-3-12 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	7486 lbs
Bending Moment	177912 ft-lbs
Torsion Moment	195021 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.00 in

**ANALYSIS - ANCHOR BOLTS**

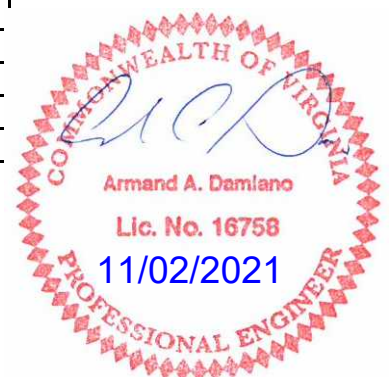
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	16.385 ksi
Bolt Direct Shear Stress	0.407 ksi
Bolt Torsion Shear Stress	9.784 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	16.385 ksi
$f_v =$	10.191 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.65 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3 in
Design Moment	123 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	18.59 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.438 in
Design Moment	59 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	9.36 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>





16362-3-12 - VA - 90 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	22050 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	2.04 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.3
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

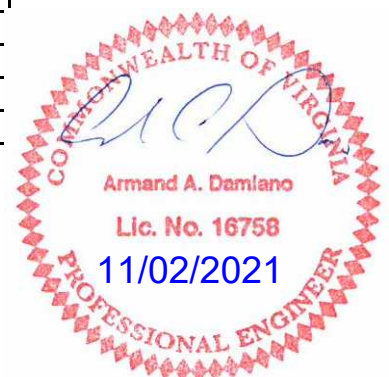
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	40963 lbs
Computed Factor-of Safety	1.51 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	40963 lbs
Total Tensile Load	327704 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.44 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	40963 lbs
Total Tensile Load	327704 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	7 Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-13 - VA - 90 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

11/02/21

**General**

Wind Vel.- mph	90	No	Roadway - mph	55	<i>Fatigue Importance Factors</i>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.00
Fatigue Cat.	0		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.00
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.00
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	1		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.2500	0.14	17.50	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.1793	0.14	12.00	30.00	18.00	-	1.57	0	55	29000	180
Traffic Arm #2						-		0	55	29000	90
Lum Arm #1	0.3750		2.88	24.00	24.00	-	5	0	36	29000	180
Lum Arm #2						-		0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	6	Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes
A.B. Bolt Circle	24.00	in	Foundation Diameter	48
Baseplate Dia.	30.00	in	Concrete Cover	4
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000
B.P. Center Hole	13.00	in	Vertical Reinforcing Bar Size #	8
Weld Type	Full Pen.		Rebar Yield Strength fy	60
				ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50	in
Flange Plate Length (V)	24.00	in
Flange Plate Width (H)	24.00	in
Spac. Between Bolt (V)	19.50	in
Spac. Between Bolt (H)	19.50	in
Flange Plate Thk.	2.00	in
Flange Plate Yield (Fy)	50	ksi
Gusset Thk.	0.375	in
Plate Center Hole	6.00	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.09	0.12	0.25								3.36	0.00
GP II CSR	0.55	0.29	0.74				0.95					
GP III CSR	0.31	0.22	0.50				0.69				5.98	
Nat.Wind (psi)	0	0										

Arm #1 Flange Bolt (Max.) CSR	0.16
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.34
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.00
Handhole at Toe (Fatigue) CSR	0.00
Minimum Qty of Vertical Reinf. Bars	5

Fatigue Allowable - Shaft to Baseplate	
Fatigue Allowable - Arm#1 to Flange	
Fatigue Allowable - Arm#2 to Flange	
Anchor Bolt Max. CSR	0.45
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.44
Anchorage Capacity S.F.	1.78
Concrete Pull Out Capacity S.F.	2.04

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
3835	5338	107410	57392



16362-3-13 - VA - 90 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.2
	#2	Ped Head	10.5	2.4	1			1	6	30	1.2
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.2
	#4										
Lum #1	#1	Cobra Head w/Camera	24	2	1			4.54	9	57	1
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	12'x2.5' Sign	7			12	2.5	1	30	66	1.20
	#3	Camera	10	1	1			1	3	22	1.20
	#4	2.5'x3' Sign	15			2.5	3	1	7.5	22.5	1.13
	#5	5 Section Head w/BP	19	13.75	4			2	42	105	1.20
	#6	Camera	21	1	1			1	3	22	1.20
	#7	3'x3.5' Sign	26			3	3.5	1	10.5	26.7	1.13
	#8	4 Section Head w/BP	29	11	5			1	34	80	1.20
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
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	#18										
	#19										
	#20										



16362-3-13 - VA - 90 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	17.500	17.352	48.60	0.5287	0.53	1.538	14.99	0.80
2	I	1.06	1.06	17.352	17.204	48.18	0.5287	1.59	1.524	14.87	0.80
3	I	1.06	2.12	17.204	17.055	47.76	0.5286	2.65	1.511	14.74	0.80
4	I	1.06	3.18	17.055	16.907	47.34	0.5286	3.71	1.498	14.62	0.80
5	I	1.06	4.24	16.907	16.759	46.92	0.5286	4.76	1.485	14.50	0.80
6	I	1.06	5.29	16.759	16.611	46.51	0.5286	5.82	1.472	14.37	0.80
7	I	1.06	6.35	16.611	16.462	46.09	0.5286	6.88	1.459	14.25	0.80
8	I	1.06	7.41	16.462	16.314	45.67	0.5286	7.94	1.446	14.13	0.80
9	I	1.06	8.47	16.314	16.166	45.25	0.5286	9.00	1.433	14.00	0.80
10	I	1.06	9.53	16.166	16.018	44.83	0.5286	10.06	1.420	13.88	0.80
11	I	1.06	10.59	16.018	15.869	44.41	0.5286	11.12	1.407	13.76	0.80
12	I	1.06	11.65	15.869	15.721	43.99	0.5286	12.18	1.394	13.63	0.80
13	I	1.06	12.71	15.721	15.573	43.57	0.5286	13.23	1.381	13.51	1.00
14	I	1.06	13.76	15.573	15.425	43.15	0.5286	14.29	1.368	13.39	1.00
15	I	1.06	14.82	15.425	15.276	42.73	0.5286	15.35	1.354	13.26	1.00
16	I	1.06	15.88	15.276	15.128	42.31	0.5286	16.41	1.341	13.14	1.00
17	I	1.06	16.94	15.128	14.980	41.89	0.5285	17.47	1.328	13.02	1.00
18	J	3.00	18.00	14.980	14.560	116.41	1.4929	19.49	3.693	36.21	1.00
19	I	3.00	21.00	14.560	14.140	113.05	1.4927	22.49	3.588	35.22	1.00
20	J	1.00	24.00	14.140	14.000	36.93	0.4992	24.50	1.173	11.52	1.00
						1036					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	503.67	313.61	0.00	255.09
Section Modulus (in^3)	58.40	42.58	0.00	
Cross-Section Area (in^2)	13.54	11.56	0.00	
Width-Thickness Ratio	70.00	59.92	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	35.991	36.300	0.000	
Allow. Compressive Str (ksi)	11.295	11.295	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

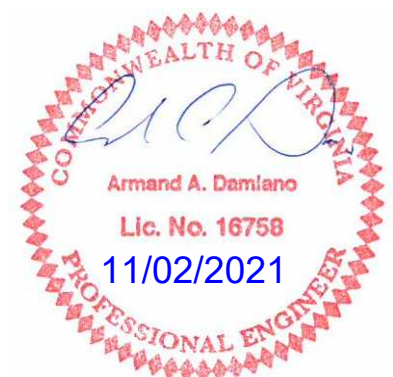
Shaft Deflection From Arm#1 GP I Load (in)	0.322
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-13 - VA - 90 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

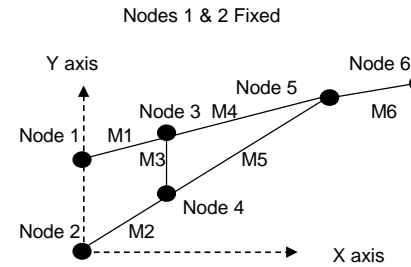
## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	19.40	0.000	19.22	1.100	0.000	0.00
2	0.450	12.62	19.24	0.000	19.06	1.100	0.000	0.00
3	0.450	12.62	19.07	0.000	18.89	1.100	0.000	0.00
4	0.450	12.62	18.91	0.000	18.73	1.100	0.000	0.00
5	0.450	12.62	18.74	0.001	18.57	1.100	0.000	0.00
6	0.450	12.62	18.58	0.001	18.40	1.100	0.000	0.00
7	0.450	12.62	18.41	0.001	18.24	1.100	0.000	0.00
8	0.450	12.62	18.25	0.002	18.08	1.100	0.000	0.00
9	0.450	12.62	18.08	0.002	17.91	1.100	0.000	0.00
10	0.450	12.62	17.92	0.003	17.75	1.100	0.000	0.00
11	0.450	12.62	17.75	0.003	17.58	1.100	0.000	0.00
12	0.450	12.62	17.59	0.004	17.42	1.100	0.000	0.00
13	0.450	15.77	21.77	0.005	17.26	1.100	0.000	0.00
14	0.450	15.77	21.57	0.006	17.09	1.100	0.000	0.00
15	0.450	15.77	21.36	0.007	16.93	1.100	0.000	0.00
16	0.450	15.77	21.15	0.007	16.77	1.100	0.000	0.00
17	0.450	15.77	20.95	0.008	16.60	1.100	0.000	0.00
18	0.450	15.77	58.23	0.028	46.16	1.100	0.000	0.00
19	0.450	15.77	56.57	0.035	44.84	1.100	0.000	0.00
20	0.450	15.77	18.49	0.013	14.66	1.100	0.000	0.00
Fix. #1	1.200	33.65	80.76	0.012	40.38	1.200	0.000	0.00
Fix. #2	1.200	33.65	80.76	0.012	40.38	1.200	0.000	0.00
Fix. #3	1.200	42.06	578.33	0.174	289.16	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-13 - VA - 90 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum. - Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-44.01	-40.6	0	0	0
Node #2	0	0	0	0	-46.58	-42.9	0	0	0
Node #3	100	59.5	0	0	-87	-84.8	0	0	0
Node #4	100	48.8	0	0	-90.64	-88.2	0	0	0
Node #5	200	79	0	0	-123.35	-125	0	0	0
Node #6	288	87	0	0	-93.99	-114.6	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-88.02	1.1	1	-81.07	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-93.14	1.1	1	-85.79	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.95	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-85.28	1.1	1.1	-86.40	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-87.44	1.1	1.1	-88.59	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-73.97	1.1	1.1	-74.94	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-77.10					

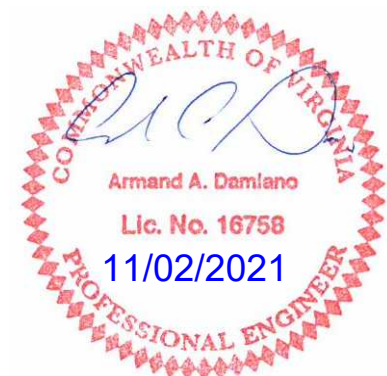
AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2629.3	lbs
P1y	-827.0	lbs
P1z	294.4	lbs
M1x	10996.1	in-lbs
M1y	-41528.6	in-lbs
M1z	-716.1	in-lbs
P2x	2629.3	lbs
P2y	1312.5	lbs
P2z	201.7	lbs
M2x	11346.6	in-lbs
M2y	-33776.2	in-lbs
M2z	-770.7	in-lbs

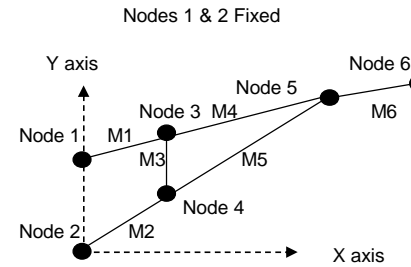
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-939	173	26099	-644	0.76
#2	989	109	21500	-1250	0.95
#3	1807	572	11253	-534	0.45
#4	-919	78	10031	-29	0.28
#5	936	91	11105	-380	0.58
#6	3	101	7955	-1	0.24

V09.19.15



16362-3-13 - VA - 90 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum. - Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-51.2	-20.3	0	0	0
Node #2	0	0	0	0	-54.18	-21.5	0	0	0
Node #3	100	59.5	0	0	-101.41	-42.4	0	0	0
Node #4	100	48.8	0	0	-105.65	-44.1	0	0	0
Node #5	200	79	0	0	-143.49	-62.5	0	0	0
Node #6	288	87	0	0	-124.03	-57.3	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-102.39	1.1	1	-40.53	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-108.35	1.1	1	-42.89	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.98	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-99.21	1.1	1.1	-43.20	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-101.72	1.1	1.1	-44.29	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-86.04	1.1	1.1	-37.47	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-38.55					

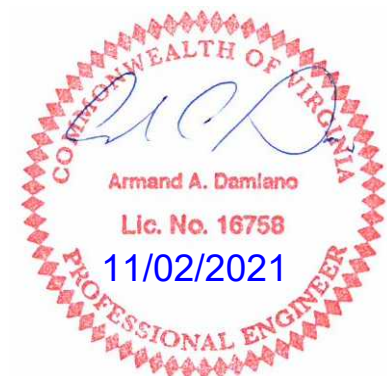
AASHTO Gp	3
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-3247.7	lbs
P1y	-1031.5	lbs
P1z	147.2	lbs
M1x	5498.0	in-lbs
M1y	-20764.3	in-lbs
M1z	-1257.5	in-lbs
P2x	3247.7	lbs
P2y	1611.4	lbs
P2z	100.9	lbs
M2x	5673.3	in-lbs
M2y	-16888.1	in-lbs
M2z	-1306.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1160	88	13070	-322	0.36
#2	1221	57	10777	-625	0.69
#3	2226	425	8530	-267	0.39
#4	-1137	47	5068	-15	0.12
#5	1159	52	5600	-190	0.48
#6	4	93	7320	-1	0.23

V09.19.15



16362-3-13 - VA - 90 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	1.50	0.00	12.000	11.790	33.7	0.7478	0.75	1.487	1.487	14.72
2	I	1.50	1.50	11.790	11.580	33.1	0.7478	2.25	1.461	1.461	14.47
3	I	1.50	3.00	11.580	11.370	32.5	0.7477	3.75	1.434	1.434	14.23
4	I	1.50	4.50	11.370	11.160	31.9	0.7477	5.25	1.408	1.408	13.98
5	I	1.50	6.00	11.160	10.950	31.3	0.7476	6.75	1.382	1.382	13.73
6	I	1.50	7.50	10.950	10.740	30.7	0.7476	8.25	1.356	1.356	13.48
7	I	1.50	9.00	10.740	10.530	30.1	0.7475	9.75	1.329	1.329	13.24
8	I	1.50	10.50	10.530	10.320	29.5	0.7475	11.25	1.303	1.303	12.99
9	I	1.50	12.00	10.320	10.110	28.9	0.7474	12.75	1.277	1.277	12.74
10	I	1.50	13.50	10.110	9.900	28.2	0.7474	14.25	1.251	1.251	12.49
11	I	1.50	15.00	9.900	9.690	27.6	0.7473	15.75	1.224	1.224	12.25
12	I	1.50	16.50	9.690	9.480	27.0	0.7473	17.25	1.198	1.198	12.00
13	I	1.50	18.00	9.480	9.270	26.4	0.7472	18.75	1.172	1.172	11.75
14	I	1.50	19.50	9.270	9.060	25.8	0.7471	20.25	1.146	1.146	11.50
15	I	1.50	21.00	9.060	8.850	25.2	0.7471	21.75	1.119	1.119	11.26
16	I	1.50	22.50	8.850	8.640	24.6	0.7470	23.25	1.093	1.093	11.01
17	I	1.50	24.00	8.640	8.430	24.0	0.7469	24.75	1.067	1.067	10.76
18	I	1.50	25.50	8.430	8.220	23.4	0.7468	26.25	1.041	1.041	10.51
19	I	1.50	27.00	8.220	8.010	22.8	0.7468	27.75	1.014	1.014	10.27
20	I	1.50	28.50	8.010	7.800	22.2	0.7467	29.25	0.988	0.988	10.02
		<u>30.00</u>				<u>559</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	66	7.00	30.000	1.000	90.00
Fix. #3	22	10.00	1.000	1.000	9.00
Fix. #4	22.5	15.00	7.500	1.000	22.50
Fix. #5	105	19.00	13.750	2.000	126.00
Fix. #6	22	21.00	1.000	1.000	9.00
Fix. #7	26.7	26.00	10.500	1.000	31.50
Fix. #8	80	29.00	11.000	1.000	102.00
Fix. #9	0	0.00	0.000	0.000	0.00
Fix. #10	0	0.00	0.000	0.000	0.00
Fix. #11	0	0.00	0.000	0.000	0.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	19.667	0.000
Cross-Section Area (in^2)	6.655	0.000
Width-Thickness Ratio	66.93	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	36.300	0.000
Allow. Shear Stress (ksi)	18.150	0.000





16362-3-13 - VA - 90 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000 Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	23.45	18.59	1.100	0.000	0.00	0	0.784	0.00	0.00	
2	1.00	0.450	15.77	23.03	18.26	1.100	0.000	0.00	0	0.802	0.00	0.00	
3	1.00	0.450	15.77	22.62	17.93	1.100	0.000	0.00	0	0.821	0.00	0.00	
4	1.00	0.450	15.77	22.21	17.60	1.100	0.000	0.00	0	0.841	0.00	0.00	
5	1.00	0.450	15.77	21.79	17.27	1.100	0.000	0.00	0	0.862	0.00	0.00	
6	1.00	0.450	15.77	21.38	16.95	1.100	0.000	0.00	0	0.884	0.00	0.00	
7	1.00	0.450	15.77	20.96	16.62	1.100	0.000	0.00	0	0.906	0.00	0.00	
8	1.00	0.450	15.77	20.55	16.29	1.100	0.000	0.00	0	0.930	0.00	0.00	
9	1.00	0.450	15.77	20.14	15.96	1.100	0.000	0.00	0	0.955	0.00	0.00	
10	1.00	0.450	15.77	19.72	15.63	1.100	0.000	0.00	0	0.981	0.00	0.00	
11	1.00	0.450	15.77	19.31	15.30	1.100	0.000	0.00	1	1.009	0.00	0.00	
12	1.00	0.450	15.77	18.89	14.98	1.100	0.000	0.00	1	1.037	0.00	0.00	
13	1.00	0.450	15.77	18.48	14.65	1.100	0.000	0.00	1	1.068	0.00	0.00	
14	1.00	0.450	15.77	18.07	14.32	1.100	0.000	0.00	1	1.100	0.00	0.00	
15	1.00	0.450	15.77	17.65	13.99	1.100	0.000	0.00	1	1.100	0.00	0.00	
16	1.00	0.450	15.77	17.24	13.66	1.100	0.000	0.00	1	1.100	0.00	0.00	
17	1.00	0.450	15.77	16.82	13.34	1.100	0.000	0.00	1	1.100	0.00	0.00	
18	1.00	0.463	16.24	16.90	13.01	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.479	16.79	17.03	12.68	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.496	17.37	17.16	12.35	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	42.03	1260.90	630.45	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	578.33	289.16	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.132	39.66	416.43	208.22	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	462.66	231.33	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #10	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #11	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



16362-3-13 - VA - 90 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

Flange Analysis - Arm #1

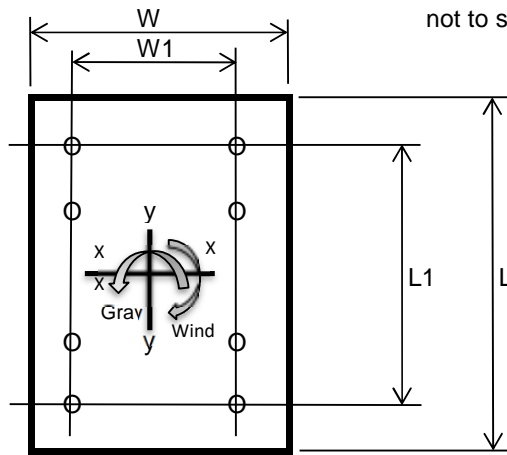
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Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	925	1572	-	lbs
Shear (Wind)	3536	1881	-	lbs
Torsion (Arm Rise)	5559	2957	-	ft-lbs
Moment (Gravity)	14359	25276	-	ft-lbs
Moment (Wind)	55530	29313	-	ft-lbs
Nat. Wind Moment	-	-	0	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	12.00	in
Tube Wall Thick.	0.1793	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.00
W	24
W1	19.50
L	24
L1	19.50
L2 - Dist. between bolts (Typ.)	6.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	596.99	596.99	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1073.57	1073.57	in <sup>4</sup>
Bolt Tensile Stress - ft	6.68	5.90	ksi
Bolt Shear Stress - fv	0.93	0.56	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.16	0.14	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	0	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	3.63	6.38	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	14.26	7.53	ksi
Combined applied stress for interaction (SRSS)	14.71	9.87	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-13 - VA - 90 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	925		925	14359		14360		278	8762		0.25
Gp II	925	3536	3655	14359	55530	57357	5559	1099	34997	1696	0.74
Gp III	1572	1881	2451	25276	29313	38707	2957	737	23617	903	0.50
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-13 - VA - 90 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	2611		14359	0	14359		193		2951		0.09
Gp II	2611	5338	28201	103642	107410	57392	193	789	22072	5897	0.55
Gp III	3835	2966	32638	56023	64837	30244	283	439	13323	3107	0.31
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9976										

<b>Shaft At Arm</b>											
Gp I	1677		14359	0	14359		145		4047		0.12
Gp II	1677	4165	5559	24073	24707	57392	145	721	6963	8087	0.29
Gp III	2418	2234	2957	30268	30412	30244	209	387	8571	4262	0.22
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9976										



16362-3-13 - VA - 90 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	5338 lbs
Bending Moment	107410 ft-lbs
Torsion Moment	57392 ft-lbs
Num. Anchor Bolts	6
Bolt Circle	24 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	30 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	17.50 in

**ANALYSIS - ANCHOR BOLTS**

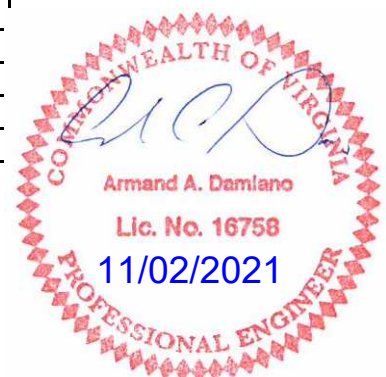
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1082.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	14.282 ksi
Bolt Direct Shear Stress	0.387 ksi
Bolt Torsion Shear Stress	4.159 ksi
Combined Bolt Stress	
$F_v = .3 F_y$ * Allowable Increase Factor	21.945 ksi
$F_t = .5 F_y$ * Allowable Increase Factor	36.575 ksi
$f_t =$	14.282 ksi
$f_v =$	4.546 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.45 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	12.701 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	117 in-kip
Section Modulus of Failure Plane	8.46 in <sup>3</sup>
Applied Plate Stress	13.83 ksi
Allowable Plate Stress = $.66 F_y$ * Allow. Incr.	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	12.052 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	61 in-kip
Section Modulus of Failure Plane	8.03 in <sup>3</sup>
Applied Plate Stress	7.6 ksi
Allowable Plate Stress = $.66 F_y$ * Allow. Incr.	31.6 ksi
Therefore	<b>OK</b>



16362-3-13 - VA - 90 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1082.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	0 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

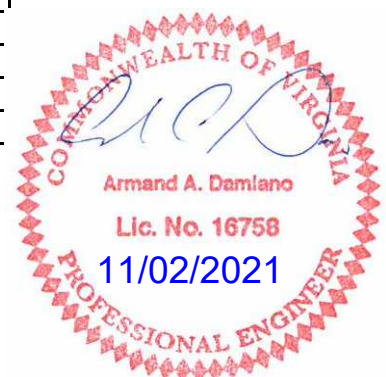
Anchor Bolt Length	60.0 in
Anchor Bolt Max. Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	127540 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	11 in
T Reduced For Group Action	63770 lbs
Maximum Applied Tensile Load	35705 lbs
Computed Factor-of Safety	1.78 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	35705 lbs
Total Tensile Load	214230 lbs
Concrete Failure Surface Area	4002.39 in <sup>2</sup>
Concrete Shear Strength	438440 psi
Computed Factor-of Safety	2.04 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	35705 lbs
Total Tensile Load	214230 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	45.36 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	5 Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-14 - VA - 90 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

11/02/21

**General**

Wind Vel. - mph	90	No	Roadway - mph	55	<b>Fatigue Importance Factors</b>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.00
Fatigue Cat.	0		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.00
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.00
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	1		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.2500	0.14	17.50	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.1793	0.14	13.00	40.00	18.00	-	2.10	0	55	29000	180
Traffic Arm #2					-	-		0	55	29000	90
Lum Arm #1	0.3750		2.88	24.00	24.00	-	5	0	36	29000	180
Lum Arm #2					-	-		0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	6	Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	Double Top Nuts	Yes	
A.B. Bolt Circle	24.00	Foundation Diameter	48	in
Baseplate Dia.	30.00	Concrete Cover	4	in
Baseplate Thk.	2.00	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	13.00	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.	Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50	in
Flange Plate Length (V)	24.00	in
Flange Plate Width (H)	24.00	in
Spac. Between Bolt (V)	19.50	in
Spac. Between Bolt (H)	19.50	in
Flange Plate Thk.	2.00	in
Flange Plate Yield (Fy)	50	ksi
Gusset Thk.	0.375	in
Plate Center Hole	6.00	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.15	0.20	0.35								7.94	0.00
GP II CSR	0.70	0.49	0.97				0.95					
GP III CSR	0.41	0.36	0.68				0.69				13.88	
Nat.Wind (psi)	0	0										

Arm #1 Flange Bolt (Max.) CSR	0.24
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.49
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.00
Handhole at Toe (Fatigue) CSR	0.00
Minimum Qty of Vertical Reinf. Bars	6

Fatigue Allowable - Shaft to Baseplate	
Fatigue Allowable - Arm#1 to Flange	
Fatigue Allowable - Arm#2 to Flange	
Anchor Bolt Max. CSR	0.54
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.50
Anchorage Capacity S.F.	1.56
Concrete Pull Out Capacity S.F.	1.79

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
4279	5864	122643	84813



16362-3-14 - VA - 90 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1	Cobra Head w/Camera	24	2	1			4.54	9	57	1.00
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	12'x2.5' Sign	8			12	2.5	1	30	66	1.20
	#3	5 Section Head w/BP	17	13.75	4			2	42	105	1.20
	#4		Camera	20	1	1			1	3	22
	#5	2.5'x3' Sign	25			2.5	3	1	7.5	22.5	1.13
	#6	3 Section Head w/BP	28	8.7	4			1	26	65	1.20
	#7		Camera	30	1	1			1	3	22
	#8	3'x3.5' Sign	36			3	3.5	1	10.5	26.7	1.13
	#9	4 Section Head w/BP	39	11	5			1	34	80	1.20
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										





16362-3-14 - VA - 90 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	17.500	17.352	48.60	0.5287	0.53	1.538	14.99	0.80
2	I	1.06	1.06	17.352	17.204	48.18	0.5287	1.59	1.524	14.87	0.80
3	I	1.06	2.12	17.204	17.055	47.76	0.5286	2.65	1.511	14.74	0.80
4	I	1.06	3.18	17.055	16.907	47.34	0.5286	3.71	1.498	14.62	0.80
5	I	1.06	4.24	16.907	16.759	46.92	0.5286	4.76	1.485	14.50	0.80
6	I	1.06	5.29	16.759	16.611	46.51	0.5286	5.82	1.472	14.37	0.80
7	I	1.06	6.35	16.611	16.462	46.09	0.5286	6.88	1.459	14.25	0.80
8	I	1.06	7.41	16.462	16.314	45.67	0.5286	7.94	1.446	14.13	0.80
9	I	1.06	8.47	16.314	16.166	45.25	0.5286	9.00	1.433	14.00	0.80
10	I	1.06	9.53	16.166	16.018	44.83	0.5286	10.06	1.420	13.88	0.80
11	I	1.06	10.59	16.018	15.869	44.41	0.5286	11.12	1.407	13.76	0.80
12	I	1.06	11.65	15.869	15.721	43.99	0.5286	12.18	1.394	13.63	0.80
13	I	1.06	12.71	15.721	15.573	43.57	0.5286	13.23	1.381	13.51	1.00
14	I	1.06	13.76	15.573	15.425	43.15	0.5286	14.29	1.368	13.39	1.00
15	I	1.06	14.82	15.425	15.276	42.73	0.5286	15.35	1.354	13.26	1.00
16	I	1.06	15.88	15.276	15.128	42.31	0.5286	16.41	1.341	13.14	1.00
17	I	1.06	16.94	15.128	14.980	41.89	0.5285	17.47	1.328	13.02	1.00
18	J	3.00	18.00	14.980	14.560	116.41	1.4929	19.49	3.693	36.21	1.00
19	I	3.00	21.00	14.560	14.140	113.05	1.4927	22.49	3.588	35.22	1.00
20	J	1.00	24.00	14.140	14.000	36.93	0.4992	24.50	1.173	11.52	1.00
						1036					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	503.67	313.61	0.00	255.09
Section Modulus (in^3)	58.40	42.58	0.00	
Cross-Section Area (in^2)	13.54	11.56	0.00	
Width-Thickness Ratio	70.00	59.92	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	35.991	36.300	0.000	
Allow. Compressive Str (ksi)	11.295	11.295	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.536
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-14 - VA - 90 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

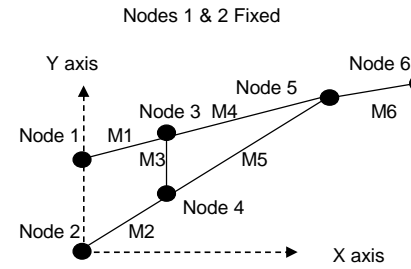
## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	19.40	0.000	19.22	1.100	0.000	0.00
2	0.450	12.62	19.24	0.000	19.06	1.100	0.000	0.00
3	0.450	12.62	19.07	0.000	18.89	1.100	0.000	0.00
4	0.450	12.62	18.91	0.000	18.73	1.100	0.000	0.00
5	0.450	12.62	18.74	0.001	18.57	1.100	0.000	0.00
6	0.450	12.62	18.58	0.001	18.40	1.100	0.000	0.00
7	0.450	12.62	18.41	0.001	18.24	1.100	0.000	0.00
8	0.450	12.62	18.25	0.002	18.08	1.100	0.000	0.00
9	0.450	12.62	18.08	0.002	17.91	1.100	0.000	0.00
10	0.450	12.62	17.92	0.003	17.75	1.100	0.000	0.00
11	0.450	12.62	17.75	0.003	17.58	1.100	0.000	0.00
12	0.450	12.62	17.59	0.004	17.42	1.100	0.000	0.00
13	0.450	15.77	21.77	0.005	17.26	1.100	0.000	0.00
14	0.450	15.77	21.57	0.006	17.09	1.100	0.000	0.00
15	0.450	15.77	21.36	0.007	16.93	1.100	0.000	0.00
16	0.450	15.77	21.15	0.007	16.77	1.100	0.000	0.00
17	0.450	15.77	20.95	0.008	16.60	1.100	0.000	0.00
18	0.450	15.77	58.23	0.028	46.16	1.100	0.000	0.00
19	0.450	15.77	56.57	0.035	44.84	1.100	0.000	0.00
20	0.450	15.77	18.49	0.013	14.66	1.100	0.000	0.00
Fix. #1	1.200	33.65	80.76	0.012	40.38	1.200	0.000	0.00
Fix. #2	1.200	33.65	80.76	0.012	40.38	1.200	0.000	0.00
Fix. #3	1.200	42.06	578.33	0.174	289.16	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-14 - VA - 90 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum. - Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-44.01	-40.6	0	0	0
Node #2	0	0	0	0	-46.58	-42.9	0	0	0
Node #3	100	59.5	0	0	-87	-84.8	0	0	0
Node #4	100	48.8	0	0	-90.64	-88.2	0	0	0
Node #5	200	79	0	0	-123.35	-125	0	0	0
Node #6	288	87	0	0	-93.99	-114.6	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-88.02	1.1	1	-81.07	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-93.14	1.1	1	-85.79	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.95	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-85.28	1.1	1.1	-86.40	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-87.44	1.1	1.1	-88.59	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-73.97	1.1	1.1	-74.94	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-77.10					

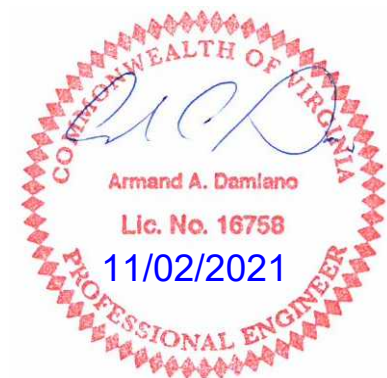
AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2629.3	lbs
P1y	-827.0	lbs
P1z	294.4	lbs
M1x	10996.1	in-lbs
M1y	-41528.6	in-lbs
M1z	-716.1	in-lbs
P2x	2629.3	lbs
P2y	1312.5	lbs
P2z	201.7	lbs
M2x	11346.6	in-lbs
M2y	-33776.2	in-lbs
M2z	-770.7	in-lbs

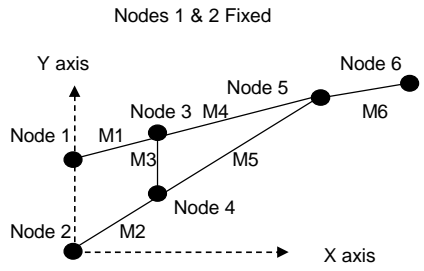
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-939	173	26099	-644	0.76
#2	989	109	21500	-1250	0.95
#3	1807	572	11253	-534	0.45
#4	-919	78	10031	-29	0.28
#5	936	91	11105	-380	0.58
#6	3	101	7955	-1	0.24

V09.19.15



16362-3-14 - VA - 90 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum. - Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-51.2	-20.3	0	0	0
Node #2	0	0	0	0	-54.18	-21.5	0	0	0
Node #3	100	59.5	0	0	-101.41	-42.4	0	0	0
Node #4	100	48.8	0	0	-105.65	-44.1	0	0	0
Node #5	200	79	0	0	-143.49	-62.5	0	0	0
Node #6	288	87	0	0	-124.03	-57.3	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-102.39	1.1	1	-40.53	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-108.35	1.1	1	-42.89	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.98	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-99.21	1.1	1.1	-43.20	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-101.72	1.1	1.1	-44.29	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-86.04	1.1	1.1	-37.47	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-38.55					

AASHTO Gp	3
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-3247.7	lbs
P1y	-1031.5	lbs
P1z	147.2	lbs
M1x	5498.0	in-lbs
M1y	-20764.3	in-lbs
M1z	-1257.5	in-lbs
P2x	3247.7	lbs
P2y	1611.4	lbs
P2z	100.9	lbs
M2x	5673.3	in-lbs
M2y	-16888.1	in-lbs
M2z	-1306.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1160	88	13070	-322	0.36
#2	1221	57	10777	-625	0.69
#3	2226	425	8530	-267	0.39
#4	-1137	47	5068	-15	0.12
#5	1159	52	5600	-190	0.48
#6	4	93	7320	-1	0.23

V09.19.15



16362-3-14 - VA - 90 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	2.00	0.00	13.000	12.720	48.6	0.9964	1.00	2.143	2.143	21.14
2	I	2.00	2.00	12.720	12.440	47.5	0.9963	3.00	2.097	2.097	20.70
3	I	2.00	4.00	12.440	12.160	46.5	0.9962	5.00	2.050	2.050	20.26
4	I	2.00	6.00	12.160	11.880	45.4	0.9961	7.00	2.003	2.003	19.82
5	I	2.00	8.00	11.880	11.600	44.3	0.9960	9.00	1.957	1.957	19.38
6	I	2.00	10.00	11.600	11.320	43.2	0.9959	11.00	1.910	1.910	18.94
7	I	2.00	12.00	11.320	11.040	42.2	0.9958	13.00	1.863	1.863	18.50
8	I	2.00	14.00	11.040	10.760	41.1	0.9957	15.00	1.817	1.817	18.06
9	I	2.00	16.00	10.760	10.480	40.0	0.9956	17.00	1.770	1.770	17.62
10	I	2.00	18.00	10.480	10.200	39.0	0.9955	19.00	1.723	1.723	17.18
11	I	2.00	20.00	10.200	9.920	37.9	0.9954	21.00	1.677	1.677	16.74
12	I	2.00	22.00	9.920	9.640	36.8	0.9952	23.00	1.630	1.630	16.30
13	I	2.00	24.00	9.640	9.360	35.7	0.9951	25.00	1.583	1.583	15.86
14	I	2.00	26.00	9.360	9.080	34.7	0.9949	26.99	1.537	1.537	15.43
15	I	2.00	28.00	9.080	8.800	33.6	0.9948	28.99	1.490	1.490	14.99
16	I	2.00	30.00	8.800	8.520	32.5	0.9946	30.99	1.443	1.443	14.55
17	I	2.00	32.00	8.520	8.240	31.4	0.9944	32.99	1.397	1.397	14.11
18	I	2.00	34.00	8.240	7.960	30.4	0.9942	34.99	1.350	1.350	13.67
19	I	2.00	36.00	7.960	7.680	29.3	0.9940	36.99	1.303	1.303	13.23
20	I	2.00	38.00	7.680	7.400	28.2	0.9938	38.99	1.257	1.257	12.79
		<u>40.00</u>				<u>768</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	66	8.00	30.000	1.000	90.00
Fix. #3	105	17.00	13.750	2.000	126.00
Fix. #4	22	20.00	1.000	1.000	9.00
Fix. #5	22.5	25.00	7.500	1.000	22.50
Fix. #6	65	28.00	8.700	1.000	78.00
Fix. #7	22	30.00	1.000	1.000	9.00
Fix. #8	26.7	36.00	10.500	1.000	31.50
Fix. #9	80	39.00	11.000	1.000	102.00
Fix. #10	0	0.00	0.000	0.000	0.00
Fix. #11	0	0.00	0.000	0.000	0.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	23.135	0.000
Cross-Section Area (in^2)	7.218	0.000
Width-Thickness Ratio	72.50	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	35.489	0.000
Allow. Shear Stress (ksi)	18.150	0.000



16362-3-14 - VA - 90 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000 Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	33.80	26.79	1.100	0.000	0.00	0	0.708	0.00	0.00	
2	1.00	0.450	15.77	33.06	26.21	1.100	0.000	0.00	0	0.729	0.00	0.00	
3	1.00	0.450	15.77	32.33	25.63	1.100	0.000	0.00	0	0.750	0.00	0.00	
4	1.00	0.450	15.77	31.59	25.04	1.100	0.000	0.00	0	0.773	0.00	0.00	
5	1.00	0.450	15.77	30.86	24.46	1.100	0.000	0.00	0	0.797	0.00	0.00	
6	1.00	0.450	15.77	30.12	23.88	1.100	0.000	0.00	0	0.822	0.00	0.00	
7	1.00	0.450	15.77	29.38	23.29	1.100	0.000	0.00	0	0.849	0.00	0.00	
8	1.00	0.450	15.77	28.65	22.71	1.100	0.000	0.00	0	0.878	0.00	0.00	
9	1.00	0.450	15.77	27.91	22.13	1.100	0.000	0.00	0	0.908	0.00	0.00	
10	1.00	0.450	15.77	27.18	21.54	1.100	0.000	0.00	0	0.940	0.00	0.00	
11	1.00	0.450	15.77	26.44	20.96	1.100	0.000	0.00	0	0.974	0.00	0.00	
12	1.00	0.450	15.77	25.71	20.38	1.100	0.000	0.00	0	1.011	0.00	0.00	
13	1.00	0.450	15.77	24.97	19.79	1.100	0.000	0.00	1	1.050	0.00	0.00	
14	1.00	0.450	15.77	24.23	19.21	1.100	0.000	0.00	1	1.091	0.00	0.00	
15	1.00	0.450	15.77	23.50	18.63	1.100	0.000	0.00	1	1.100	0.00	0.00	
16	1.00	0.450	15.77	22.76	18.04	1.100	0.000	0.00	1	1.100	0.00	0.00	
17	1.00	0.459	16.1	22.49	17.46	1.100	0.000	0.00	1	1.100	0.00	0.00	
18	1.00	0.480	16.83	22.72	16.88	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.503	17.62	22.96	16.29	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.527	18.47	23.21	15.71	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	42.03	1260.90	630.45	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #5	1.00	1.134	39.74	298.05	149.03	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	365.92	182.96	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.200	42.06	42.06	21.03	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.132	39.66	416.43	208.22	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	462.66	231.33	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #11	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



16362-3-14 - VA - 90 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.  
Flange Analysis - Arm #1

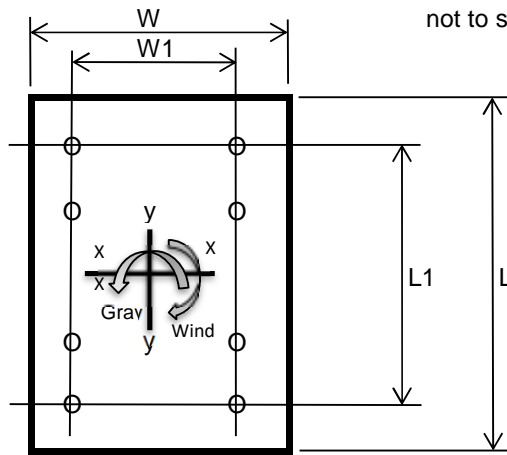
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V06-21-16

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1199	2016	-	lbs
Shear (Wind)	4052	2179	-	lbs
Torsion (Arm Rise)	8494	4568	-	ft-lbs
Moment (Gravity)	23899	41305	-	ft-lbs
Moment (Wind)	82951	44183	-	ft-lbs
Nat. Wind Moment	-	-	0	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	13.00	in
Tube Wall Thick.	0.1793	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.00
W	24
W1	19.50
L	24
L1	19.50
L2 - Dist. between bolts (Typ.)	6.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	596.99	596.99	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1073.57	1073.57	in <sup>4</sup>
Bolt Tensile Stress - ft	10.19	9.42	ksi
Bolt Shear Stress - fv	1.3	0.79	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.24	0.22	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	0	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	5.87	10.15	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	20.74	11.05	ksi
Combined applied stress for interaction (SRSS)	21.55	15.00	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-14 - VA - 90 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					
<b>Arm#1 Base</b>											
Gp I	1199		1199	23899		23900		333	12397		0.35
Gp II	1199	4052	4227	23899	82951	86326	8494	1172	44777	2203	0.97
Gp III	2016	2179	2969	41305	44183	60484	4568	823	31373	1185	0.68
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-
<b>Arm#1 Joint</b>											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-
<b>Arm#2 Base</b>											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-
<b>Arm#2 Joint</b>											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-





16362-3-14 - VA - 90 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	2886		23899	0	23899		213		4911		0.15
Gp II	2886	5864	40186	115872	122643	84813	213	867	25202	8714	0.70
Gp III	4279	3271	43794	69278	81959	45114	316	484	16842	4635	0.41
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9972										

<b>Shaft At Arm</b>											
Gp I	1951		23899	0	23899		169		6735		0.20
Gp II	1951	4682	8494	33612	34669	84813	169	810	9770	11951	0.49
Gp III	2862	2533	4568	46297	46522	45114	248	439	13111	6357	0.36
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9972										



16362-3-14 - VA - 90 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	5864 lbs
Bending Moment	122643 ft-lbs
Torsion Moment	84813 ft-lbs
Num. Anchor Bolts	6
Bolt Circle	24 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	30 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	17.50 in

**ANALYSIS - ANCHOR BOLTS**

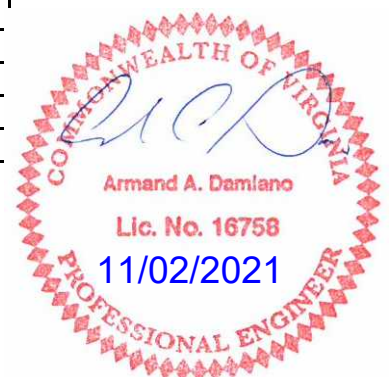
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1082.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	16.308 ksi
Bolt Direct Shear Stress	0.425 ksi
Bolt Torsion Shear Stress	6.146 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	16.308 ksi
$f_v =$	6.571 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.54 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	12.701 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	133 in-kip
Section Modulus of Failure Plane	8.46 in <sup>3</sup>
Applied Plate Stress	15.73 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	12.052 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	69 in-kip
Section Modulus of Failure Plane	8.03 in <sup>3</sup>
Applied Plate Stress	8.6 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-14 - VA - 90 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1082.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	0 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

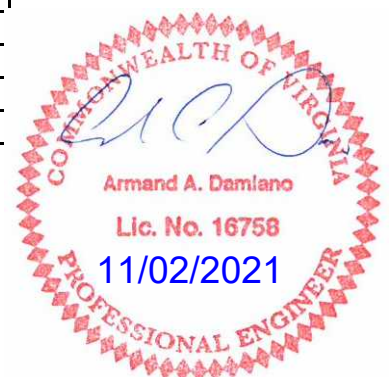
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	127540 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	11 in
T Reduced For Group Action	63770 lbs
Maximum Applied Tensile Load	40770 lbs
Computed Factor-of Safety	1.56 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	40770 lbs
Total Tensile Load	244620 lbs
Concrete Failure Surface Area	4002.39 in <sup>2</sup>
Concrete Shear Strength	438440 psi
Computed Factor-of Safety	1.79 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	40770 lbs
Total Tensile Load	244620 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	45.36 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	<b>6</b> Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

11/02/21

**General**

Wind Vel. - mph	90	No	Roadway - mph	55	<i>Fatigue Importance Factors</i>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	1		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.00	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	0.14	15.58	23.69	18.00	-	3.14	0	55	29000	180
	0.1793	0.14	13.00	39.00	-	2.69		0	55	29000	
Traffic Arm #2								0	55	29000	90
								0	55	29000	
Lum Arm #1	0.3750		2.88	24.00	24.00	-	5	0	36	29000	180
Lum Arm #2						-		0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8		Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes	
A.B. Bolt Circle	26.00	in	Foundation Diameter	48	in
Baseplate Dia.	32.00	in	Concrete Cover	4	in
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	15.25	in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.		Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50 in	in
Flange Plate Length (V)	27.00 in	in
Flange Plate Width (H)	27.00 in	in
Spac. Between Bolt (V)	22.50 in	in
Spac. Between Bolt (H)	22.50 in	in
Flange Plate Thk.	2.25 in	in
Flange Plate Yield (Fy)	50 ksi	ksi
Gusset Thk.	0.500 in	in
Plate Center Hole	6.00 in	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	<i>Shaft At</i>		<i>Arm#1</i>		<i>Arm#2</i>		<i>Lum#1</i>		<i>Lum#2</i>		<i>Tip Deflection (in)</i>	
	Base	Flange	Root	Joint	Root	Joint	Root	Root			Arm #1	Arm #2
GP I CSR	0.18	0.24	0.43	0.34							18.49	0.00
GP II CSR	0.55	0.48	0.99	0.88			0.95					
GP III CSR	0.37	0.38	0.73	0.63			0.69				31.01	
Nat.Wind (psi)	2148	372	6306	5372								

Arm #1 Flange Bolt (Max.) CSR	0.44
Arm #1 Flange Bolt Fatigue CSR	0.33
Arm #1 Flange Plate (Max.) CSR	0.70
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.51
Handhole at Toe (Fatigue) CSR	0.32
Minimum Qty of Vertical Reinf. Bars	7

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.60
Anchor Bolt Max. Fatigue Stress Ratio	0.27
Base Plate Max. CSR	0.56
Anchorage Capacity S.F.	1.57
Concrete Pull Out Capacity S.F.	1.50

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
6405	7332	170773	171167



16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

Input Loads

**Fixture Input Data**

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1	Cobra Head w/Camera	24	2	1			4.54	9	57	1.00
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	12.5			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	26	13.75	4			2	42	105	1.20
	#4	2.5'x3' Sign	34			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	37	8.7	4			1	26	65	1.20
	#6	Camera	46	1	1			1	3	22	1.20
	#7	2.5'x3' Sign	45			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	48	8.7	4			1	26	65	1.20
	#9	Camera	57	1	1			1	3	22	1.20
	#10	3'x3.5' Sign	56			3	3.5	1	10.5	26.7	1.13
	#11	4 Section Head w/BP	59	11	5			1	34	80	1.20
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										



16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.000	19.852	82.99	0.5288	0.53	1.758	17.07	0.80
2	I	1.06	1.06	19.852	19.704	82.36	0.5288	1.59	1.745	16.95	0.80
3	I	1.06	2.12	19.704	19.555	81.73	0.5287	2.65	1.732	16.82	0.80
4	I	1.06	3.18	19.555	19.407	81.10	0.5287	3.71	1.719	16.70	0.80
5	I	1.06	4.24	19.407	19.259	80.47	0.5287	4.76	1.706	16.58	0.80
6	I	1.06	5.29	19.259	19.111	79.84	0.5287	5.82	1.693	16.45	0.80
7	I	1.06	6.35	19.111	18.962	79.21	0.5287	6.88	1.680	16.33	0.80
8	I	1.06	7.41	18.962	18.814	78.58	0.5287	7.94	1.667	16.21	0.80
9	I	1.06	8.47	18.814	18.666	77.95	0.5287	9.00	1.654	16.08	0.80
10	I	1.06	9.53	18.666	18.518	77.32	0.5287	10.06	1.640	15.96	0.80
11	I	1.06	10.59	18.518	18.369	76.69	0.5287	11.12	1.627	15.84	0.80
12	I	1.06	11.65	18.369	18.221	76.06	0.5287	12.18	1.614	15.71	0.80
13	I	1.06	12.71	18.221	18.073	75.43	0.5287	13.23	1.601	15.59	1.00
14	I	1.06	13.76	18.073	17.925	74.81	0.5287	14.29	1.588	15.47	1.00
15	I	1.06	14.82	17.925	17.776	74.18	0.5287	15.35	1.575	15.34	1.00
16	I	1.06	15.88	17.776	17.628	73.55	0.5287	16.41	1.562	15.22	1.00
17	I	1.06	16.94	17.628	17.480	72.92	0.5287	17.47	1.549	15.10	1.00
18	J	3.00	18.00	17.480	17.060	203.18	1.4939	19.49	4.318	42.10	1.00
19	I	3.00	21.00	17.060	16.640	198.13	1.4938	22.49	4.213	41.12	1.00
20	J	1.00	24.00	16.640	16.500	64.92	0.4993	24.50	1.381	13.49	1.00
						1792					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	1112.50	736.61	0.00	617.12
Section Modulus (in^3)	113.38	86.13	0.00	
Cross-Section Area (in^2)	23.11	20.14	0.00	
Width-Thickness Ratio	53.33	46.61	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	14.993	14.993	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

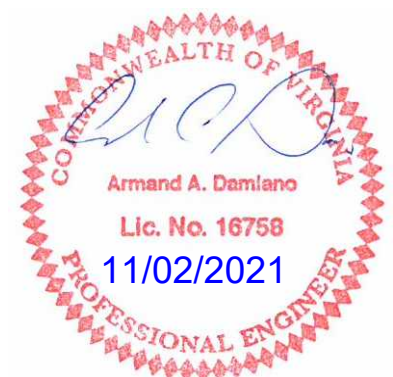
Shaft Deflection From Arm#1 GP I Load (in)	0.585
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

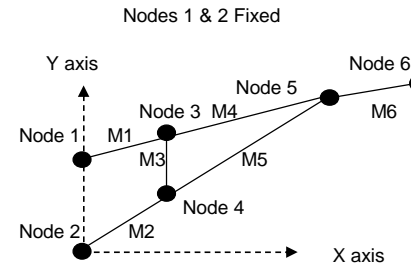
## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.19	0.000	21.98	1.100	4.576	8.05
2	0.450	12.62	22.02	0.000	21.81	1.100	4.576	7.99
3	0.450	12.62	21.86	0.000	21.65	1.100	4.576	7.93
4	0.450	12.62	21.69	0.000	21.49	1.100	4.576	7.87
5	0.450	12.62	21.53	0.000	21.32	1.100	4.576	7.81
6	0.450	12.62	21.36	0.000	21.16	1.100	4.576	7.75
7	0.450	12.62	21.20	0.001	21.00	1.100	4.576	7.69
8	0.450	12.62	21.03	0.001	20.83	1.100	4.576	7.63
9	0.450	12.62	20.87	0.001	20.67	1.100	4.576	7.57
10	0.450	12.62	20.70	0.001	20.51	1.100	4.576	7.51
11	0.450	12.62	20.54	0.002	20.34	1.100	4.576	7.45
12	0.450	12.62	20.37	0.002	20.18	1.100	4.576	7.39
13	0.450	15.77	25.25	0.003	20.02	1.100	4.576	7.33
14	0.450	15.77	25.04	0.003	19.85	1.100	4.576	7.27
15	0.450	15.77	24.84	0.003	19.69	1.100	4.576	7.21
16	0.450	15.77	24.63	0.004	19.52	1.100	4.576	7.15
17	0.450	15.77	24.43	0.004	19.36	1.100	4.576	7.09
18	0.450	15.77	68.09	0.015	53.97	1.100	4.576	19.76
19	0.450	15.77	66.43	0.018	52.66	1.100	4.576	19.28
20	0.450	15.77	21.78	0.007	17.26	1.100	4.576	6.32
Fix. #1	1.200	33.65	80.76	0.006	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.006	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.077	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum. - Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-44.01	-40.6	0	0	0
Node #2	0	0	0	0	-46.58	-42.9	0	0	0
Node #3	100	59.5	0	0	-87	-84.8	0	0	0
Node #4	100	48.8	0	0	-90.64	-88.2	0	0	0
Node #5	200	79	0	0	-123.35	-125	0	0	0
Node #6	288	87	0	0	-93.99	-114.6	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-88.02	1.1	1	-81.07	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-93.14	1.1	1	-85.79	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.95	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-85.28	1.1	1.1	-86.40	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-87.44	1.1	1.1	-88.59	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-73.97	1.1	1.1	-74.94	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-77.10					

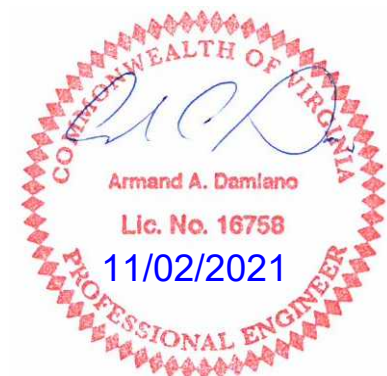
AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2629.3	lbs
P1y	-827.0	lbs
P1z	294.4	lbs
M1x	10996.1	in-lbs
M1y	-41528.6	in-lbs
M1z	-716.1	in-lbs
P2x	2629.3	lbs
P2y	1312.5	lbs
P2z	201.7	lbs
M2x	11346.6	in-lbs
M2y	-33776.2	in-lbs
M2z	-770.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-939	173	26099	-644	0.76
#2	989	109	21500	-1250	0.95
#3	1807	572	11253	-534	0.45
#4	-919	78	10031	-29	0.28
#5	936	91	11105	-380	0.58
#6	3	101	7955	-1	0.24

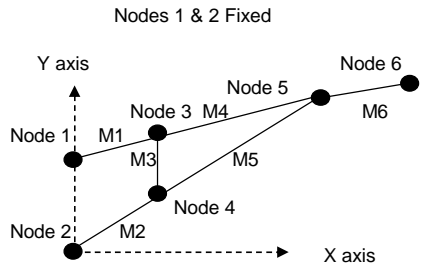
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16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum. - Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-51.2	-20.3	0	0	0
Node #2	0	0	0	0	-54.18	-21.5	0	0	0
Node #3	100	59.5	0	0	-101.41	-42.4	0	0	0
Node #4	100	48.8	0	0	-105.65	-44.1	0	0	0
Node #5	200	79	0	0	-143.49	-62.5	0	0	0
Node #6	288	87	0	0	-124.03	-57.3	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-102.39	1.1	1	-40.53	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-108.35	1.1	1	-42.89	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.98	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-99.21	1.1	1.1	-43.20	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-101.72	1.1	1.1	-44.29	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-86.04	1.1	1.1	-37.47	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-38.55					

AASHTO Gp	3
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-3247.7	lbs
P1y	-1031.5	lbs
P1z	147.2	lbs
M1x	5498.0	in-lbs
M1y	-20764.3	in-lbs
M1z	-1257.5	in-lbs
P2x	3247.7	lbs
P2y	1611.4	lbs
P2z	100.9	lbs
M2x	5673.3	in-lbs
M2y	-16888.1	in-lbs
M2z	-1306.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1160	88	13070	-322	0.36
#2	1221	57	10777	-625	0.69
#3	2226	425	8530	-267	0.39
#4	-1137	47	5068	-15	0.12
#5	1159	52	5600	-190	0.48
#6	4	93	7320	-1	0.23

V09.19.15



16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	3.00	0.00	15.580	15.160	121.2	1.4932	1.49	3.843	3.843	37.63
2	I	3.00	3.00	15.160	14.740	117.9	1.4930	4.49	3.738	3.738	36.64
3	I	3.00	6.00	14.740	14.320	114.5	1.4928	7.49	3.633	3.633	35.65
4	I	3.00	9.00	14.320	13.900	111.1	1.4926	10.49	3.528	3.528	34.66
5	I	3.00	12.00	13.900	13.480	107.8	1.4923	13.49	3.423	3.423	33.67
6	I	3.00	15.00	13.480	13.060	104.4	1.4921	16.49	3.318	3.318	32.68
7	I	3.00	18.00	13.060	12.640	101.0	1.4918	19.49	3.213	3.213	31.69
8	J	2.69	21.00	13.000	12.623	152.9	1.3384	22.34	2.872	2.872	28.33
9	O	3.03	23.69	12.623	12.200	70.9	1.5043	25.19	3.130	3.130	30.92
10	O	3.03	26.72	12.200	11.776	68.5	1.5040	28.22	3.023	3.023	29.91
11	O	3.03	29.74	11.776	11.353	66.0	1.5037	31.25	2.916	2.916	28.91
12	O	3.03	32.77	11.353	10.929	63.6	1.5033	34.27	2.809	2.809	27.90
13	O	3.03	35.79	10.929	10.505	61.1	1.5029	37.30	2.702	2.702	26.89
14	O	3.03	38.82	10.505	10.082	58.7	1.5025	40.32	2.596	2.596	25.89
15	O	3.03	41.85	10.082	9.658	56.2	1.5021	43.35	2.489	2.489	24.88
16	O	3.03	44.87	9.658	9.234	53.7	1.5016	46.37	2.382	2.382	23.87
17	O	3.03	47.90	9.234	8.811	51.3	1.5011	49.40	2.275	2.275	22.87
18	O	3.03	50.92	8.811	8.387	48.8	1.5005	52.42	2.168	2.168	21.86
19	O	3.03	53.95	8.387	7.964	46.4	1.4999	55.45	2.061	2.061	20.85
20	O	3.03	56.97	7.964	7.540	43.9	1.4991	58.47	1.955	1.955	19.85
		<u>60.00</u>				<u>1620</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	12.50	37.500	1.000	112.50
Fix. #3	105	26.00	13.750	2.000	126.00
Fix. #4	22.5	34.00	7.500	1.000	22.50
Fix. #5	65	37.00	8.700	1.000	78.00
Fix. #6	22	46.00	1.000	1.000	9.00
Fix. #7	22.5	45.00	7.500	1.000	22.50
Fix. #8	65	48.00	8.700	1.000	78.00
Fix. #9	22	57.00	1.000	1.000	9.00
Fix. #10	26.7	56.00	10.500	1.000	31.50
Fix. #11	80	59.00	11.000	1.000	102.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	46.120	23.135
Cross-Section Area (in^2)	12.034	7.218
Width-Thickness Ratio	62.32	72.50
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	35.489
Allow. Shear Stress (ksi)	18.150	18.150



16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

Arm #1 Analysis Continued

Sec. Num.	Kz	Truck Induced Gust											
		Group 2			Group 3	Natural Wind Gust			Hght Corr. Factor = 1.000				Gallop
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	Loads (lbs)
1	1.00	0.450	15.77	60.60	48.03	1.100	4.576	17.58	0	0.562	0.00	0.00	
2	1.00	0.450	15.77	58.94	46.72	1.100	4.576	17.10	0	0.582	0.00	0.00	
3	1.00	0.450	15.77	57.28	45.41	1.100	4.576	16.62	0	0.604	0.00	0.00	
4	1.00	0.450	15.77	55.63	44.09	1.100	4.576	16.14	0	0.628	0.00	0.00	
5	1.00	0.450	15.77	53.97	42.78	1.100	4.576	15.66	0	0.653	0.00	0.00	
6	1.00	0.450	15.77	52.32	41.47	1.100	4.576	15.18	0	0.680	0.00	0.00	
7	1.00	0.450	15.77	50.66	40.16	1.100	4.576	14.70	0	0.709	0.00	0.00	
8	1.00	0.450	15.77	45.29	35.90	1.100	4.576	13.14	0	0.711	0.00	0.00	
9	1.00	0.450	15.77	49.35	39.12	1.100	4.576	14.32	0	0.741	0.00	0.00	
10	1.00	0.450	15.77	47.67	37.79	1.100	4.576	13.83	0	0.776	0.00	0.00	
11	1.00	0.450	15.77	45.99	36.45	1.100	4.576	13.34	0	0.813	0.00	0.00	
12	1.00	0.450	15.77	44.30	35.11	1.100	4.576	12.85	0	0.853	0.00	0.00	
13	1.00	0.450	15.77	42.62	33.78	1.100	4.576	12.37	0	0.897	0.00	0.00	
14	1.00	0.450	15.77	40.93	32.44	1.100	4.576	11.88	0	0.946	0.00	0.00	
15	1.00	0.450	15.77	39.25	31.11	1.100	4.576	11.39	0	0.999	0.00	0.00	
16	1.00	0.450	15.77	37.56	29.77	1.100	4.576	10.90	1	1.057	0.00	0.00	
17	1.00	0.450	15.77	35.88	28.44	1.100	4.576	10.41	1	1.100	0.00	0.00	
18	1.00	0.450	15.77	34.19	27.10	1.100	4.576	9.92	1	1.100	0.00	0.00	
19	1.00	0.474	16.63	34.28	25.77	1.100	4.576	9.43	1	1.100	0.00	0.00	
20	1.00	0.508	17.82	34.83	24.43	1.100	4.576	8.94	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



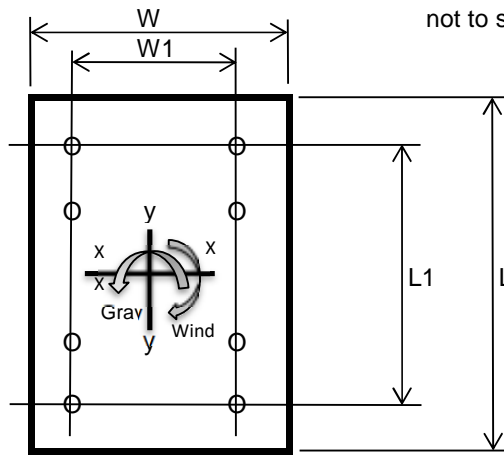
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2161	3337	-	lbs
Shear (Wind)	5418	2974	-	lbs
Torsion (Arm Rise)	17035	9351	-	ft-lbs
Moment (Gravity)	58769	96007	-	ft-lbs
Moment (Wind)	169305	91613	-	ft-lbs
Nat. Wind Moment	-	-	24233	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	15.58	in
Tube Wall Thick.	0.25	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	18.86	18.47	ksi
Bolt Shear Stress - fv	2.14	1.32	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Fv =	44.22	44.22	ksi
Allowable Shear Stress = Ft =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.44	0.43	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	2.29	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.33	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	9.97	16.28	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	29.20	15.80	ksi
Combined applied stress for interaction (SRSS)	30.86	22.69	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.3	
Dop - Baseplate center hole diameter	15.25	in
Cop - Center hole to shaft diameter ratio	0.7625	
Kf - Fatigue stress concentration factor for finite life	2.49	
Ki - Fatigue stress concentration factor for infinite life	5.82	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.25	in
Dt - Arm base diameter	15.58	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.04	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.385109	
Kf - Fatigue stress concentration factor for finite life	1.83	
Ki - Fatigue stress concentration factor for infinite life	3.50	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



## 16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

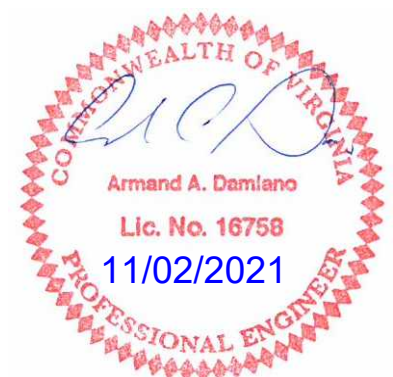
## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	19.57	in
Shaft Thickness	0.375	in
Total Area	27.3136	in <sup>2</sup>
Ix	1143	in <sup>4</sup>
Iy	1250	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	20290	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	8.18	ksi
CSR	0.51	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.25	ksi
CSR	0.32	
Therefore	<b>OK</b>	



16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	2161		2161	58769		58770		360	15292		0.43
Gp II	2161	5418	5834	58769	169305	179215	17035	970	46630	2217	0.99
Gp III	3337	2974	4470	96007	91613	132705	9351	743	34529	1217	0.73
Gp IV Natural		799	799		24233	24233	2514	133	6306	328	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	1273		1273	22969		22969		353	11914		0.34
Gp II	1273	3402	3632	22969	73942	77428	10695	1007	40161	2774	0.88
Gp III	2084	1852	2789	39262	39603	55767	5823	773	28926	1511	0.63
Gp IV Natural		493	493		10356	10356	1552	137	5372	403	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	4603		58769	0	58769		199		6220		0.18
Gp II	4603	7332	81682	149972	170773	171167	199	635	18075	9058	0.55
Gp III	6405	4148	62887	128613	143165	92544	277	360	15153	4898	0.37
Gp IV Natural			20290	0	20290				2148		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9979										

<b>Shaft At Arm</b>											
Gp I	3113		58769	0	58769		155		8188		0.24
Gp II	3113	6071	17035	68563	70648	171167	155	603	9843	11924	0.48
Gp III	4383	3346	9351	101063	101495	92544	218	333	14141	6447	0.38
Gp IV Natural			2671	0	2671				372		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9979										





16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	7332 lbs
Bending Moment	170773 ft-lbs
Torsion Moment	171167 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.00 in

**ANALYSIS - ANCHOR BOLTS**

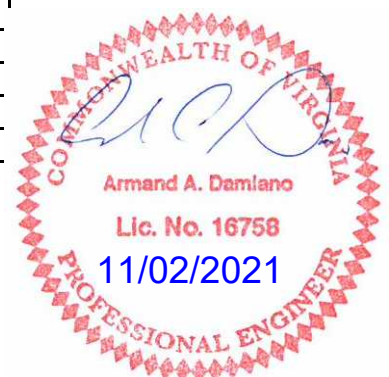
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	15.727 ksi
Bolt Direct Shear Stress	0.399 ksi
Bolt Torsion Shear Stress	8.587 ksi
Combined Bolt Stress	
$F_v = .3 F_y * \text{Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y * \text{Allowable Increase Factor}$	36.575 ksi
$f_t =$	15.727 ksi
$f_v =$	8.986 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.6 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3 in
Design Moment	118 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	17.83 ksi
Allowable Plate Stress = $.66 F_y * \text{Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.438 in
Design Moment	57 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	9.04 ksi
Allowable Plate Stress = $.66 F_y * \text{Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-15 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	20290 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	1.87 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.27
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	39318 lbs
Computed Factor-of Safety	1.57 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	39318 lbs
Total Tensile Load	314544 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.5 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	39318 lbs
Total Tensile Load	314544 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	7 Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-16 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 65' Arm W/24' Lum.

11/02/21

**General**

Wind Vel. - mph	90	No	Roadway - mph	55	<i>Fatigue Importance Factors</i>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	1		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

**Pole Variables**

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.00	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.3125	0.14	16.28	28.69	18.00	-	3.41	0	55	29000	180
	0.1793	0.14	13.00	39.00	-	2.69		0	55	29000	
Traffic Arm #2								0	55	29000	90
								0	55	29000	
Lum Arm #1	0.3750		2.88	24.00	24.00	-	5	0	36	29000	180
Lum Arm #2						-		0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8		Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes	
A.B. Bolt Circle	26.00	in	Foundation Diameter	48	in
Baseplate Dia.	32.00	in	Concrete Cover	4	in
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	15.25	in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.		Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50 in	in
Flange Plate Length (V)	27.00 in	in
Flange Plate Width (H)	27.00 in	in
Spac. Between Bolt (V)	22.50 in	in
Spac. Between Bolt (H)	22.50 in	in
Flange Plate Thk.	2.25 in	in
Flange Plate Yield (Fy)	50.00 ksi	ksi
Gusset Thk.	0.500 in	in
Plate Center Hole	6.00 in	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.23	0.29	0.40	0.33							20.89	0.00
GP II CSR	0.65	0.61	0.85	0.86			0.95					
GP III CSR	0.45	0.47	0.64	0.61			0.69				34.46	
Nat.Wind (psi)	2417	453	5394	5252								

Arm #1 Flange Bolt (Max.) CSR	0.52
Arm #1 Flange Bolt Fatigue CSR	0.38
Arm #1 Flange Plate (Max.) CSR	0.80
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.58
Handhole at Toe (Fatigue) CSR	0.36
Minimum Qty of Vertical Reinf. Bars	8

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.69
Anchor Bolt Max. Fatigue Stress Ratio	0.31
Base Plate Max. CSR	0.65
Anchorage Capacity S.F.	1.37
Concrete Pull Out Capacity S.F.	1.31

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
7130	8116	195526	196883



16362-3-16 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 65' Arm W/24' Lum.

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1	Cobra Head w/Camera	24	2	1			4.54	9	57	1.00
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	9.5			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	20	13.75	4			2	42	105	1.20
	#4	2.5'x3' Sign	24			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	31	8.7	4			1	26	65	1.20
	#6	Camera	35	1	1			1	3	22	1.20
	#7	2.5'x3' Sign	39			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	42	8.7	4			1	26	65	1.20
	#9	2.5'x3' Sign	50			2.5	3	1	7.5	22.5	1.13
	#10	3 Section Head w/BP	53	8.7	4			1	26	65	1.20
	#11	Camera	57	1	1			1	3	22	1.20
	#12	3'x3.5' Sign	61			3	3.5	1	10.5	26.7	1.13
	#13	4 Section Head w/BP	64	11	5			1	34	80	1.20
	#14										
#15											
#16											
#17											
#18											
#19											
#20											
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
#15											
#16											
#17											
#18											
#19											
#20											



16362-3-16 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 65' Arm W/24' Lum.

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.000	19.852	82.99	0.5288	0.53	1.758	17.07	0.80
2	I	1.06	1.06	19.852	19.704	82.36	0.5288	1.59	1.745	16.95	0.80
3	I	1.06	2.12	19.704	19.555	81.73	0.5287	2.65	1.732	16.82	0.80
4	I	1.06	3.18	19.555	19.407	81.10	0.5287	3.71	1.719	16.70	0.80
5	I	1.06	4.24	19.407	19.259	80.47	0.5287	4.76	1.706	16.58	0.80
6	I	1.06	5.29	19.259	19.111	79.84	0.5287	5.82	1.693	16.45	0.80
7	I	1.06	6.35	19.111	18.962	79.21	0.5287	6.88	1.680	16.33	0.80
8	I	1.06	7.41	18.962	18.814	78.58	0.5287	7.94	1.667	16.21	0.80
9	I	1.06	8.47	18.814	18.666	77.95	0.5287	9.00	1.654	16.08	0.80
10	I	1.06	9.53	18.666	18.518	77.32	0.5287	10.06	1.640	15.96	0.80
11	I	1.06	10.59	18.518	18.369	76.69	0.5287	11.12	1.627	15.84	0.80
12	I	1.06	11.65	18.369	18.221	76.06	0.5287	12.18	1.614	15.71	0.80
13	I	1.06	12.71	18.221	18.073	75.43	0.5287	13.23	1.601	15.59	1.00
14	I	1.06	13.76	18.073	17.925	74.81	0.5287	14.29	1.588	15.47	1.00
15	I	1.06	14.82	17.925	17.776	74.18	0.5287	15.35	1.575	15.34	1.00
16	I	1.06	15.88	17.776	17.628	73.55	0.5287	16.41	1.562	15.22	1.00
17	I	1.06	16.94	17.628	17.480	72.92	0.5287	17.47	1.549	15.10	1.00
18	J	3.00	18.00	17.480	17.060	203.18	1.4939	19.49	4.318	42.10	1.00
19	I	3.00	21.00	17.060	16.640	198.13	1.4938	22.49	4.213	41.12	1.00
20	J	1.00	24.00	16.640	16.500	64.92	0.4993	24.50	1.381	13.49	1.00
						1792					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	1112.50	736.61	0.00	617.12
Section Modulus (in^3)	113.38	86.13	0.00	
Cross-Section Area (in^2)	23.11	20.14	0.00	
Width-Thickness Ratio	53.33	46.61	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	14.993	14.993	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

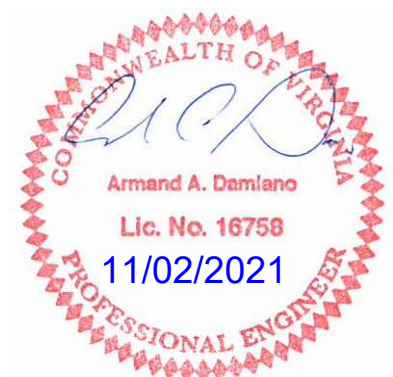
Shaft Deflection From Arm#1 GP I Load (in)	0.735
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-16 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 65' Arm W/24' Lum.

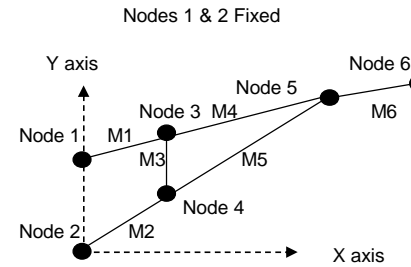
## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.19	0.000	21.98	1.100	4.576	8.05
2	0.450	12.62	22.02	0.000	21.81	1.100	4.576	7.99
3	0.450	12.62	21.86	0.000	21.65	1.100	4.576	7.93
4	0.450	12.62	21.69	0.000	21.49	1.100	4.576	7.87
5	0.450	12.62	21.53	0.000	21.32	1.100	4.576	7.81
6	0.450	12.62	21.36	0.000	21.16	1.100	4.576	7.75
7	0.450	12.62	21.20	0.001	21.00	1.100	4.576	7.69
8	0.450	12.62	21.03	0.001	20.83	1.100	4.576	7.63
9	0.450	12.62	20.87	0.001	20.67	1.100	4.576	7.57
10	0.450	12.62	20.70	0.001	20.51	1.100	4.576	7.51
11	0.450	12.62	20.54	0.002	20.34	1.100	4.576	7.45
12	0.450	12.62	20.37	0.002	20.18	1.100	4.576	7.39
13	0.450	15.77	25.25	0.003	20.02	1.100	4.576	7.33
14	0.450	15.77	25.04	0.003	19.85	1.100	4.576	7.27
15	0.450	15.77	24.84	0.003	19.69	1.100	4.576	7.21
16	0.450	15.77	24.63	0.004	19.52	1.100	4.576	7.15
17	0.450	15.77	24.43	0.004	19.36	1.100	4.576	7.09
18	0.450	15.77	68.09	0.015	53.97	1.100	4.576	19.76
19	0.450	15.77	66.43	0.018	52.66	1.100	4.576	19.28
20	0.450	15.77	21.78	0.007	17.26	1.100	4.576	6.32
Fix. #1	1.200	33.65	80.76	0.006	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.006	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.077	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-16 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 65' Arm W/24' Lum. - Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-44.01	-40.6	0	0	0
Node #2	0	0	0	0	-46.58	-42.9	0	0	0
Node #3	100	59.5	0	0	-87	-84.8	0	0	0
Node #4	100	48.8	0	0	-90.64	-88.2	0	0	0
Node #5	200	79	0	0	-123.35	-125	0	0	0
Node #6	288	87	0	0	-93.99	-114.6	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-88.02	1.1	1	-81.07	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-93.14	1.1	1	-85.79	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.95	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-85.28	1.1	1.1	-86.40	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-87.44	1.1	1.1	-88.59	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-73.97	1.1	1.1	-74.94	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-77.10					

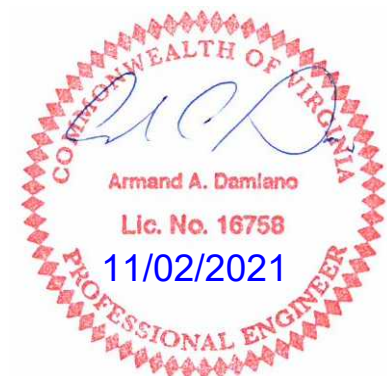
AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2629.3	lbs
P1y	-827.0	lbs
P1z	294.4	lbs
M1x	10996.1	in-lbs
M1y	-41528.6	in-lbs
M1z	-716.1	in-lbs
P2x	2629.3	lbs
P2y	1312.5	lbs
P2z	201.7	lbs
M2x	11346.6	in-lbs
M2y	-33776.2	in-lbs
M2z	-770.7	in-lbs

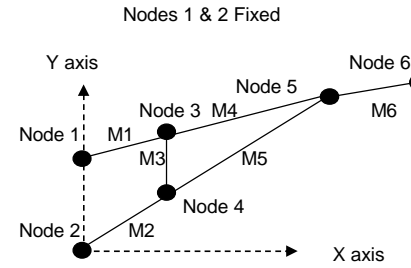
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-939	173	26099	-644	0.76
#2	989	109	21500	-1250	0.95
#3	1807	572	11253	-534	0.45
#4	-919	78	10031	-29	0.28
#5	936	91	11105	-380	0.58
#6	3	101	7955	-1	0.24

V09.19.15



16362-3-16 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 65' Arm W/24' Lum. - Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-51.2	-20.3	0	0	0
Node #2	0	0	0	0	-54.18	-21.5	0	0	0
Node #3	100	59.5	0	0	-101.41	-42.4	0	0	0
Node #4	100	48.8	0	0	-105.65	-44.1	0	0	0
Node #5	200	79	0	0	-143.49	-62.5	0	0	0
Node #6	288	87	0	0	-124.03	-57.3	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-102.39	1.1	1	-40.53	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-108.35	1.1	1	-42.89	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.98	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-99.21	1.1	1.1	-43.20	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-101.72	1.1	1.1	-44.29	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-86.04	1.1	1.1	-37.47	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-38.55					

AASHTO Gp	3
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-3247.7	lbs
P1y	-1031.5	lbs
P1z	147.2	lbs
M1x	5498.0	in-lbs
M1y	-20764.3	in-lbs
M1z	-1257.5	in-lbs
P2x	3247.7	lbs
P2y	1611.4	lbs
P2z	100.9	lbs
M2x	5673.3	in-lbs
M2y	-16888.1	in-lbs
M2z	-1306.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1160	88	13070	-322	0.36
#2	1221	57	10777	-625	0.69
#3	2226	425	8530	-267	0.39
#4	-1137	47	5068	-15	0.12
#5	1159	52	5600	-190	0.48
#6	4	93	7320	-1	0.23

V09.19.15





16362-3-16 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 65' Arm W/24' Lum.

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	3.25	0.00	16.280	15.825	170.9	1.6173	1.62	4.348	4.348	42.51
2	I	3.25	3.25	15.825	15.370	166.0	1.6171	4.87	4.224	4.224	41.34
3	I	3.25	6.50	15.370	14.915	161.0	1.6169	8.12	4.101	4.101	40.18
4	I	3.25	9.75	14.915	14.460	156.1	1.6166	11.37	3.978	3.978	39.02
5	I	3.25	13.00	14.460	14.005	151.1	1.6163	14.62	3.855	3.855	37.86
6	I	3.25	16.25	14.005	13.550	146.2	1.6161	17.87	3.731	3.731	36.70
7	I	3.25	19.50	13.550	13.095	141.3	1.6158	21.12	3.608	3.608	35.54
8	I	3.25	22.75	13.095	12.640	136.3	1.6154	24.37	3.485	3.485	34.38
9	J	2.69	26.00	13.000	12.623	174.2	1.3384	27.34	2.872	2.872	28.33
10	O	3.30	28.69	12.623	12.161	77.3	1.6402	30.33	3.409	3.409	33.68
11	O	3.30	31.99	12.161	11.699	74.3	1.6398	33.63	3.282	3.282	32.48
12	O	3.30	35.29	11.699	11.237	71.4	1.6394	36.93	3.155	3.155	31.29
13	O	3.30	38.59	11.237	10.775	68.5	1.6389	40.23	3.027	3.027	30.09
14	O	3.30	41.89	10.775	10.313	65.6	1.6384	43.53	2.900	2.900	28.89
15	O	3.30	45.19	10.313	9.851	62.7	1.6378	46.83	2.773	2.773	27.69
16	O	3.30	48.50	9.851	9.389	59.7	1.6372	50.13	2.646	2.646	26.49
17	O	3.30	51.80	9.389	8.926	56.8	1.6366	53.43	2.519	2.519	25.30
18	O	3.30	55.10	8.926	8.464	53.9	1.6358	56.73	2.392	2.392	24.10
19	O	3.30	58.40	8.464	8.002	51.0	1.6350	60.03	2.265	2.265	22.90
20	O	3.30	61.70	8.002	7.540	48.0	1.6341	63.33	2.138	2.138	21.70
		<u>65.00</u>				<u>2092</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	9.50	37.500	1.000	112.50
Fix. #3	105	20.00	13.750	2.000	126.00
Fix. #4	22.5	24.00	7.500	1.000	22.50
Fix. #5	65	31.00	8.700	1.000	78.00
Fix. #6	22	35.00	1.000	1.000	9.00
Fix. #7	22.5	39.00	7.500	1.000	22.50
Fix. #8	65	42.00	8.700	1.000	78.00
Fix. #9	22.5	50.00	7.500	1.000	22.50
Fix. #10	65	53.00	8.700	1.000	78.00
Fix. #11	22	57.00	1.000	1.000	9.00
Fix. #12	26.7	61.00	10.500	1.000	31.50
Fix. #13	80	64.00	11.000	1.000	102.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	62.545	23.135
Cross-Section Area (in^2)	15.668	7.218
Width-Thickness Ratio	52.10	72.50
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	35.489
Allow. Shear Stress (ksi)	18.150	18.150



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Arm #1 Analysis Continued

Sec. Num.	Kz	Truck Induced Gust											
		Group 2			Group 3	Natural Wind Gust			Hght Corr. Factor = 1.000				Gallop
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	Loads (lbs)
1	1.00	0.450	15.77	68.56	54.34	1.100	4.576	19.89	0	0.531	0.00	0.00	
2	1.00	0.450	15.77	66.62	52.80	1.100	4.576	19.33	0	0.551	0.00	0.00	
3	1.00	0.450	15.77	64.67	51.26	1.100	4.576	18.77	0	0.572	0.00	0.00	
4	1.00	0.450	15.77	62.73	49.72	1.100	4.576	18.20	0	0.596	0.00	0.00	
5	1.00	0.450	15.77	60.79	48.18	1.100	4.576	17.64	0	0.621	0.00	0.00	
6	1.00	0.450	15.77	58.84	46.64	1.100	4.576	17.07	0	0.647	0.00	0.00	
7	1.00	0.450	15.77	56.90	45.10	1.100	4.576	16.51	0	0.676	0.00	0.00	
8	1.00	0.450	15.77	54.96	43.56	1.100	4.576	15.95	0	0.707	0.00	0.00	
9	1.00	0.450	15.77	45.29	35.90	1.100	4.576	13.14	0	0.711	0.00	0.00	
10	1.00	0.450	15.77	53.76	42.61	1.100	4.576	15.60	0	0.743	0.00	0.00	
11	1.00	0.450	15.77	51.75	41.02	1.100	4.576	15.02	0	0.781	0.00	0.00	
12	1.00	0.450	15.77	49.75	39.43	1.100	4.576	14.44	0	0.822	0.00	0.00	
13	1.00	0.450	15.77	47.74	37.84	1.100	4.576	13.85	0	0.867	0.00	0.00	
14	1.00	0.450	15.77	45.74	36.25	1.100	4.576	13.27	0	0.916	0.00	0.00	
15	1.00	0.450	15.77	43.73	34.67	1.100	4.576	12.69	0	0.971	0.00	0.00	
16	1.00	0.450	15.77	41.73	33.08	1.100	4.576	12.11	0	1.033	0.00	0.00	
17	1.00	0.450	15.77	39.72	31.49	1.100	4.576	11.53	1	1.101	0.00	0.00	
18	1.00	0.450	15.77	37.72	29.90	1.100	4.576	10.95	1	1.100	0.00	0.00	
19	1.00	0.470	16.48	37.32	28.31	1.100	4.576	10.36	1	1.100	0.00	0.00	
20	1.00	0.507	17.76	37.96	26.72	1.100	4.576	9.78	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



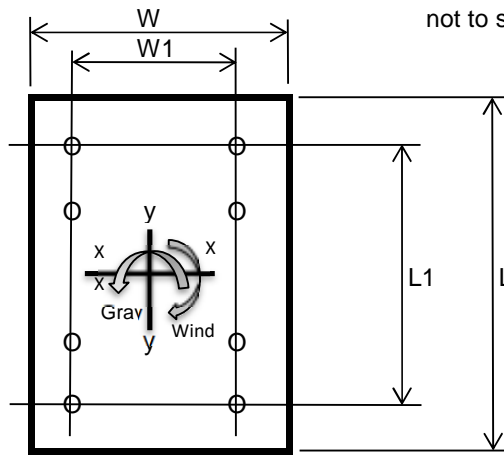
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2721	4062	-	lbs
Shear (Wind)	6187	3389	-	lbs
Torsion (Arm Rise)	21073	11544	-	ft-lbs
Moment (Gravity)	73801	117516	-	ft-lbs
Moment (Wind)	195021	105871	-	ft-lbs
Nat. Wind Moment	-	-	28111	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	16.28	in
Tube Wall Thick.	0.3125	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	22.29	22.34	ksi
Bolt Shear Stress - fv	2.61	1.6	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.52	0.52	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	2.66	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.38	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	12.23	19.47	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	32.86	17.84	ksi
Combined applied stress for interaction (SRSS)	35.06	26.41	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



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Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.3	
Dop - Baseplate center hole diameter	15.25	in
Cop - Center hole to shaft diameter ratio	0.7625	
Kf - Fatigue stress concentration factor for finite life	2.49	
Ki - Fatigue stress concentration factor for infinite life	5.82	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.3125	in
Dt - Arm base diameter	16.28	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	1.95	
Dop - Baseplate center hole diameter	6.00	in
Cop - Center hole to arm diameter ratio	0.36855	
Kf - Fatigue stress concentration factor for finite life	1.89	
Ki - Fatigue stress concentration factor for infinite life	3.90	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



## 16362-3-16 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 65' Arm W/24' Lum.

## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	19.57	in
Shaft Thickness	0.375	in
Total Area	27.3136	in <sup>2</sup>
Ix	1143	in <sup>4</sup>
Iy	1250	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	22837	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	9.20	ksi
CSR	0.58	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.54	ksi
CSR	0.36	
Therefore	<b>OK</b>	



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Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	2721		2721	73801		73801		348	14160		0.40
Gp II	2721	6187	6759	73801	195021	208518	21073	863	40007	2022	0.85
Gp III	4062	3389	5291	117516	105871	158173	11544	676	30348	1108	0.64
Gp IV Natural		909	909		28111	28111	3095	117	5394	297	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	1254		1254	22336		22336		348	11586		0.33
Gp II	1254	3189	3428	22336	71999	75384	10863	950	39101	2818	0.86
Gp III	2018	1746	2668	38199	38630	54328	5947	740	28180	1543	0.61
Gp IV Natural		468	468		10125	10125	1595	130	5252	414	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



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**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	5163		73801	0	73801		223		7811		0.23
Gp II	5163	8116	100288	167847	195526	196883	223	703	20695	10419	0.65
Gp III	7130	4571	72549	152054	168475	106802	309	396	17832	5652	0.45
Gp IV Natural			22837	0	22837				2417		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9976										

<b>Shaft At Arm</b>											
Gp I	3673		73801	0	73801		182		10282		0.29
Gp II	3673	6839	21073	83594	86209	196883	182	680	12011	13715	0.61
Gp III	5108	3761	11544	122571	123113	106802	254	374	17153	7440	0.47
Gp IV Natural			3252	0	3252				453		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9976										



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## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	8116 lbs
Bending Moment	195526 ft-lbs
Torsion Moment	196883 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.00 in

**ANALYSIS - ANCHOR BOLTS**

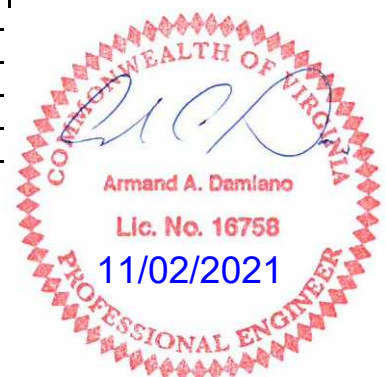
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	18.007 ksi
Bolt Direct Shear Stress	0.442 ksi
Bolt Torsion Shear Stress	9.878 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	18.007 ksi
$f_v =$	10.32 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.69 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3 in
Design Moment	136 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	20.55 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.438 in
Design Moment	65 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	10.31 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>





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## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	22837 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	2.11 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.31
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	45018 lbs
Computed Factor-of Safety	1.37 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	45018 lbs
Total Tensile Load	360144 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.31 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	45018 lbs
Total Tensile Load	360144 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	8 Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-17 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

11/02/21

**General**

Wind Vel.- mph	90	No	Roadway - mph	55	<i>Fatigue Importance Factors</i>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	0		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.00	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.3125	0.14	17.50	25.00	18.00	-	3.67	0	55	29000	180
	0.1880	0.14	14.79	47.92	-	2.92		0	55	29000	
Traffic Arm #2								0	55	29000	90
								0	55	29000	
Lum Arm #1								0	36	29000	180
Lum Arm #2								0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8		Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes	
A.B. Bolt Circle	26.00	in	Foundation Diameter	48	in
Baseplate Dia.	32.00	in	Concrete Cover	4	in
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	15.25	in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.		Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1		Arm #2	
Flange Bolt Qty.	8		NA	
Bolt Diameter	1.50	in		in
Flange Plate Length (V)	27.00	in		in
Flange Plate Width (H)	27.00	in		in
Spac. Between Bolt (V)	22.50	in		in
Spac. Between Bolt (H)	22.50	in		in
Flange Plate Thk.	2.25	in		in
Flange Plate Yield (Fy)	50	ksi		ksi
Gusset Thk.	0.500	in		in
Plate Center Hole	6.00	in		in
Weld Type	Full Pen.			

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.27	0.35	0.41	0.41							25.05	0.00
GP II CSR	0.70	0.72	0.84	0.97								
GP III CSR	0.49	0.55	0.65	0.71							40.88	
Nat.Wind (psi)	2467	489	5428	5792								

Arm #1 Flange Bolt (Max.) CSR	0.61
Arm #1 Flange Bolt Fatigue CSR	0.45
Arm #1 Flange Plate (Max.) CSR	0.89
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.59
Handhole at Toe (Fatigue) CSR	0.37
Minimum Qty of Vertical Reinf. Bars	8

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.72
Anchor Bolt Max. Fatigue Stress Ratio	0.31
Base Plate Max. CSR	0.63
Anchorage Capacity S.F.	1.41
Concrete Pull Out Capacity S.F.	1.34

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
6491	7647	190987	223585



16362-3-17 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.2
	#2	Ped Head	10.5	2.4	1			1	6	30	1.2
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.2
	#4										
Lum #1	#1										
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	12			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	25	13.75	4			2	42	105	1.20
	#4		2.5'x3' Sign	29			2.5	3	1	7.5	22.5
	#5	3 Section Head w/BP	36	8.7	4			1	26	65	1.20
	#6		Camera	40	1	1			1	3	22
	#7	2.5'x3' Sign	44			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	47	8.7	4			1	26	65	1.20
	#9		2.5'x3' Sign	55			2.5	3	1	7.5	22.5
	#10	3 Section Head w/BP	58	8.7	4			1	26	65	1.20
	#11		Camera	62	1	1			1	3	22
	#12	3'x3.5' Sign	66			3	3.5	1	10.5	26.7	1.13
	#13	4 Section Head w/BP	69	11	5			1	34	80	1.20
#14											
#15											
#16											
#17											
#18											
#19											
#20											
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
#12											
#13											
#14											
#15											
#16											
#17											
#18											
#19											
#20											



16362-3-17 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.000	19.852	82.99	0.5288	0.53	1.758	17.07	0.80
2	I	1.06	1.06	19.852	19.704	82.36	0.5288	1.59	1.745	16.95	0.80
3	I	1.06	2.12	19.704	19.555	81.73	0.5287	2.65	1.732	16.82	0.80
4	I	1.06	3.18	19.555	19.407	81.10	0.5287	3.71	1.719	16.70	0.80
5	I	1.06	4.24	19.407	19.259	80.47	0.5287	4.76	1.706	16.58	0.80
6	I	1.06	5.29	19.259	19.111	79.84	0.5287	5.82	1.693	16.45	0.80
7	I	1.06	6.35	19.111	18.962	79.21	0.5287	6.88	1.680	16.33	0.80
8	I	1.06	7.41	18.962	18.814	78.58	0.5287	7.94	1.667	16.21	0.80
9	I	1.06	8.47	18.814	18.666	77.95	0.5287	9.00	1.654	16.08	0.80
10	I	1.06	9.53	18.666	18.518	77.32	0.5287	10.06	1.640	15.96	0.80
11	I	1.06	10.59	18.518	18.369	76.69	0.5287	11.12	1.627	15.84	0.80
12	I	1.06	11.65	18.369	18.221	76.06	0.5287	12.18	1.614	15.71	0.80
13	I	1.06	12.71	18.221	18.073	75.43	0.5287	13.23	1.601	15.59	1.00
14	I	1.06	13.76	18.073	17.925	74.81	0.5287	14.29	1.588	15.47	1.00
15	I	1.06	14.82	17.925	17.776	74.18	0.5287	15.35	1.575	15.34	1.00
16	I	1.06	15.88	17.776	17.628	73.55	0.5287	16.41	1.562	15.22	1.00
17	I	1.06	16.94	17.628	17.480	72.92	0.5287	17.47	1.549	15.10	1.00
18	J	0.50	18.00	17.480	17.410	34.21	0.2498	18.25	0.727	7.09	1.00
19	I	0.50	18.50	17.410	17.340	34.07	0.2498	18.75	0.724	7.06	1.00
20	I	0.50	19.00	17.340	17.270	33.93	0.2498	19.25	0.721	7.03	1.00
						1428					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in <sup>4</sup> )	1112.50	736.61	0.00	709.82
Section Modulus (in <sup>3</sup> )	113.38	86.13	0.00	
Cross-Section Area (in <sup>2</sup> )	23.11	20.14	0.00	
Width-Thickness Ratio	53.33	46.61	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	20.948	20.948	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.878
Shaft Deflection From Arm#2 GP I Load (in)	0.000



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## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.19	0.000	21.98	1.100	4.576	8.05
2	0.450	12.62	22.02	0.000	21.81	1.100	4.576	7.99
3	0.450	12.62	21.86	0.000	21.65	1.100	4.576	7.93
4	0.450	12.62	21.69	0.000	21.49	1.100	4.576	7.87
5	0.450	12.62	21.53	0.000	21.32	1.100	4.576	7.81
6	0.450	12.62	21.36	0.000	21.16	1.100	4.576	7.75
7	0.450	12.62	21.20	0.000	21.00	1.100	4.576	7.69
8	0.450	12.62	21.03	0.001	20.83	1.100	4.576	7.63
9	0.450	12.62	20.87	0.001	20.67	1.100	4.576	7.57
10	0.450	12.62	20.70	0.001	20.51	1.100	4.576	7.51
11	0.450	12.62	20.54	0.001	20.34	1.100	4.576	7.45
12	0.450	12.62	20.37	0.001	20.18	1.100	4.576	7.39
13	0.450	15.77	25.25	0.002	20.02	1.100	4.576	7.33
14	0.450	15.77	25.04	0.002	19.85	1.100	4.576	7.27
15	0.450	15.77	24.84	0.002	19.69	1.100	4.576	7.21
16	0.450	15.77	24.63	0.003	19.52	1.100	4.576	7.15
17	0.450	15.77	24.43	0.003	19.36	1.100	4.576	7.09
18	0.450	15.77	11.46	0.002	9.09	1.100	4.576	3.33
19	0.450	15.77	11.42	0.002	9.05	1.100	4.576	3.31
20	0.450	15.77	11.37	0.002	9.01	1.100	4.576	3.30
Fix. #1	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.056	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-17 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	3.68	0.00	17.500	16.985	208.1	1.8308	1.83	5.288	5.288	51.57
2	I	3.68	3.68	16.985	16.470	201.8	1.8306	5.51	5.130	5.130	50.08
3	I	3.68	7.36	16.470	15.954	195.5	1.8303	9.19	4.972	4.972	48.59
4	I	3.68	11.04	15.954	15.439	189.1	1.8299	12.87	4.814	4.814	47.10
5	I	3.68	14.72	15.439	14.924	182.8	1.8296	16.55	4.656	4.656	45.61
6	I	3.68	18.40	14.924	14.409	176.5	1.8292	20.23	4.498	4.498	44.12
7	J	2.92	22.08	14.790	14.381	220.1	1.4532	23.53	3.549	3.549	34.83
8	O	3.46	25.00	14.381	13.897	97.1	1.7209	26.72	4.079	4.079	40.07
9	O	3.46	28.46	13.897	13.412	93.7	1.7205	30.18	3.939	3.939	38.75
10	O	3.46	31.92	13.412	12.927	90.3	1.7202	33.64	3.799	3.799	37.43
11	O	3.46	35.38	12.927	12.443	86.9	1.7197	37.10	3.659	3.659	36.12
12	O	3.46	38.85	12.443	11.958	83.6	1.7193	40.57	3.519	3.519	34.80
13	O	3.46	42.31	11.958	11.474	80.2	1.7188	44.03	3.380	3.380	33.48
14	O	3.46	45.77	11.474	10.989	76.8	1.7183	47.49	3.240	3.240	32.16
15	O	3.46	49.23	10.989	10.504	73.5	1.7178	50.95	3.100	3.100	30.85
16	O	3.46	52.69	10.504	10.020	70.1	1.7171	54.41	2.960	2.960	29.53
17	O	3.46	56.15	10.020	9.535	66.7	1.7165	57.87	2.820	2.820	28.21
18	O	3.46	59.62	9.535	9.050	63.3	1.7157	61.33	2.681	2.681	26.89
19	O	3.46	63.08	9.050	8.566	60.0	1.7149	64.79	2.541	2.541	25.58
20	O	3.46	66.54	8.566	8.081	56.6	1.7140	68.25	2.401	2.401	24.26
		<u>70.00</u>				<u>2373</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	12.00	37.500	1.000	112.50
Fix. #3	105	25.00	13.750	2.000	126.00
Fix. #4	22.5	29.00	7.500	1.000	22.50
Fix. #5	65	36.00	8.700	1.000	78.00
Fix. #6	22	40.00	1.000	1.000	9.00
Fix. #7	22.5	44.00	7.500	1.000	22.50
Fix. #8	65	47.00	8.700	1.000	78.00
Fix. #9	22.5	55.00	7.500	1.000	22.50
Fix. #10	65	58.00	8.700	1.000	78.00
Fix. #11	22	62.00	1.000	1.000	9.00
Fix. #12	26.7	66.00	10.500	1.000	31.50
Fix. #13	80	69.00	11.000	1.000	102.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	72.468	31.467
Cross-Section Area (in^2)	16.865	8.620
Width-Thickness Ratio	56.00	78.67
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	34.389
Allow. Shear Stress (ksi)	18.150	17.040



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Arm #1 Analysis Continued

Sec. Num.	Kz	Truck Induced Gust											
		Group 2			Group 3	Natural Wind Gust			Hght Corr. Factor = 1.000				Gallop
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	Loads (lbs)
1	1.00	0.450	15.77	83.39	66.10	1.100	4.576	24.20	0	0.484	0.00	0.00	
2	1.00	0.450	15.77	80.89	64.12	1.100	4.576	23.47	0	0.503	0.00	0.00	
3	1.00	0.450	15.77	78.40	62.15	1.100	4.576	22.75	0	0.524	0.00	0.00	
4	1.00	0.450	15.77	75.91	60.17	1.100	4.576	22.03	0	0.546	0.00	0.00	
5	1.00	0.450	15.77	73.42	58.20	1.100	4.576	21.30	0	0.571	0.00	0.00	
6	1.00	0.450	15.77	70.93	56.22	1.100	4.576	20.58	0	0.597	0.00	0.00	
7	1.00	0.450	15.77	55.97	44.36	1.100	4.576	16.24	0	0.601	0.00	0.00	
8	1.00	0.450	15.77	64.32	50.98	1.100	4.576	18.66	0	0.626	0.00	0.00	
9	1.00	0.450	15.77	62.11	49.23	1.100	4.576	18.02	0	0.655	0.00	0.00	
10	1.00	0.450	15.77	59.91	47.49	1.100	4.576	17.38	0	0.686	0.00	0.00	
11	1.00	0.450	15.77	57.70	45.74	1.100	4.576	16.74	0	0.721	0.00	0.00	
12	1.00	0.450	15.77	55.50	43.99	1.100	4.576	16.10	0	0.758	0.00	0.00	
13	1.00	0.450	15.77	53.30	42.24	1.100	4.576	15.46	0	0.799	0.00	0.00	
14	1.00	0.450	15.77	51.09	40.50	1.100	4.576	14.83	0	0.844	0.00	0.00	
15	1.00	0.450	15.77	48.89	38.75	1.100	4.576	14.19	0	0.894	0.00	0.00	
16	1.00	0.450	15.77	46.68	37.00	1.100	4.576	13.55	0	0.949	0.00	0.00	
17	1.00	0.450	15.77	44.48	35.25	1.100	4.576	12.91	1	1.011	0.00	0.00	
18	1.00	0.450	15.77	42.27	33.51	1.100	4.576	12.27	1	1.080	0.00	0.00	
19	1.00	0.450	15.77	40.07	31.76	1.100	4.576	11.63	1	1.100	0.00	0.00	
20	1.00	0.463	16.25	39.02	30.01	1.100	4.576	10.99	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



16362-3-17 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

Flange Analysis - Arm #1

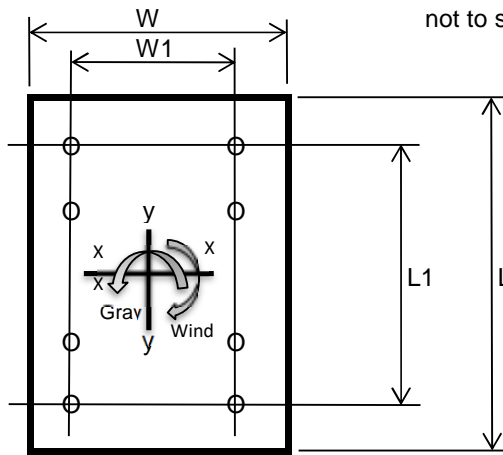
V06-21-16

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	3001	4442	-	lbs
Shear (Wind)	6345	3518	-	lbs
Torsion (Arm Rise)	23274	12905	-	ft-lbs
Moment (Gravity)	88146	139512	-	ft-lbs
Moment (Wind)	223585	122410	-	ft-lbs
Nat. Wind Moment	-	-	32774	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	17.50	in
Tube Wall Thick.	0.3125	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	25.90	26.38	ksi
Bolt Shear Stress - fv	2.84	1.76	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.6	0.61	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	3.1	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.45	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	14.17	22.43	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	36.56	20.02	ksi
Combined applied stress for interaction (SRSS)	39.21	30.07	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	





16362-3-17 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

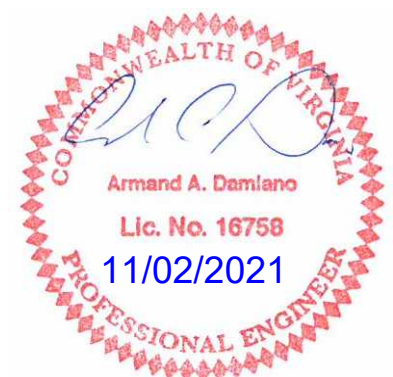
Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.3	
Dop - Baseplate center hole diameter	15.25	in
Cop - Center hole to shaft diameter ratio	0.7625	
Kf - Fatigue stress concentration factor for finite life	2.49	
Ki - Fatigue stress concentration factor for infinite life	5.82	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.3125	in
Dt - Arm base diameter	17.50	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	1.82	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.342857	
Kf - Fatigue stress concentration factor for finite life	1.84	
Ki - Fatigue stress concentration factor for infinite life	3.76	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



## 16362-3-17 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	19.57	in
Shaft Thickness	0.375	in
Total Area	27.3136	in <sup>2</sup>
Ix	1143	in <sup>4</sup>
Iy	1250	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	23311	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	9.40	ksi
CSR	0.59	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.59	ksi
CSR	0.37	
Therefore	<b>OK</b>	



16362-3-17 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	3001		3001	88146		88146		356	14597		0.41
Gp II	3001	6345	7019	88146	223585	240333	23274	833	39797	1927	0.84
Gp III	4442	3518	5667	139512	122410	185601	12905	673	30734	1069	0.65
Gp IV Natural		956	956		32774	32774	3507	114	5428	291	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	1737		1737	36325		36326		404	13853		0.41
Gp II	1737	4255	4596	36325	105504	111583	15607	1067	42553	2976	0.97
Gp III	2769	2338	3624	60449	57281	83278	8575	841	31759	1636	0.71
Gp IV Natural		628	628		15186	15186	2305	146	5792	440	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-17 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	4594		88146	0	88146		199		9330		0.27
Gp II	4594	7647	115642	151997	190987	223585	199	662	20215	11832	0.70
Gp III	6491	4351	76231	163544	180438	122410	281	377	19098	6478	0.49
Gp IV Natural			23311	0	23311				2467		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9977										

<b>Shaft At Arm</b>											
Gp I	3103		88146	0	88146		154		12281		0.35
Gp II	3103	6379	23274	88172	91192	223585	154	634	12705	15576	0.72
Gp III	4544	3545	12905	139532	140128	122410	226	353	19523	8527	0.55
Gp IV Natural			3513	0	3513				489		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9977										



16362-3-17 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	7647 lbs
Bending Moment	190987 ft-lbs
Torsion Moment	223585 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.00 in

**ANALYSIS - ANCHOR BOLTS**

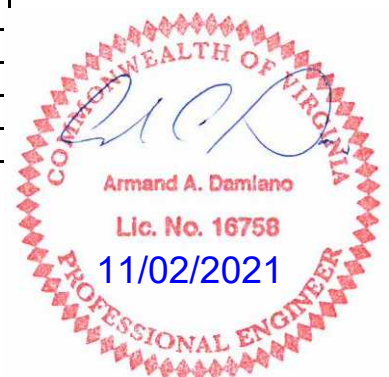
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	17.589 ksi
Bolt Direct Shear Stress	0.416 ksi
Bolt Torsion Shear Stress	11.217 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	17.589 ksi
$f_v =$	11.633 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.72 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3 in
Design Moment	132 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	19.94 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.438 in
Design Moment	64 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	10.15 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-17 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	23311 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	2.15 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.31
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

Anchor Bolt Length	60.0 in
Anchor Bolt Max. Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	43973 lbs
Computed Factor-of Safety	1.41 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	43973 lbs
Total Tensile Load	351784 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.34 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	43973 lbs
Total Tensile Load	351784 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	<b>8</b> Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

11/02/21

**General**

Wind Vel.- mph	90	No	Roadway - mph	55	<b>Fatigue Importance Factors</b>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	1		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.00	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.3125	0.14	17.50	25.00	18.00	-	3.67	0	55	29000	180
	0.1880	0.14	14.79	47.92	-	2.92		0	55	29000	
Traffic Arm #2								0	55	29000	90
								0	55	29000	
Lum Arm #1	0.3750		2.88	24.00	24.00	-	5	0	36	29000	180
Lum Arm #2						-		0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8		Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes	
A.B. Bolt Circle	26.00	in	Foundation Diameter	48	in
Baseplate Dia.	32.00	in	Concrete Cover	4	in
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	15.25	in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.		Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50 in	in
Flange Plate Length (V)	27.00 in	in
Flange Plate Width (H)	27.00 in	in
Spac. Between Bolt (V)	22.50 in	in
Spac. Between Bolt (H)	22.50 in	in
Flange Plate Thk.	2.25 in	in
Flange Plate Yield (Fy)	50 ksi	ksi
Gusset Thk.	0.500 in	in
Plate Center Hole	6.00 in	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.27	0.35	0.41	0.41							25.05	0.00
GP II CSR	0.74	0.76	0.84	0.97			0.95					
GP III CSR	0.51	0.57	0.65	0.71			0.69				40.88	
Nat.Wind (psi)	2551	510	5428	5792								

Arm #1 Flange Bolt (Max.) CSR	0.61
Arm #1 Flange Bolt Fatigue CSR	0.45
Arm #1 Flange Plate (Max.) CSR	0.89
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.61
Handhole at Toe (Fatigue) CSR	0.38
Minimum Qty of Vertical Reinf. Bars	9

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.75
Anchor Bolt Max. Fatigue Stress Ratio	0.32
Base Plate Max. CSR	0.69
Anchorage Capacity S.F.	1.29
Concrete Pull Out Capacity S.F.	1.23

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
7510	8277	208001	225447



16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1	Cobra Head w/Camera	24	2	1			4.54	9	57	1.00
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	12			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	25	13.75	4			2	42	105	1.20
	#4	2.5'x3' Sign	29			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	36	8.7	4			1	26	65	1.20
	#6	Camera	40	1	1			1	3	22	1.20
	#7	2.5'x3' Sign	44			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	47	8.7	4			1	26	65	1.20
	#9	2.5'x3' Sign	55			2.5	3	1	7.5	22.5	1.13
	#10	3 Section Head w/BP	58	8.7	4			1	26	65	1.20
	#11	Camera	62	1	1			1	3	22	1.20
	#12	3'x3.5' Sign	66			3	3.5	1	10.5	26.7	1.13
	#13	4 Section Head w/BP	69	11	5			1	34	80	1.20
	#14										
#15											
#16											
#17											
#18											
#19											
#20											
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
#15											
#16											
#17											
#18											
#19											
#20											





16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.000	19.852	82.99	0.5288	0.53	1.758	17.07	0.80
2	I	1.06	1.06	19.852	19.704	82.36	0.5288	1.59	1.745	16.95	0.80
3	I	1.06	2.12	19.704	19.555	81.73	0.5287	2.65	1.732	16.82	0.80
4	I	1.06	3.18	19.555	19.407	81.10	0.5287	3.71	1.719	16.70	0.80
5	I	1.06	4.24	19.407	19.259	80.47	0.5287	4.76	1.706	16.58	0.80
6	I	1.06	5.29	19.259	19.111	79.84	0.5287	5.82	1.693	16.45	0.80
7	I	1.06	6.35	19.111	18.962	79.21	0.5287	6.88	1.680	16.33	0.80
8	I	1.06	7.41	18.962	18.814	78.58	0.5287	7.94	1.667	16.21	0.80
9	I	1.06	8.47	18.814	18.666	77.95	0.5287	9.00	1.654	16.08	0.80
10	I	1.06	9.53	18.666	18.518	77.32	0.5287	10.06	1.640	15.96	0.80
11	I	1.06	10.59	18.518	18.369	76.69	0.5287	11.12	1.627	15.84	0.80
12	I	1.06	11.65	18.369	18.221	76.06	0.5287	12.18	1.614	15.71	0.80
13	I	1.06	12.71	18.221	18.073	75.43	0.5287	13.23	1.601	15.59	1.00
14	I	1.06	13.76	18.073	17.925	74.81	0.5287	14.29	1.588	15.47	1.00
15	I	1.06	14.82	17.925	17.776	74.18	0.5287	15.35	1.575	15.34	1.00
16	I	1.06	15.88	17.776	17.628	73.55	0.5287	16.41	1.562	15.22	1.00
17	I	1.06	16.94	17.628	17.480	72.92	0.5287	17.47	1.549	15.10	1.00
18	J	3.00	18.00	17.480	17.060	203.18	1.4939	19.49	4.318	42.10	1.00
19	I	3.00	21.00	17.060	16.640	198.13	1.4938	22.49	4.213	41.12	1.00
20	J	1.00	24.00	16.640	16.500	64.92	0.4993	24.50	1.381	13.49	1.00
						1792					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	1112.50	736.61	0.00	617.12
Section Modulus (in^3)	113.38	86.13	0.00	
Cross-Section Area (in^2)	23.11	20.14	0.00	
Width-Thickness Ratio	53.33	46.61	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	14.993	14.993	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

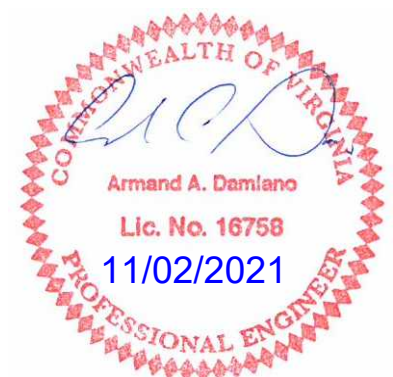
Shaft Deflection From Arm#1 GP I Load (in)	0.878
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

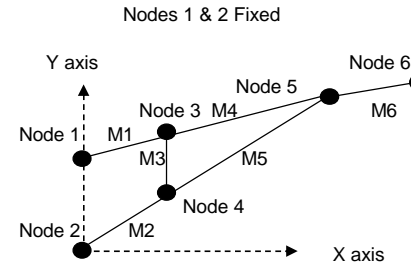
## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.19	0.000	21.98	1.100	4.576	8.05
2	0.450	12.62	22.02	0.000	21.81	1.100	4.576	7.99
3	0.450	12.62	21.86	0.000	21.65	1.100	4.576	7.93
4	0.450	12.62	21.69	0.000	21.49	1.100	4.576	7.87
5	0.450	12.62	21.53	0.000	21.32	1.100	4.576	7.81
6	0.450	12.62	21.36	0.000	21.16	1.100	4.576	7.75
7	0.450	12.62	21.20	0.001	21.00	1.100	4.576	7.69
8	0.450	12.62	21.03	0.001	20.83	1.100	4.576	7.63
9	0.450	12.62	20.87	0.001	20.67	1.100	4.576	7.57
10	0.450	12.62	20.70	0.001	20.51	1.100	4.576	7.51
11	0.450	12.62	20.54	0.002	20.34	1.100	4.576	7.45
12	0.450	12.62	20.37	0.002	20.18	1.100	4.576	7.39
13	0.450	15.77	25.25	0.003	20.02	1.100	4.576	7.33
14	0.450	15.77	25.04	0.003	19.85	1.100	4.576	7.27
15	0.450	15.77	24.84	0.003	19.69	1.100	4.576	7.21
16	0.450	15.77	24.63	0.004	19.52	1.100	4.576	7.15
17	0.450	15.77	24.43	0.004	19.36	1.100	4.576	7.09
18	0.450	15.77	68.09	0.015	53.97	1.100	4.576	19.76
19	0.450	15.77	66.43	0.018	52.66	1.100	4.576	19.28
20	0.450	15.77	21.78	0.007	17.26	1.100	4.576	6.32
Fix. #1	1.200	33.65	80.76	0.006	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.006	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.077	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm - Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-44.01	-40.6	0	0	0
Node #2	0	0	0	0	-46.58	-42.9	0	0	0
Node #3	100	59.5	0	0	-87	-84.8	0	0	0
Node #4	100	48.8	0	0	-90.64	-88.2	0	0	0
Node #5	200	79	0	0	-123.35	-125	0	0	0
Node #6	288	87	0	0	-93.99	-114.6	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-88.02	1.1	1	-81.07	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-93.14	1.1	1	-85.79	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.95	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-85.28	1.1	1.1	-86.40	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-87.44	1.1	1.1	-88.59	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-73.97	1.1	1.1	-74.94	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-77.10					

AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2629.3	lbs
P1y	-827.0	lbs
P1z	294.4	lbs
M1x	10996.1	in-lbs
M1y	-41528.6	in-lbs
M1z	-716.1	in-lbs
P2x	2629.3	lbs
P2y	1312.5	lbs
P2z	201.7	lbs
M2x	11346.6	in-lbs
M2y	-33776.2	in-lbs
M2z	-770.7	in-lbs

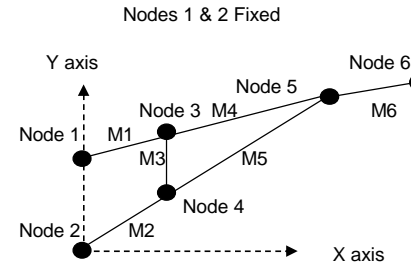
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-939	173	26099	-644	0.76
#2	989	109	21500	-1250	0.95
#3	1807	572	11253	-534	0.45
#4	-919	78	10031	-29	0.28
#5	936	91	11105	-380	0.58
#6	3	101	7955	-1	0.24

V09.19.15



16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm - Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-51.2	-20.3	0	0	0
Node #2	0	0	0	0	-54.18	-21.5	0	0	0
Node #3	100	59.5	0	0	-101.41	-42.4	0	0	0
Node #4	100	48.8	0	0	-105.65	-44.1	0	0	0
Node #5	200	79	0	0	-143.49	-62.5	0	0	0
Node #6	288	87	0	0	-124.03	-57.3	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-102.39	1.1	1	-40.53	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-108.35	1.1	1	-42.89	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.98	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-99.21	1.1	1.1	-43.20	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-101.72	1.1	1.1	-44.29	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-86.04	1.1	1.1	-37.47	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-38.55					

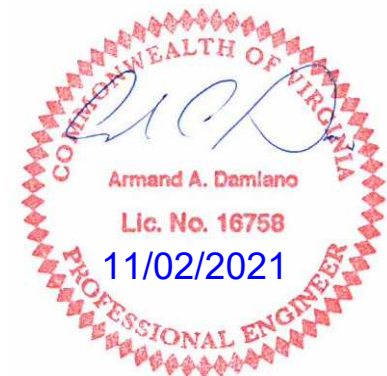
AASHTO Gp	3
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-3247.7	lbs
P1y	-1031.5	lbs
P1z	147.2	lbs
M1x	5498.0	in-lbs
M1y	-20764.3	in-lbs
M1z	-1257.5	in-lbs
P2x	3247.7	lbs
P2y	1611.4	lbs
P2z	100.9	lbs
M2x	5673.3	in-lbs
M2y	-16888.1	in-lbs
M2z	-1306.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1160	88	13070	-322	0.36
#2	1221	57	10777	-625	0.69
#3	2226	425	8530	-267	0.39
#4	-1137	47	5068	-15	0.12
#5	1159	52	5600	-190	0.48
#6	4	93	7320	-1	0.23

V09.19.15



16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	3.68	0.00	17.500	16.985	208.1	1.8308	1.83	5.288	5.288	51.57
2	I	3.68	3.68	16.985	16.470	201.8	1.8306	5.51	5.130	5.130	50.08
3	I	3.68	7.36	16.470	15.954	195.5	1.8303	9.19	4.972	4.972	48.59
4	I	3.68	11.04	15.954	15.439	189.1	1.8299	12.87	4.814	4.814	47.10
5	I	3.68	14.72	15.439	14.924	182.8	1.8296	16.55	4.656	4.656	45.61
6	I	3.68	18.40	14.924	14.409	176.5	1.8292	20.23	4.498	4.498	44.12
7	J	2.92	22.08	14.790	14.381	220.1	1.4532	23.53	3.549	3.549	34.83
8	O	3.46	25.00	14.381	13.897	97.1	1.7209	26.72	4.079	4.079	40.07
9	O	3.46	28.46	13.897	13.412	93.7	1.7205	30.18	3.939	3.939	38.75
10	O	3.46	31.92	13.412	12.927	90.3	1.7202	33.64	3.799	3.799	37.43
11	O	3.46	35.38	12.927	12.443	86.9	1.7197	37.10	3.659	3.659	36.12
12	O	3.46	38.85	12.443	11.958	83.6	1.7193	40.57	3.519	3.519	34.80
13	O	3.46	42.31	11.958	11.474	80.2	1.7188	44.03	3.380	3.380	33.48
14	O	3.46	45.77	11.474	10.989	76.8	1.7183	47.49	3.240	3.240	32.16
15	O	3.46	49.23	10.989	10.504	73.5	1.7178	50.95	3.100	3.100	30.85
16	O	3.46	52.69	10.504	10.020	70.1	1.7171	54.41	2.960	2.960	29.53
17	O	3.46	56.15	10.020	9.535	66.7	1.7165	57.87	2.820	2.820	28.21
18	O	3.46	59.62	9.535	9.050	63.3	1.7157	61.33	2.681	2.681	26.89
19	O	3.46	63.08	9.050	8.566	60.0	1.7149	64.79	2.541	2.541	25.58
20	O	3.46	66.54	8.566	8.081	56.6	1.7140	68.25	2.401	2.401	24.26
		<u>70.00</u>				<u>2373</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	12.00	37.500	1.000	112.50
Fix. #3	105	25.00	13.750	2.000	126.00
Fix. #4	22.5	29.00	7.500	1.000	22.50
Fix. #5	65	36.00	8.700	1.000	78.00
Fix. #6	22	40.00	1.000	1.000	9.00
Fix. #7	22.5	44.00	7.500	1.000	22.50
Fix. #8	65	47.00	8.700	1.000	78.00
Fix. #9	22.5	55.00	7.500	1.000	22.50
Fix. #10	65	58.00	8.700	1.000	78.00
Fix. #11	22	62.00	1.000	1.000	9.00
Fix. #12	26.7	66.00	10.500	1.000	31.50
Fix. #13	80	69.00	11.000	1.000	102.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	72.468	31.467
Cross-Section Area (in^2)	16.865	8.620
Width-Thickness Ratio	56.00	78.67
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	34.389
Allow. Shear Stress (ksi)	18.150	17.040



16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

Arm #1 Analysis Continued

Sec. Num.	Kz	Truck Induced Gust											
		Group 2			Group 3	Natural Wind Gust			Hght Corr. Factor = 1.000				Gallop
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	Loads (lbs)
1	1.00	0.450	15.77	83.39	66.10	1.100	4.576	24.20	0	0.484	0.00	0.00	
2	1.00	0.450	15.77	80.89	64.12	1.100	4.576	23.47	0	0.503	0.00	0.00	
3	1.00	0.450	15.77	78.40	62.15	1.100	4.576	22.75	0	0.524	0.00	0.00	
4	1.00	0.450	15.77	75.91	60.17	1.100	4.576	22.03	0	0.546	0.00	0.00	
5	1.00	0.450	15.77	73.42	58.20	1.100	4.576	21.30	0	0.571	0.00	0.00	
6	1.00	0.450	15.77	70.93	56.22	1.100	4.576	20.58	0	0.597	0.00	0.00	
7	1.00	0.450	15.77	55.97	44.36	1.100	4.576	16.24	0	0.601	0.00	0.00	
8	1.00	0.450	15.77	64.32	50.98	1.100	4.576	18.66	0	0.626	0.00	0.00	
9	1.00	0.450	15.77	62.11	49.23	1.100	4.576	18.02	0	0.655	0.00	0.00	
10	1.00	0.450	15.77	59.91	47.49	1.100	4.576	17.38	0	0.686	0.00	0.00	
11	1.00	0.450	15.77	57.70	45.74	1.100	4.576	16.74	0	0.721	0.00	0.00	
12	1.00	0.450	15.77	55.50	43.99	1.100	4.576	16.10	0	0.758	0.00	0.00	
13	1.00	0.450	15.77	53.30	42.24	1.100	4.576	15.46	0	0.799	0.00	0.00	
14	1.00	0.450	15.77	51.09	40.50	1.100	4.576	14.83	0	0.844	0.00	0.00	
15	1.00	0.450	15.77	48.89	38.75	1.100	4.576	14.19	0	0.894	0.00	0.00	
16	1.00	0.450	15.77	46.68	37.00	1.100	4.576	13.55	0	0.949	0.00	0.00	
17	1.00	0.450	15.77	44.48	35.25	1.100	4.576	12.91	1	1.011	0.00	0.00	
18	1.00	0.450	15.77	42.27	33.51	1.100	4.576	12.27	1	1.080	0.00	0.00	
19	1.00	0.450	15.77	40.07	31.76	1.100	4.576	11.63	1	1.100	0.00	0.00	
20	1.00	0.463	16.25	39.02	30.01	1.100	4.576	10.99	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



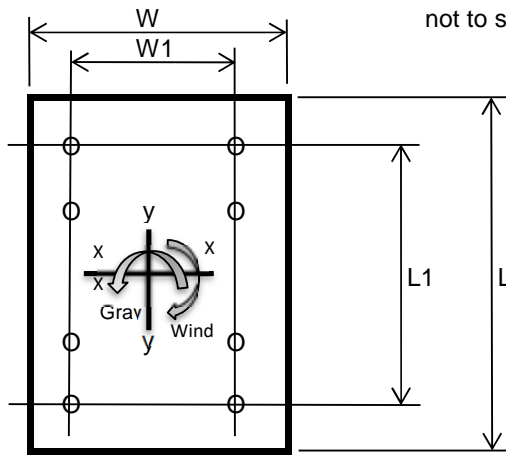
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	3001	4442	-	lbs
Shear (Wind)	6345	3518	-	lbs
Torsion (Arm Rise)	23274	12905	-	ft-lbs
Moment (Gravity)	88146	139512	-	ft-lbs
Moment (Wind)	223585	122410	-	ft-lbs
Nat. Wind Moment	-	-	32774	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	17.50	in
Tube Wall Thick.	0.3125	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	25.90	26.38	ksi
Bolt Shear Stress - fv	2.84	1.76	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.6	0.61	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	3.1	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.45	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	14.17	22.43	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	36.56	20.02	ksi
Combined applied stress for interaction (SRSS)	39.21	30.07	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.3	
Dop - Baseplate center hole diameter	15.25	in
Cop - Center hole to shaft diameter ratio	0.7625	
Kf - Fatigue stress concentration factor for finite life	2.49	
Ki - Fatigue stress concentration factor for infinite life	5.82	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.3125	in
Dt - Arm base diameter	17.50	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	1.82	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.342857	
Kf - Fatigue stress concentration factor for finite life	1.84	
Ki - Fatigue stress concentration factor for infinite life	3.76	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle





## 16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	19.57	in
Shaft Thickness	0.375	in
Total Area	27.3136	in <sup>2</sup>
Ix	1143	in <sup>4</sup>
Iy	1250	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	24098	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	9.71	ksi
CSR	0.61	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.68	ksi
CSR	0.38	
Therefore	<b>OK</b>	



16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	3001		3001	88146		88146		356	14597		0.41
Gp II	3001	6345	7019	88146	223585	240333	23274	833	39797	1927	0.84
Gp III	4442	3518	5667	139512	122410	185601	12905	673	30734	1069	0.65
Gp IV Natural		956	956		32774	32774	3507	114	5428	291	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	1737		1737	36325		36326		404	13853		0.41
Gp II	1737	4255	4596	36325	105504	111583	15607	1067	42553	2976	0.97
Gp III	2769	2338	3624	60449	57281	83278	8575	841	31759	1636	0.71
Gp IV Natural		628	628		15186	15186	2305	146	5792	440	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	5443		88146	0	88146		236		9330		0.27
Gp II	5443	8277	115642	172891	208001	225447	236	717	22015	11931	0.74
Gp III	7510	4703	76231	174786	190686	123341	325	408	20183	6527	0.51
Gp IV Natural			24098	0	24098				2551		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9974										

<b>Shaft At Arm</b>											
Gp I	3953		88146	0	88146		196		12281		0.35
Gp II	3953	6997	23274	97940	100667	225447	196	695	14026	15705	0.76
Gp III	5488	3890	12905	144567	145142	123341	272	387	20222	8592	0.57
Gp IV Natural			3663	0	3663				510		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9974										



16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	8277 lbs
Bending Moment	208001 ft-lbs
Torsion Moment	225447 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.00 in

**ANALYSIS - ANCHOR BOLTS**

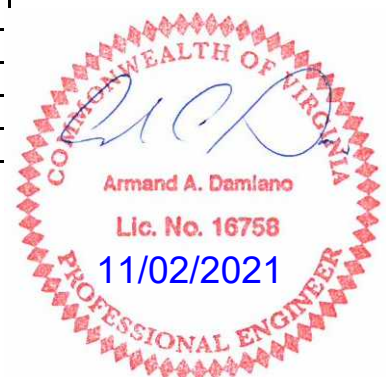
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	19.155 ksi
Bolt Direct Shear Stress	0.45 ksi
Bolt Torsion Shear Stress	11.311 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	19.155 ksi
$f_v =$	11.761 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.75 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3 in
Design Moment	144 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	21.76 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.438 in
Design Moment	69 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	10.94 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-18 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	24098 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	2.22 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.32
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	47888 lbs
Computed Factor-of Safety	1.29 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	47888 lbs
Total Tensile Load	383104 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.23 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	47888 lbs
Total Tensile Load	383104 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	<b>9</b> Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49/49' Arms

11/02/21

**General**

Wind Vel.- mph	90	No	Roadway - mph	55	<i>Fatigue Importance Factors</i>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	2		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	0		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.50	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.2190	0.14	14.00	49.00	18.00	-	2.57	0	55	29000	180
Traffic Arm #2	0.2190	0.14	14.00	49.00	18.00	-	2.57	0	55	29000	270
Lum Arm #1						-		0	36	29000	180
Lum Arm #2						-		0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8	Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes
A.B. Bolt Circle	26.00	in	Foundation Diameter	48
Baseplate Dia.	32.00	in	Concrete Cover	4
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000
B.P. Center Hole	15.75	in	Vertical Reinforcing Bar Size #	8
Weld Type	Full Pen.		Rebar Yield Strength fy	60
				ksi

**Flange Simplex**

	Arm #1		Arm #2	
Flange Bolt Qty.	8		8	
Bolt Diameter	1.50	in	1.50	in
Flange Plate Length (V)	27.00	in	27.00	in
Flange Plate Width (H)	27.00	in	27.00	in
Spac. Between Bolt (V)	22.50	in	22.50	in
Spac. Between Bolt (H)	22.50	in	22.50	in
Flange Plate Thk.	2.25	in	2.25	in
Flange Plate Yield (Fy)	50	ksi	50	ksi
Gusset Thk.	0.500	in	0.500	in
Plate Center Hole	6.00	in	6.00	in
Weld Type	Full Pen.		Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.17	0.22	0.41		0.41						11.37	11.37
GP II CSR	0.50	0.42	0.97		0.97							
GP III CSR	0.37	0.35	0.70		0.70						18.80	18.80
Nat.Wind (psi)	2224	332	6059		6059							

Arm #1 Flange Bolt (Max.) CSR	0.31
Arm #1 Flange Bolt Fatigue CSR	0.23
Arm #1 Flange Plate (Max.) CSR	0.51
Arm #2 Flange Bolt (Max.) CSR	0.31
Arm #2 Flange Bolt Fatigue CSR	0.23
Arm #2 Flange Plate (Max.) CSR	0.51
Handhole at Root (Fatigue) CSR	0.53
Handhole at Toe (Fatigue) CSR	0.33
Minimum Qty of Vertical Reinf. Bars	7

Fatigue Allowable - Shaft to Baseplate	4.5	ksi
Fatigue Allowable - Arm#1 to Flange	7	ksi
Fatigue Allowable - Arm#2 to Flange	7	ksi
Anchor Bolt Max. CSR	0.58	
Anchor Bolt Max. Fatigue Stress Ratio	0.30	
Base Plate Max. CSR	0.51	
Anchorage Capacity S.F.	1.6	
Concrete Pull Out Capacity S.F.	1.52	

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
7523	6030	167690	166746



16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49/49' Arms  
Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft.)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1										
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	12'x2.5' Sign	7.5			12	2.5	1	30	66	1.20
	#3	5 Section Head w/BP	16	13.75	4			2	42	105	1.20
	#4		2.5'x3' Sign	23			2.5	3	1	7.5	22.5
	#5	Camera	24	1	1			1	3	22	1.20
	#6	3 Section Head w/BP	26	8.7	4			1	26	65	1.20
	#7	2.5'x3' Sign	34			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	37	8.7	4			1	26	65	1.20
	#9	Camera	39	1	1			1	3	22	1.20
	#10	3'x3.5' Sign	45			3	3.5	1	10.5	26.7	1.13
	#11	4 Section Head w/BP	48	11	5			1	34	80	1.20
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1	Camera	4	1	1			1	3	22	1.20
	#2	12'x2.5' Sign	7.5			12	2.5	1	30	66	1.20
	#3	5 Section Head w/BP	16	13.75	4			2	42	105	1.20
	#4		2.5'x3' Sign	23			2.5	3	1	7.5	22.5
	#5	Camera	24	1	1			1	3	22	1.20
	#6	3 Section Head w/BP	26	8.7	4			1	26	65	1.20
	#7	2.5'x3' Sign	34			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	37	8.7	4			1	26	65	1.20
	#9	Camera	39	1	1			1	3	22	1.20
	#10	3'x3.5' Sign	45			3	3.5	1	10.5	26.7	1.13
	#11	4 Section Head w/BP	48	11	5			1	34	80	1.20
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										



16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49/49' Arms

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.500	20.352	85.11	0.5288	0.53	1.802	17.48	0.80
2	I	1.06	1.06	20.352	20.204	84.48	0.5288	1.59	1.789	17.36	0.80
3	I	1.06	2.12	20.204	20.055	83.85	0.5288	2.65	1.776	17.24	0.80
4	I	1.06	3.18	20.055	19.907	83.22	0.5288	3.71	1.763	17.12	0.80
5	I	1.06	4.24	19.907	19.759	82.59	0.5288	4.76	1.750	16.99	0.80
6	I	1.06	5.29	19.759	19.611	81.96	0.5287	5.82	1.737	16.87	0.80
7	I	1.06	6.35	19.611	19.462	81.33	0.5287	6.88	1.724	16.75	0.80
8	I	1.06	7.41	19.462	19.314	80.70	0.5287	7.94	1.711	16.62	0.80
9	I	1.06	8.47	19.314	19.166	80.07	0.5287	9.00	1.698	16.50	0.80
10	I	1.06	9.53	19.166	19.018	79.44	0.5287	10.06	1.685	16.38	0.80
11	I	1.06	10.59	19.018	18.869	78.82	0.5287	11.12	1.671	16.25	0.80
12	I	1.06	11.65	18.869	18.721	78.19	0.5287	12.18	1.658	16.13	0.80
13	I	1.06	12.71	18.721	18.573	77.56	0.5287	13.23	1.645	16.01	1.00
14	I	1.06	13.76	18.573	18.425	76.93	0.5287	14.29	1.632	15.88	1.00
15	I	1.06	14.82	18.425	18.276	76.30	0.5287	15.35	1.619	15.76	1.00
16	I	1.06	15.88	18.276	18.128	75.67	0.5287	16.41	1.606	15.64	1.00
17	I	1.06	16.94	18.128	17.980	75.04	0.5287	17.47	1.593	15.51	1.00
18	J	0.50	18.00	17.980	17.910	35.22	0.2498	18.25	0.748	7.28	1.00
19	I	0.50	18.50	17.910	17.840	35.08	0.2498	18.75	0.745	7.26	1.00
20	I	0.50	19.00	17.840	17.770	34.94	0.2498	19.25	0.742	7.23	1.00
						1467					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in <sup>4</sup> )	1199.72	803.12	803.12	774.72
Section Modulus (in <sup>3</sup> )	119.23	91.24	91.24	
Cross-Section Area (in <sup>2</sup> )	23.70	20.73	20.73	
Width-Thickness Ratio	54.67	47.95	47.95	
Compact Limit	68.55	68.55	68.55	
Non-Compact Limit	137.09	137.09	137.09	
Maximum Limit	237.27	237.27	237.27	
Allow. Bending Stress (ksi)	36.300	36.300	36.300	
Allow. Compressive Str (ksi)	21.411	21.411	21.411	
Allow. Shear Stress (ksi)	18.150	18.150	18.150	

Shaft Deflection From Arm#1 GP I Load (in)	0.367
Shaft Deflection From Arm#2 GP I Load (in)	0.367

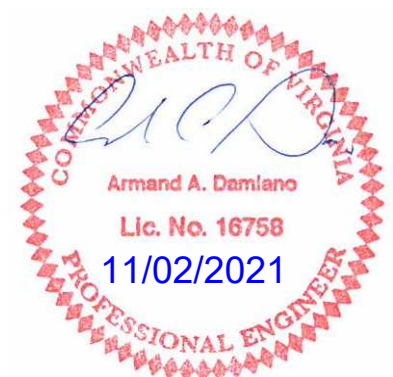




16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49'/49' Arms

## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.74	0.000	22.53	1.100	4.576	8.25
2	0.450	12.62	22.58	0.000	22.37	1.100	4.576	8.19
3	0.450	12.62	22.41	0.000	22.20	1.100	4.576	8.13
4	0.450	12.62	22.25	0.000	22.04	1.100	4.576	8.07
5	0.450	12.62	22.08	0.000	21.87	1.100	4.576	8.01
6	0.450	12.62	21.92	0.000	21.71	1.100	4.576	7.95
7	0.450	12.62	21.75	0.000	21.55	1.100	4.576	7.89
8	0.450	12.62	21.59	0.001	21.38	1.100	4.576	7.83
9	0.450	12.62	21.42	0.001	21.22	1.100	4.576	7.77
10	0.450	12.62	21.26	0.001	21.06	1.100	4.576	7.71
11	0.450	12.62	21.09	0.001	20.89	1.100	4.576	7.65
12	0.450	12.62	20.93	0.001	20.73	1.100	4.576	7.59
13	0.450	15.77	25.95	0.002	20.57	1.100	4.576	7.53
14	0.450	15.77	25.74	0.002	20.40	1.100	4.576	7.47
15	0.450	15.77	25.53	0.002	20.24	1.100	4.576	7.41
16	0.450	15.77	25.33	0.003	20.08	1.100	4.576	7.35
17	0.450	15.77	25.12	0.003	19.91	1.100	4.576	7.29
18	0.450	15.77	11.79	0.001	9.35	1.100	4.576	3.42
19	0.450	15.77	11.75	0.002	9.31	1.100	4.576	3.41
20	0.450	15.77	11.70	0.002	9.27	1.100	4.576	3.39
Fix. #1	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.052	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49'/49' Arms

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	2.45	0.00	14.000	13.657	78.1	1.2199	1.22	2.823	2.823	27.76
2	I	2.45	2.45	13.657	13.314	76.1	1.2198	3.67	2.753	2.753	27.10
3	I	2.45	4.90	13.314	12.971	74.1	1.2197	6.12	2.683	2.683	26.44
4	I	2.45	7.35	12.971	12.628	72.2	1.2195	8.57	2.613	2.613	25.78
5	I	2.45	9.80	12.628	12.285	70.2	1.2194	11.02	2.543	2.543	25.12
6	I	2.45	12.25	12.285	11.942	68.2	1.2192	13.47	2.473	2.473	24.46
7	I	2.45	14.70	11.942	11.599	66.3	1.2191	15.92	2.403	2.403	23.80
8	I	2.45	17.15	11.599	11.256	64.3	1.2189	18.37	2.333	2.333	23.14
9	I	2.45	19.60	11.256	10.913	62.3	1.2187	20.82	2.263	2.263	22.48
10	I	2.45	22.05	10.913	10.570	60.4	1.2185	23.27	2.193	2.193	21.82
11	I	2.45	24.50	10.570	10.227	58.4	1.2183	25.72	2.123	2.123	21.16
12	I	2.45	26.95	10.227	9.884	56.4	1.2180	28.17	2.053	2.053	20.50
13	I	2.45	29.40	9.884	9.541	54.5	1.2178	30.62	1.983	1.983	19.84
14	I	2.45	31.85	9.541	9.198	52.5	1.2175	33.07	1.913	1.913	19.18
15	I	2.45	34.30	9.198	8.855	50.5	1.2172	35.52	1.843	1.843	18.52
16	I	2.45	36.75	8.855	8.512	48.6	1.2169	37.97	1.773	1.773	17.86
17	I	2.45	39.20	8.512	8.169	46.6	1.2166	40.42	1.703	1.703	17.20
18	I	2.45	41.65	8.169	7.826	44.6	1.2162	42.87	1.633	1.633	16.54
19	I	2.45	44.10	7.826	7.483	42.6	1.2159	45.32	1.563	1.563	15.88
20	I	2.45	46.55	7.483	7.140	40.7	1.2154	47.77	1.493	1.493	15.22
		<u>49.00</u>				<u>1187</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	66	7.50	30.000	1.000	90.00
Fix. #3	105	16.00	13.750	2.000	126.00
Fix. #4	22.5	23.00	7.500	1.000	22.50
Fix. #5	22	24.00	1.000	1.000	9.00
Fix. #6	65	26.00	8.700	1.000	78.00
Fix. #7	22.5	34.00	7.500	1.000	22.50
Fix. #8	65	37.00	8.700	1.000	78.00
Fix. #9	22	39.00	1.000	1.000	9.00
Fix. #10	26.7	45.00	10.500	1.000	31.50
Fix. #11	80	48.00	11.000	1.000	102.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	32.649	0.000
Cross-Section Area (in^2)	9.477	0.000
Width-Thickness Ratio	63.93	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	36.300	0.000
Allow. Shear Stress (ksi)	18.150	0.000



16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49/49' Arms

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000 Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	44.52	35.29	1.100	4.576	12.92	0	0.644	0.00	0.00	
2	1.00	0.450	15.77	43.42	34.42	1.100	4.576	12.60	0	0.666	0.00	0.00	
3	1.00	0.450	15.77	42.32	33.54	1.100	4.576	12.28	0	0.688	0.00	0.00	
4	1.00	0.450	15.77	41.21	32.67	1.100	4.576	11.96	0	0.712	0.00	0.00	
5	1.00	0.450	15.77	40.11	31.79	1.100	4.576	11.64	0	0.738	0.00	0.00	
6	1.00	0.450	15.77	39.00	30.91	1.100	4.576	11.32	0	0.765	0.00	0.00	
7	1.00	0.450	15.77	37.90	30.04	1.100	4.576	11.00	0	0.794	0.00	0.00	
8	1.00	0.450	15.77	36.79	29.16	1.100	4.576	10.68	0	0.825	0.00	0.00	
9	1.00	0.450	15.77	35.69	28.29	1.100	4.576	10.36	0	0.859	0.00	0.00	
10	1.00	0.450	15.77	34.58	27.41	1.100	4.576	10.04	0	0.895	0.00	0.00	
11	1.00	0.450	15.77	33.48	26.54	1.100	4.576	9.71	0	0.933	0.00	0.00	
12	1.00	0.450	15.77	32.38	25.66	1.100	4.576	9.39	0	0.975	0.00	0.00	
13	1.00	0.450	15.77	31.27	24.79	1.100	4.576	9.07	0	1.020	0.00	0.00	
14	1.00	0.450	15.77	30.17	23.91	1.100	4.576	8.75	0	1.069	0.00	0.00	
15	1.00	0.450	15.77	29.06	23.04	1.100	4.576	8.43	1	1.100	0.00	0.00	
16	1.00	0.450	15.77	27.96	22.16	1.100	4.576	8.11	1	1.100	0.00	0.00	
17	1.00	0.462	16.2	27.59	21.29	1.100	4.576	7.79	1	1.100	0.00	0.00	
18	1.00	0.488	17.11	27.94	20.41	1.100	4.576	7.47	1	1.100	0.00	0.00	
19	1.00	0.517	18.12	28.32	19.53	1.100	4.576	7.15	1	1.100	0.00	0.00	
20	1.00	0.549	19.23	28.71	18.66	1.100	4.576	6.83	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	42.03	1260.90	630.45	1.199	4.990	149.70	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



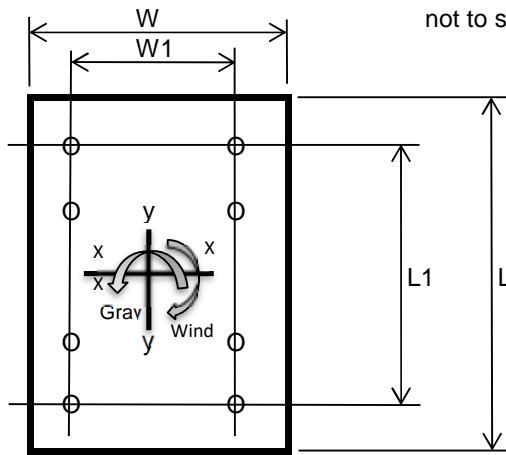
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1706	2713	-	lbs
Shear (Wind)	4865	2626	-	lbs
Torsion (Arm Rise)	12491	6742	-	ft-lbs
Moment (Gravity)	39946	65204	-	ft-lbs
Moment (Wind)	117926	63047	-	ft-lbs
Nat. Wind Moment	-	-	16484	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	14.00	in
Tube Wall Thick.	0.219	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	13.05	12.59	ksi
Bolt Shear Stress - fv	1.64	1	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Fv =	44.22	44.22	ksi
Allowable Shear Stress = Ft =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.31	0.29	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	1.56	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.23	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	7.05	11.51	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	21.17	11.32	ksi
Combined applied stress for interaction (SRSS)	22.31	16.14	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49'/49' Arms

Arm #2 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	2.45	0.00	14.000	13.657	78.1	1.2199	1.22	2.823	2.823	27.76
2	I	2.45	2.45	13.657	13.314	76.1	1.2198	3.67	2.753	2.753	27.10
3	I	2.45	4.90	13.314	12.971	74.1	1.2197	6.12	2.683	2.683	26.44
4	I	2.45	7.35	12.971	12.628	72.2	1.2195	8.57	2.613	2.613	25.78
5	I	2.45	9.80	12.628	12.285	70.2	1.2194	11.02	2.543	2.543	25.12
6	I	2.45	12.25	12.285	11.942	68.2	1.2192	13.47	2.473	2.473	24.46
7	I	2.45	14.70	11.942	11.599	66.3	1.2191	15.92	2.403	2.403	23.80
8	I	2.45	17.15	11.599	11.256	64.3	1.2189	18.37	2.333	2.333	23.14
9	I	2.45	19.60	11.256	10.913	62.3	1.2187	20.82	2.263	2.263	22.48
10	I	2.45	22.05	10.913	10.570	60.4	1.2185	23.27	2.193	2.193	21.82
11	I	2.45	24.50	10.570	10.227	58.4	1.2183	25.72	2.123	2.123	21.16
12	I	2.45	26.95	10.227	9.884	56.4	1.2180	28.17	2.053	2.053	20.50
13	I	2.45	29.40	9.884	9.541	54.5	1.2178	30.62	1.983	1.983	19.84
14	I	2.45	31.85	9.541	9.198	52.5	1.2175	33.07	1.913	1.913	19.18
15	I	2.45	34.30	9.198	8.855	50.5	1.2172	35.52	1.843	1.843	18.52
16	I	2.45	36.75	8.855	8.512	48.6	1.2169	37.97	1.773	1.773	17.86
17	I	2.45	39.20	8.512	8.169	46.6	1.2166	40.42	1.703	1.703	17.20
18	I	2.45	41.65	8.169	7.826	44.6	1.2162	42.87	1.633	1.633	16.54
19	I	2.45	44.10	7.826	7.483	42.6	1.2159	45.32	1.563	1.563	15.88
20	I	2.45	46.55	7.483	7.140	40.7	1.2154	47.77	1.493	1.493	15.22
		49.00				1187					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	66	7.50	30.000	1.000	90.00
Fix. #3	105	16.00	13.750	2.000	126.00
Fix. #4	22.5	23.00	7.500	1.000	22.50
Fix. #5	22	24.00	1.000	1.000	9.00
Fix. #6	65	26.00	8.700	1.000	78.00
Fix. #7	22.5	34.00	7.500	1.000	22.50
Fix. #8	65	37.00	8.700	1.000	78.00
Fix. #9	22	39.00	1.000	1.000	9.00
Fix. #10	26.7	45.00	10.500	1.000	31.50
Fix. #11	80	48.00	11.000	1.000	102.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#2 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	32.649	0.000
Cross-Section Area (in^2)	9.477	0.000
Width-Thickness Ratio	63.93	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	36.300	0.000
Allow. Shear Stress (ksi)	18.150	0.000



16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49/49' Arms

Arm #2 Analysis Continued

Sec. Num.	Kz	Truck Induced Gust											Gallop Loads (lbs)
		Group 2			Group 3	Natural Wind Gust			Hght Corr. Factor = 1.00				
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	44.52	35.29	1.100	4.576	12.92	0	0.644	0.00	0.00	
2	1.00	0.450	15.77	43.42	34.42	1.100	4.576	12.60	0	0.666	0.00	0.00	
3	1.00	0.450	15.77	42.32	33.54	1.100	4.576	12.28	0	0.688	0.00	0.00	
4	1.00	0.450	15.77	41.21	32.67	1.100	4.576	11.96	0	0.712	0.00	0.00	
5	1.00	0.450	15.77	40.11	31.79	1.100	4.576	11.64	0	0.738	0.00	0.00	
6	1.00	0.450	15.77	39.00	30.91	1.100	4.576	11.32	0	0.765	0.00	0.00	
7	1.00	0.450	15.77	37.90	30.04	1.100	4.576	11.00	0	0.794	0.00	0.00	
8	1.00	0.450	15.77	36.79	29.16	1.100	4.576	10.68	0	0.825	0.00	0.00	
9	1.00	0.450	15.77	35.69	28.29	1.100	4.576	10.36	0	0.859	0.00	0.00	
10	1.00	0.450	15.77	34.58	27.41	1.100	4.576	10.04	0	0.895	0.00	0.00	
11	1.00	0.450	15.77	33.48	26.54	1.100	4.576	9.71	0	0.933	0.00	0.00	
12	1.00	0.450	15.77	32.38	25.66	1.100	4.576	9.39	0	0.975	0.00	0.00	
13	1.00	0.450	15.77	31.27	24.79	1.100	4.576	9.07	0	1.020	0.00	0.00	
14	1.00	0.450	15.77	30.17	23.91	1.100	4.576	8.75	0	1.069	0.00	0.00	
15	1.00	0.450	15.77	29.06	23.04	1.100	4.576	8.43	1	1.100	0.00	0.00	
16	1.00	0.450	15.77	27.96	22.16	1.100	4.576	8.11	1	1.100	0.00	0.00	
17	1.00	0.462	16.20	27.59	21.29	1.100	4.576	7.79	1	1.100	0.00	0.00	
18	1.00	0.488	17.11	27.94	20.41	1.100	4.576	7.47	1	1.100	0.00	0.00	
19	1.00	0.517	18.12	28.32	19.53	1.100	4.576	7.15	1	1.100	0.00	0.00	
20	1.00	0.549	19.23	28.71	18.66	1.100	4.576	6.83	1	1.100	0.00	0.00	
Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	42.03	1260.90	630.45	1.199	4.990	149.70	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49/49' Arms  
Flange Analysis - Arm #2

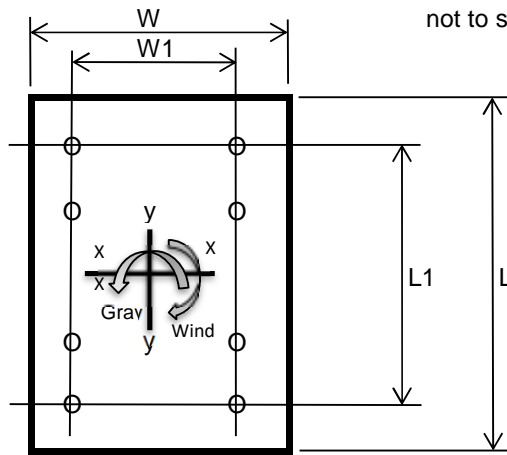
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Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1706	2713	-	lbs
Shear (Wind)	4865	2626	-	lbs
Torsion (Arm Rise)	12491	6742	-	ft-lbs
Moment (Gravity)	39946	65204	-	ft-lbs
Moment (Wind)	117926	63047	-	ft-lbs
Nat. Wind Moment	-	-	16484	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	14.00	in
Tube Wall Thick.	0.219	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	13.05	12.59	ksi
Bolt Shear Stress - fv	1.64	1	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.31	0.29	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	1.56	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.23	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	7.05	11.51	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	21.17	11.32	ksi
Combined applied stress for interaction (SRSS)	22.31	16.14	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



## 16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49'/49' Arms

## Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.268293	
Dop - Baseplate center hole diameter	15.75	in
Cop - Center hole to shaft diameter ratio	0.768293	
Kf - Fatigue stress concentration factor for finite life	2.43	
Ki - Fatigue stress concentration factor for infinite life	5.66	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.219	in
Dt - Arm base diameter	14.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.27	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.428571	
Kf - Fatigue stress concentration factor for finite life	1.83	
Ki - Fatigue stress concentration factor for infinite life	3.40	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle

**ARM 2 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.219	in
Dt - Arm base diameter	14.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.272843	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.428571	
Kf - Fatigue stress concentration factor for finite life	1.83	
Ki - Fatigue stress concentration factor for infinite life	3.40	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle





## 16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49'/49' Arms

## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	20.07	in
Shaft Thickness	0.375	in
Total Area	27.9058	in <sup>2</sup>
Ix	1226	in <sup>4</sup>
Iy	1349	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	22094	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	8.52	ksi
CSR	0.53	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.33	ksi
CSR	0.33	
Therefore	<b>OK</b>	



16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49'/49' Arms

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear	Shear	Bending	Torsion	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	1706		1706	39946		39947		361	14682		0.41
Gp II	1706	4865	5156	39946	117926	124508	12491	1089	45762	2296	0.97
Gp III	2713	2626	3776	65204	63047	90700	6742	797	33336	1239	0.70
Gp IV Natural		693	693		16484	16484	1779	147	6059	327	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	1706		1706	39946		39947		361	14682		0.41
Gp II	1706	4865	5156	39946	117926	124508	12491	1089	45762	2296	0.97
Gp III	2713	2626	3776	65204	63047	90700	6742	797	33336	1239	0.70
Gp IV Natural		693	693		16484	16484	1779	147	6059	327	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49/49' Arms

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	5044		39946	39946	56493		213		5686		0.17
Gp II	5044	6030	98759	135524	167690	166746	213	509	16878	8391	0.50
Gp III	7523	3384	101340	114223	152698	89148	317	286	15369	4486	0.37
Gp IV Natural			16885	14249	22094				2224		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9976										

<b>Shaft At Arm</b>											
Gp I	3517		39946	39946	56493		170		7430		0.22
Gp II	3517	4900	48623	48958	69001	166746	170	473	9075	10966	0.42
Gp III	5532	2654	69887	70075	98968	89148	267	257	13017	5863	0.35
Gp IV Natural			1786	1779	2521				332		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9976										



16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49/49' Arms

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	6030 lbs
Bending Moment	167690 ft-lbs
Torsion Moment	166746 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.50 in

**ANALYSIS - ANCHOR BOLTS**

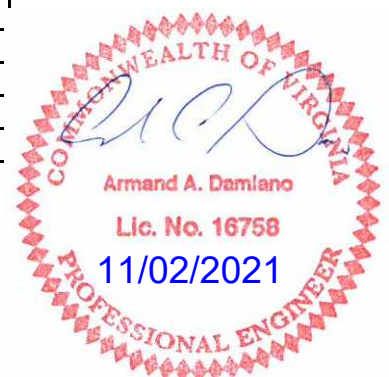
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	15.443 ksi
Bolt Direct Shear Stress	0.328 ksi
Bolt Torsion Shear Stress	8.366 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	15.443 ksi
$f_v =$	8.694 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.58 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	2.75 in
Design Moment	107 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	16.17 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.188 in
Design Moment	46 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	7.3 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-19 - VA - 90 MPH - MP-3 Std. Loads - Type C - 49'/49' Arms

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	22094 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	2.04 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.3
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	38608 lbs
Computed Factor-of Safety	1.6 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	38608 lbs
Total Tensile Load	308864 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.52 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	38608 lbs
Total Tensile Load	308864 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	7 Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

11/02/21

**General**

Wind Vel.- mph	90	No	Roadway - mph	55	<i>Fatigue Importance Factors</i>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	2		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	1		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	21.00	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.2190	0.14	14.00	49.00	18.00	-	2.57	0	55	29000	180
Traffic Arm #2	0.2190	0.14	14.00	49.00	18.00	-	2.57	0	55	29000	270
Lum Arm #1	0.3750		2.88	24.00	24.00	-	5	0	36	29000	180
Lum Arm #2						-		0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8	Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes
A.B. Bolt Circle	29.00	in	Foundation Diameter	48
Baseplate Dia.	35.00	in	Concrete Cover	4
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000
B.P. Center Hole	15.25	in	Vertical Reinforcing Bar Size #	8
Weld Type	Full Pen.		Rebar Yield Strength fy	60
				ksi

**Flange Simplex**

	Arm #1		Arm #2	
Flange Bolt Qty.	8		8	
Bolt Diameter	1.50	in	1.50	in
Flange Plate Length (V)	27.00	in	27.00	in
Flange Plate Width (H)	27.00	in	27.00	in
Spac. Between Bolt (V)	22.50	in	22.50	in
Spac. Between Bolt (H)	22.50	in	22.50	in
Flange Plate Thk.	2.25	in	2.25	in
Flange Plate Yield (Fy)	50.00	ksi	50.00	ksi
Gusset Thk.	0.500	in	0.500	in
Plate Center Hole	6.00	in	6.00	in
Weld Type	Full Pen.		Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.16	0.21	0.41		0.41						11.20	11.20
GP II CSR	0.51	0.41	0.97		0.97		0.95					
GP III CSR	0.37	0.34	0.70		0.70		0.69				18.54	18.54
Nat.Wind (psi)	2182	328	6059		6059							

Arm #1 Flange Bolt (Max.) CSR	0.31
Arm #1 Flange Bolt Fatigue CSR	0.23
Arm #1 Flange Plate (Max.) CSR	0.51
Arm #2 Flange Bolt (Max.) CSR	0.31
Arm #2 Flange Bolt Fatigue CSR	0.23
Arm #2 Flange Plate (Max.) CSR	0.51
Handhole at Root (Fatigue) CSR	0.52
Handhole at Toe (Fatigue) CSR	0.33
Minimum Qty of Vertical Reinf. Bars	7

Fatigue Allowable - Shaft to Baseplate	4.5	ksi
Fatigue Allowable - Arm#1 to Flange	7	ksi
Fatigue Allowable - Arm#2 to Flange	7	ksi
Anchor Bolt Max. CSR	0.56	
Anchor Bolt Max. Fatigue Stress Ratio	0.27	
Base Plate Max. CSR	0.65	
Anchorage Capacity S.F.	1.54	
Concrete Pull Out Capacity S.F.	1.70	

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
8615	6666	185687	168608



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49/49' Arms w/24' Lum.

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft.)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1	Cobra Head w/Camera	24	2	1			4.54	9	57	1.00
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	12'x2.5' Sign	7.5			12	2.5	1	30	66	1.20
	#3	5 Section Head w/BP	16	13.75	4			2	42	105	1.20
	#4		2.5'x3' Sign			23		2.5	3	1	7.5
	#5	Camera	24	1	1			1	3	22	1.20
	#6	3 Section Head w/BP	26	8.7	4			1	26	65	1.20
	#7	2.5'x3' Sign	34			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	37	8.7	4			1	26	65	1.20
	#9	Camera	39	1	1			1	3	22	1.20
	#10	3'x3.5' Sign	45			3	3.5	1	10.5	26.7	1.13
	#11	4 Section Head w/BP	48	11	5			1	34	80	1.20
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1	Camera	4	1	1			1	3	22	1.20
	#2	12'x2.5' Sign	7.5			12	2.5	1	30	66	1.20
	#3	5 Section Head w/BP	16	13.75	4			2	42	105	1.20
	#4		2.5'x3' Sign			23		2.5	3	1	7.5
	#5	Camera	24	1	1			1	3	22	1.20
	#6	3 Section Head w/BP	26	8.7	4			1	26	65	1.20
	#7	2.5'x3' Sign	34			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	37	8.7	4			1	26	65	1.20
	#9	Camera	39	1	1			1	3	22	1.20
	#10	3'x3.5' Sign	45			3	3.5	1	10.5	26.7	1.13
	#11	4 Section Head w/BP	48	11	5			1	34	80	1.20
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	21.000	20.852	87.23	0.5288	0.53	1.846	17.90	0.80
2	I	1.06	1.06	20.852	20.704	86.60	0.5288	1.59	1.833	17.78	0.80
3	I	1.06	2.12	20.704	20.555	85.97	0.5288	2.65	1.820	17.65	0.80
4	I	1.06	3.18	20.555	20.407	85.34	0.5288	3.71	1.807	17.53	0.80
5	I	1.06	4.24	20.407	20.259	84.71	0.5288	4.76	1.794	17.41	0.80
6	I	1.06	5.29	20.259	20.111	84.08	0.5288	5.82	1.781	17.28	0.80
7	I	1.06	6.35	20.111	19.962	83.45	0.5288	6.88	1.768	17.16	0.80
8	I	1.06	7.41	19.962	19.814	82.83	0.5288	7.94	1.755	17.04	0.80
9	I	1.06	8.47	19.814	19.666	82.20	0.5287	9.00	1.742	16.91	0.80
10	I	1.06	9.53	19.666	19.518	81.57	0.5287	10.06	1.729	16.79	0.80
11	I	1.06	10.59	19.518	19.369	80.94	0.5287	11.12	1.716	16.67	0.80
12	I	1.06	11.65	19.369	19.221	80.31	0.5287	12.18	1.703	16.54	0.80
13	I	1.06	12.71	19.221	19.073	79.68	0.5287	13.23	1.689	16.42	1.00
14	I	1.06	13.76	19.073	18.925	79.05	0.5287	14.29	1.676	16.30	1.00
15	I	1.06	14.82	18.925	18.776	78.42	0.5287	15.35	1.663	16.17	1.00
16	I	1.06	15.88	18.776	18.628	77.79	0.5287	16.41	1.650	16.05	1.00
17	I	1.06	16.94	18.628	18.480	77.16	0.5287	17.47	1.637	15.93	1.00
18	J	3.00	18.00	18.480	18.060	215.21	1.4943	19.49	4.568	44.46	1.00
19	I	3.00	21.00	18.060	17.640	210.16	1.4941	22.49	4.463	43.47	1.00
20	J	1.00	24.00	17.640	17.500	68.93	0.4993	24.50	1.464	14.27	1.00
						1892					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	1291.38	873.51	873.51	739.20
Section Modulus (in^3)	125.22	96.49	96.49	
Cross-Section Area (in^2)	24.29	21.32	21.32	
Width-Thickness Ratio	56.00	49.28	49.28	
Compact Limit	68.55	68.55	68.55	
Non-Compact Limit	137.09	137.09	137.09	
Maximum Limit	237.27	237.27	237.27	
Allow. Bending Stress (ksi)	36.300	36.300	36.300	
Allow. Compressive Str (ksi)	16.423	16.423	16.423	
Allow. Shear Stress (ksi)	18.150	18.150	18.150	

Shaft Deflection From Arm#1 GP I Load (in)	0.340
Shaft Deflection From Arm#2 GP I Load (in)	0.340

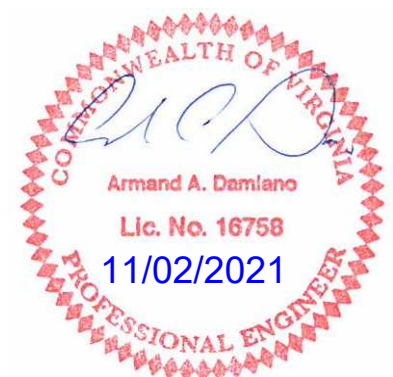




16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49/49' Arms w/24' Lum.

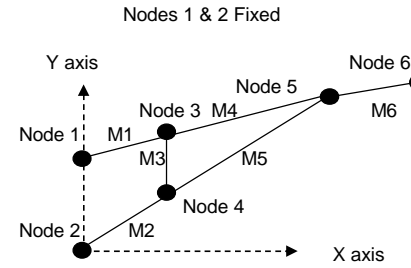
## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	23.30	0.000	23.08	1.100	4.576	8.45
2	0.450	12.62	23.14	0.000	22.92	1.100	4.576	8.39
3	0.450	12.62	22.97	0.000	22.75	1.100	4.576	8.33
4	0.450	12.62	22.81	0.000	22.59	1.100	4.576	8.27
5	0.450	12.62	22.64	0.000	22.43	1.100	4.576	8.21
6	0.450	12.62	22.48	0.000	22.26	1.100	4.576	8.15
7	0.450	12.62	22.31	0.001	22.10	1.100	4.576	8.09
8	0.450	12.62	22.15	0.001	21.94	1.100	4.576	8.03
9	0.450	12.62	21.98	0.001	21.77	1.100	4.576	7.97
10	0.450	12.62	21.82	0.001	21.61	1.100	4.576	7.91
11	0.450	12.62	21.65	0.001	21.45	1.100	4.576	7.85
12	0.450	12.62	21.49	0.002	21.28	1.100	4.576	7.79
13	0.450	15.77	26.64	0.002	21.12	1.100	4.576	7.73
14	0.450	15.77	26.44	0.003	20.95	1.100	4.576	7.67
15	0.450	15.77	26.23	0.003	20.79	1.100	4.576	7.61
16	0.450	15.77	26.02	0.004	20.63	1.100	4.576	7.55
17	0.450	15.77	25.82	0.004	20.46	1.100	4.576	7.49
18	0.450	15.77	72.03	0.013	57.09	1.100	4.576	20.90
19	0.450	15.77	70.37	0.016	55.78	1.100	4.576	20.42
20	0.450	15.77	23.09	0.006	18.30	1.100	4.576	6.70
Fix. #1	1.200	33.65	80.76	0.005	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.005	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.066	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum. - Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-44.01	-40.6	0	0	0
Node #2	0	0	0	0	-46.58	-42.9	0	0	0
Node #3	100	59.5	0	0	-87	-84.8	0	0	0
Node #4	100	48.8	0	0	-90.64	-88.2	0	0	0
Node #5	200	79	0	0	-123.35	-125	0	0	0
Node #6	288	87	0	0	-93.99	-114.6	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-88.02	1.1	1	-81.07	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-93.14	1.1	1	-85.79	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.95	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-85.28	1.1	1.1	-86.40	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-87.44	1.1	1.1	-88.59	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-73.97	1.1	1.1	-74.94	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-77.10					

AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2629.3	lbs
P1y	-827.0	lbs
P1z	294.4	lbs
M1x	10996.1	in-lbs
M1y	-41528.6	in-lbs
M1z	-716.1	in-lbs
P2x	2629.3	lbs
P2y	1312.5	lbs
P2z	201.7	lbs
M2x	11346.6	in-lbs
M2y	-33776.2	in-lbs
M2z	-770.7	in-lbs

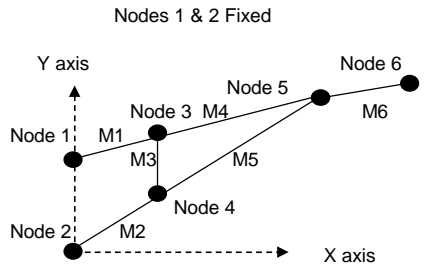
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-939	173	26099	-644	0.76
#2	989	109	21500	-1250	0.95
#3	1807	572	11253	-534	0.45
#4	-919	78	10031	-29	0.28
#5	936	91	11105	-380	0.58
#6	3	101	7955	-1	0.24

V09.19.15



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum. - Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-51.2	-20.3	0	0	0
Node #2	0	0	0	0	-54.18	-21.5	0	0	0
Node #3	100	59.5	0	0	-101.41	-42.4	0	0	0
Node #4	100	48.8	0	0	-105.65	-44.1	0	0	0
Node #5	200	79	0	0	-143.49	-62.5	0	0	0
Node #6	288	87	0	0	-124.03	-57.3	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-102.39	1.1	1	-40.53	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-108.35	1.1	1	-42.89	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.98	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-99.21	1.1	1.1	-43.20	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-101.72	1.1	1.1	-44.29	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-86.04	1.1	1.1	-37.47	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-38.55					

AASHTO Gp	3
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-3247.7	lbs
P1y	-1031.5	lbs
P1z	147.2	lbs
M1x	5498.0	in-lbs
M1y	-20764.3	in-lbs
M1z	-1257.5	in-lbs
P2x	3247.7	lbs
P2y	1611.4	lbs
P2z	100.9	lbs
M2x	5673.3	in-lbs
M2y	-16888.1	in-lbs
M2z	-1306.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1160	88	13070	-322	0.36
#2	1221	57	10777	-625	0.69
#3	2226	425	8530	-267	0.39
#4	-1137	47	5068	-15	0.12
#5	1159	52	5600	-190	0.48
#6	4	93	7320	-1	0.23

V09.19.15



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	2.45	0.00	14.000	13.657	78.1	1.2199	1.22	2.823	2.823	27.76
2	I	2.45	2.45	13.657	13.314	76.1	1.2198	3.67	2.753	2.753	27.10
3	I	2.45	4.90	13.314	12.971	74.1	1.2197	6.12	2.683	2.683	26.44
4	I	2.45	7.35	12.971	12.628	72.2	1.2195	8.57	2.613	2.613	25.78
5	I	2.45	9.80	12.628	12.285	70.2	1.2194	11.02	2.543	2.543	25.12
6	I	2.45	12.25	12.285	11.942	68.2	1.2192	13.47	2.473	2.473	24.46
7	I	2.45	14.70	11.942	11.599	66.3	1.2191	15.92	2.403	2.403	23.80
8	I	2.45	17.15	11.599	11.256	64.3	1.2189	18.37	2.333	2.333	23.14
9	I	2.45	19.60	11.256	10.913	62.3	1.2187	20.82	2.263	2.263	22.48
10	I	2.45	22.05	10.913	10.570	60.4	1.2185	23.27	2.193	2.193	21.82
11	I	2.45	24.50	10.570	10.227	58.4	1.2183	25.72	2.123	2.123	21.16
12	I	2.45	26.95	10.227	9.884	56.4	1.2180	28.17	2.053	2.053	20.50
13	I	2.45	29.40	9.884	9.541	54.5	1.2178	30.62	1.983	1.983	19.84
14	I	2.45	31.85	9.541	9.198	52.5	1.2175	33.07	1.913	1.913	19.18
15	I	2.45	34.30	9.198	8.855	50.5	1.2172	35.52	1.843	1.843	18.52
16	I	2.45	36.75	8.855	8.512	48.6	1.2169	37.97	1.773	1.773	17.86
17	I	2.45	39.20	8.512	8.169	46.6	1.2166	40.42	1.703	1.703	17.20
18	I	2.45	41.65	8.169	7.826	44.6	1.2162	42.87	1.633	1.633	16.54
19	I	2.45	44.10	7.826	7.483	42.6	1.2159	45.32	1.563	1.563	15.88
20	I	2.45	46.55	7.483	7.140	40.7	1.2154	47.77	1.493	1.493	15.22
		<u>49.00</u>				<u>1187</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	66	7.50	30.000	1.000	90.00
Fix. #3	105	16.00	13.750	2.000	126.00
Fix. #4	22.5	23.00	7.500	1.000	22.50
Fix. #5	22	24.00	1.000	1.000	9.00
Fix. #6	65	26.00	8.700	1.000	78.00
Fix. #7	22.5	34.00	7.500	1.000	22.50
Fix. #8	65	37.00	8.700	1.000	78.00
Fix. #9	22	39.00	1.000	1.000	9.00
Fix. #10	26.7	45.00	10.500	1.000	31.50
Fix. #11	80	48.00	11.000	1.000	102.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	32.649	0.000
Cross-Section Area (in^2)	9.477	0.000
Width-Thickness Ratio	63.93	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	36.300	0.000
Allow. Shear Stress (ksi)	18.150	0.000



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

Arm #1 Analysis Continued

Sec. Num.	Kz	Truck Induced Gust											
		Group 2			Group 3	Natural Wind Gust			Hght Corr. Factor = 1.000				Gallop
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	Loads (lbs)
1	1.00	0.450	15.77	44.52	35.29	1.100	4.576	12.92	0	0.644	0.00	0.00	
2	1.00	0.450	15.77	43.42	34.42	1.100	4.576	12.60	0	0.666	0.00	0.00	
3	1.00	0.450	15.77	42.32	33.54	1.100	4.576	12.28	0	0.688	0.00	0.00	
4	1.00	0.450	15.77	41.21	32.67	1.100	4.576	11.96	0	0.712	0.00	0.00	
5	1.00	0.450	15.77	40.11	31.79	1.100	4.576	11.64	0	0.738	0.00	0.00	
6	1.00	0.450	15.77	39.00	30.91	1.100	4.576	11.32	0	0.765	0.00	0.00	
7	1.00	0.450	15.77	37.90	30.04	1.100	4.576	11.00	0	0.794	0.00	0.00	
8	1.00	0.450	15.77	36.79	29.16	1.100	4.576	10.68	0	0.825	0.00	0.00	
9	1.00	0.450	15.77	35.69	28.29	1.100	4.576	10.36	0	0.859	0.00	0.00	
10	1.00	0.450	15.77	34.58	27.41	1.100	4.576	10.04	0	0.895	0.00	0.00	
11	1.00	0.450	15.77	33.48	26.54	1.100	4.576	9.71	0	0.933	0.00	0.00	
12	1.00	0.450	15.77	32.38	25.66	1.100	4.576	9.39	0	0.975	0.00	0.00	
13	1.00	0.450	15.77	31.27	24.79	1.100	4.576	9.07	0	1.020	0.00	0.00	
14	1.00	0.450	15.77	30.17	23.91	1.100	4.576	8.75	0	1.069	0.00	0.00	
15	1.00	0.450	15.77	29.06	23.04	1.100	4.576	8.43	1	1.100	0.00	0.00	
16	1.00	0.450	15.77	27.96	22.16	1.100	4.576	8.11	1	1.100	0.00	0.00	
17	1.00	0.462	16.2	27.59	21.29	1.100	4.576	7.79	1	1.100	0.00	0.00	
18	1.00	0.488	17.11	27.94	20.41	1.100	4.576	7.47	1	1.100	0.00	0.00	
19	1.00	0.517	18.12	28.32	19.53	1.100	4.576	7.15	1	1.100	0.00	0.00	
20	1.00	0.549	19.23	28.71	18.66	1.100	4.576	6.83	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	42.03	1260.90	630.45	1.199	4.990	149.70	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



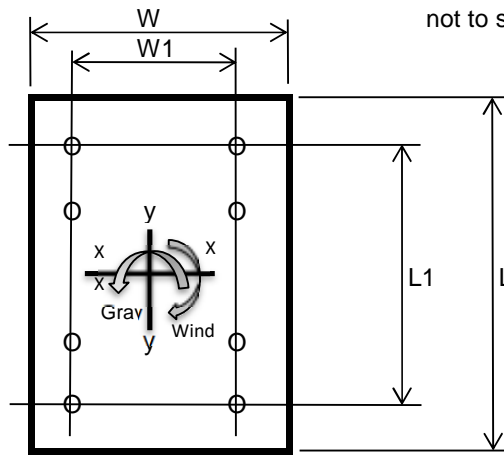
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1706	2713	-	lbs
Shear (Wind)	4865	2626	-	lbs
Torsion (Arm Rise)	12491	6742	-	ft-lbs
Moment (Gravity)	39946	65204	-	ft-lbs
Moment (Wind)	117926	63047	-	ft-lbs
Nat. Wind Moment	-	-	16484	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	14.00	in
Tube Wall Thick.	0.219	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	13.05	12.59	ksi
Bolt Shear Stress - fv	1.64	1	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.31	0.29	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	1.56	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.23	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	7.05	11.51	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	21.17	11.32	ksi
Combined applied stress for interaction (SRSS)	22.31	16.14	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

Arm #2 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	2.45	0.00	14.000	13.657	78.1	1.2199	1.22	2.823	2.823	27.76
2	I	2.45	2.45	13.657	13.314	76.1	1.2198	3.67	2.753	2.753	27.10
3	I	2.45	4.90	13.314	12.971	74.1	1.2197	6.12	2.683	2.683	26.44
4	I	2.45	7.35	12.971	12.628	72.2	1.2195	8.57	2.613	2.613	25.78
5	I	2.45	9.80	12.628	12.285	70.2	1.2194	11.02	2.543	2.543	25.12
6	I	2.45	12.25	12.285	11.942	68.2	1.2192	13.47	2.473	2.473	24.46
7	I	2.45	14.70	11.942	11.599	66.3	1.2191	15.92	2.403	2.403	23.80
8	I	2.45	17.15	11.599	11.256	64.3	1.2189	18.37	2.333	2.333	23.14
9	I	2.45	19.60	11.256	10.913	62.3	1.2187	20.82	2.263	2.263	22.48
10	I	2.45	22.05	10.913	10.570	60.4	1.2185	23.27	2.193	2.193	21.82
11	I	2.45	24.50	10.570	10.227	58.4	1.2183	25.72	2.123	2.123	21.16
12	I	2.45	26.95	10.227	9.884	56.4	1.2180	28.17	2.053	2.053	20.50
13	I	2.45	29.40	9.884	9.541	54.5	1.2178	30.62	1.983	1.983	19.84
14	I	2.45	31.85	9.541	9.198	52.5	1.2175	33.07	1.913	1.913	19.18
15	I	2.45	34.30	9.198	8.855	50.5	1.2172	35.52	1.843	1.843	18.52
16	I	2.45	36.75	8.855	8.512	48.6	1.2169	37.97	1.773	1.773	17.86
17	I	2.45	39.20	8.512	8.169	46.6	1.2166	40.42	1.703	1.703	17.20
18	I	2.45	41.65	8.169	7.826	44.6	1.2162	42.87	1.633	1.633	16.54
19	I	2.45	44.10	7.826	7.483	42.6	1.2159	45.32	1.563	1.563	15.88
20	I	2.45	46.55	7.483	7.140	40.7	1.2154	47.77	1.493	1.493	15.22
		<u>49.00</u>				<u>1187</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	66	7.50	30.000	1.000	90.00
Fix. #3	105	16.00	13.750	2.000	126.00
Fix. #4	22.5	23.00	7.500	1.000	22.50
Fix. #5	22	24.00	1.000	1.000	9.00
Fix. #6	65	26.00	8.700	1.000	78.00
Fix. #7	22.5	34.00	7.500	1.000	22.50
Fix. #8	65	37.00	8.700	1.000	78.00
Fix. #9	22	39.00	1.000	1.000	9.00
Fix. #10	26.7	45.00	10.500	1.000	31.50
Fix. #11	80	48.00	11.000	1.000	102.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#2 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	32.649	0.000
Cross-Section Area (in^2)	9.477	0.000
Width-Thickness Ratio	63.93	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	36.300	0.000
Allow. Shear Stress (ksi)	18.150	0.000



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49/49' Arms w/24' Lum.

Arm #2 Analysis Continued

Sec. Num.	Kz	Truck Induced Gust											Gallop Loads (lbs)
		Group 2			Group 3	Natural Wind Gust			Hght Corr. Factor = 1.00				
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	44.52	35.29	1.100	4.576	12.92	0	0.644	0.00	0.00	
2	1.00	0.450	15.77	43.42	34.42	1.100	4.576	12.60	0	0.666	0.00	0.00	
3	1.00	0.450	15.77	42.32	33.54	1.100	4.576	12.28	0	0.688	0.00	0.00	
4	1.00	0.450	15.77	41.21	32.67	1.100	4.576	11.96	0	0.712	0.00	0.00	
5	1.00	0.450	15.77	40.11	31.79	1.100	4.576	11.64	0	0.738	0.00	0.00	
6	1.00	0.450	15.77	39.00	30.91	1.100	4.576	11.32	0	0.765	0.00	0.00	
7	1.00	0.450	15.77	37.90	30.04	1.100	4.576	11.00	0	0.794	0.00	0.00	
8	1.00	0.450	15.77	36.79	29.16	1.100	4.576	10.68	0	0.825	0.00	0.00	
9	1.00	0.450	15.77	35.69	28.29	1.100	4.576	10.36	0	0.859	0.00	0.00	
10	1.00	0.450	15.77	34.58	27.41	1.100	4.576	10.04	0	0.895	0.00	0.00	
11	1.00	0.450	15.77	33.48	26.54	1.100	4.576	9.71	0	0.933	0.00	0.00	
12	1.00	0.450	15.77	32.38	25.66	1.100	4.576	9.39	0	0.975	0.00	0.00	
13	1.00	0.450	15.77	31.27	24.79	1.100	4.576	9.07	0	1.020	0.00	0.00	
14	1.00	0.450	15.77	30.17	23.91	1.100	4.576	8.75	0	1.069	0.00	0.00	
15	1.00	0.450	15.77	29.06	23.04	1.100	4.576	8.43	1	1.100	0.00	0.00	
16	1.00	0.450	15.77	27.96	22.16	1.100	4.576	8.11	1	1.100	0.00	0.00	
17	1.00	0.462	16.20	27.59	21.29	1.100	4.576	7.79	1	1.100	0.00	0.00	
18	1.00	0.488	17.11	27.94	20.41	1.100	4.576	7.47	1	1.100	0.00	0.00	
19	1.00	0.517	18.12	28.32	19.53	1.100	4.576	7.15	1	1.100	0.00	0.00	
20	1.00	0.549	19.23	28.71	18.66	1.100	4.576	6.83	1	1.100	0.00	0.00	
Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	42.03	1260.90	630.45	1.199	4.990	149.70	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00





Flange Analysis - Arm #2

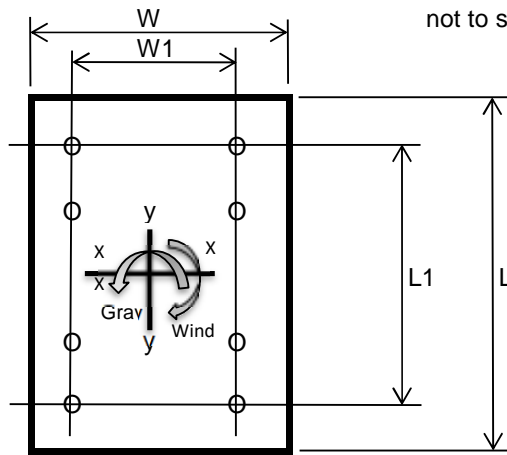
Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1706	2713	-	lbs
Shear (Wind)	4865	2626	-	lbs
Torsion (Arm Rise)	12491	6742	-	ft-lbs
Moment (Gravity)	39946	65204	-	ft-lbs
Moment (Wind)	117926	63047	-	ft-lbs
Nat. Wind Moment	-	-	16484	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs

Diameter of tube	14.00	in
Tube Wall Thick.	0.219	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)

	Results GpII	Results GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	13.05	12.59	ksi
Bolt Shear Stress - fv	1.64	1	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.31	0.29	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	1.56	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.23	<b>OK</b>	

Plate Analysis

Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	7.05	11.51	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	21.17	11.32	ksi
Combined applied stress for interaction (SRSS)	22.31	16.14	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	21.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	29.00	in
Cbc - Bolt circle ratio	1.380952	
Dop - Baseplate center hole diameter	15.25	in
Cop - Center hole to shaft diameter ratio	0.72619	
Kf - Fatigue stress concentration factor for finite life	2.72	
Ki - Fatigue stress concentration factor for infinite life	6.44	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.219	in
Dt - Arm base diameter	14.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.27	
Dop - Baseplate center hole diameter	6.00	in
Cop - Center hole to arm diameter ratio	0.428571	
Kf - Fatigue stress concentration factor for finite life	1.83	
Ki - Fatigue stress concentration factor for infinite life	3.40	
Fatigue Allowable	7	ksi

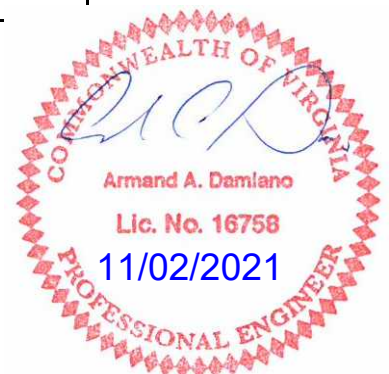
Note: Maximum diagonal distance between bolts used as bolt circle

**ARM 2 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.219	in
Dt - Arm base diameter	14.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.272843	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.428571	
Kf - Fatigue stress concentration factor for finite life	1.83	
Ki - Fatigue stress concentration factor for infinite life	3.40	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	20.57	in
Shaft Thickness	0.375	in
Total Area	28.4979	in <sup>2</sup>
Ix	1314	in <sup>4</sup>
Iy	1454	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	22766	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	8.40	ksi
CSR	0.52	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.28	ksi
CSR	0.33	
Therefore	<b>OK</b>	



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear	Shear	Bending	Torsion	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	1706		1706	39946		39947		361	14682		0.41
Gp II	1706	4865	5156	39946	117926	124508	12491	1089	45762	2296	0.97
Gp III	2713	2626	3776	65204	63047	90700	6742	797	33336	1239	0.70
Gp IV Natural		693	693		16484	16484	1779	147	6059	327	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	1706		1706	39946		39947		361	14682		0.41
Gp II	1706	4865	5156	39946	117926	124508	12491	1089	45762	2296	0.97
Gp III	2713	2626	3776	65204	63047	90700	6742	797	33336	1239	0.70
Gp IV Natural		693	693		16484	16484	1779	147	6059	327	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49/49' Arms w/24' Lum.

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	5954		39946	39946	56493		245		5414		0.16
Gp II	5954	6666	85372	164898	185687	168608	245	549	17794	8079	0.51
Gp III	8615	3745	98453	128115	161575	90079	355	309	15483	4316	0.37
Gp IV Natural			17755	14249	22766				2182		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9975										

<b>Shaft At Arm</b>											
Gp I	4392		39946	39946	56493		206		7026		0.21
Gp II	4392	5526	47637	59615	76310	168608	206	519	9490	10484	0.41
Gp III	6501	3005	69715	75296	102614	90079	305	282	12761	5601	0.34
Gp IV Natural			1945	1779	2636				328		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9975										



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	6666 lbs
Bending Moment	185687 ft-lbs
Torsion Moment	168608 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	29 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	35 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	21.00 in

**ANALYSIS - ANCHOR BOLTS**

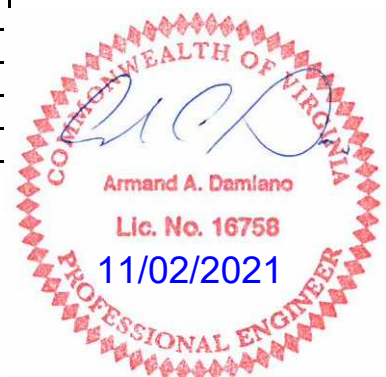
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	2106.48 in <sup>4</sup>
c Dist. (Section 5.17.7)	14.50 in
Bolt Tensile Stress	15.339 ksi
Bolt Direct Shear Stress	0.363 ksi
Bolt Torsion Shear Stress	7.584 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	15.339 ksi
$f_v =$	7.947 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.56 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	11.183 in
Dist. Shaft Face To Bolt Center	4 in
Design Moment	154 in-kip
Section Modulus of Failure Plane	7.45 in <sup>3</sup>
Applied Plate Stress	20.68 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	10.717 in
Dist From Shaft To Nut Face	2.438 in
Design Moment	94 in-kip
Section Modulus of Failure Plane	7.14 in <sup>3</sup>
Applied Plate Stress	13.17 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-20 - VA - 90 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	22766 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	2106.48 in <sup>4</sup>
c Dist. (Section 5.17.7)	14.50 in
Bolt Tensile Stress	1.89 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.27
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	118588 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	8.5 in
T Reduced For Group Action	59294 lbs
Maximum Applied Tensile Load	38348 lbs
Computed Factor-of Safety	1.54 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	38348 lbs
Total Tensile Load	306784 lbs
Concrete Failure Surface Area	4772.08 in <sup>2</sup>
Concrete Shear Strength	522755 psi
Computed Factor-of Safety	1.7 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	38348 lbs
Total Tensile Load	306784 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	43.59 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	7 Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-21 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

11/02/21

**General**

Wind Vel.- mph	90	No	Roadway - mph	55	<b>Fatigue Importance Factors</b>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	0		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.00	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	0.14	14.00	50.00	18.00	-	2.62	0	55	29000	180
Traffic Arm #2					-	-		0	55	29000	90
Lum Arm #1					-	-		0	36	29000	180
Lum Arm #2					-	-		0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8	Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	Double Top Nuts	Yes	
A.B. Bolt Circle	26.00	Foundation Diameter	48	in
Baseplate Dia.	32.00	Concrete Cover	4	in
Baseplate Thk.	2.00	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	15.25	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.	Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50	in
Flange Plate Length (V)	27.00	in
Flange Plate Width (H)	27.00	in
Spac. Between Bolt (V)	22.50	in
Spac. Between Bolt (H)	22.50	in
Flange Plate Thk.	2.25	in
Flange Plate Yield (Fy)	50	ksi
Gusset Thk.	0.500	in
Plate Center Hole	6.00	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.14	0.18	0.41								12.53	0.00
GP II CSR	0.41	0.31	0.96									
GP III CSR	0.28	0.27	0.69								20.09	
Nat.Wind (psi)	1877	269	5889									

Arm #1 Flange Bolt (Max.) CSR	0.35
Arm #1 Flange Bolt Fatigue CSR	0.25
Arm #1 Flange Plate (Max.) CSR	0.57
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.45
Handhole at Toe (Fatigue) CSR	0.28
Minimum Qty of Vertical Reinf. Bars	6

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.48
Anchor Bolt Max. Fatigue Stress Ratio	0.24
Base Plate Max. CSR	0.46
Anchorage Capacity S.F.	1.94
Concrete Pull Out Capacity S.F.	1.84

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
4996	6480	139067	131913





16362-3-21 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.2
	#2	Ped Head	10.5	2.4	1			1	6	30	1.2
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.2
	#4										
Lum #1	#1										
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	12.5			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	16	13.75	4			2	42	105	1.20
	#4		2.5'x3' Sign			24		2.5	3	1	7.5
	#5	3 Section Head w/BP	27	8.7	4			1	26	65	1.20
	#6	Camera	36	1	1			1	3	22	1.20
	#7	2.5'x3' Sign	35			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	38	8.7	4			1	26	65	1.20
	#9		Camera			47	1	1	1	3	22
	#10	3'x3.5' Sign	46			3	3.5	1	10.5	26.7	1.13
	#11	4 Section Head w/BP	49	11	5			1	34	80	1.20
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										



16362-3-21 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.000	19.852	82.99	0.5288	0.53	1.758	17.07	0.80
2	I	1.06	1.06	19.852	19.704	82.36	0.5288	1.59	1.745	16.95	0.80
3	I	1.06	2.12	19.704	19.555	81.73	0.5287	2.65	1.732	16.82	0.80
4	I	1.06	3.18	19.555	19.407	81.10	0.5287	3.71	1.719	16.70	0.80
5	I	1.06	4.24	19.407	19.259	80.47	0.5287	4.76	1.706	16.58	0.80
6	I	1.06	5.29	19.259	19.111	79.84	0.5287	5.82	1.693	16.45	0.80
7	I	1.06	6.35	19.111	18.962	79.21	0.5287	6.88	1.680	16.33	0.80
8	I	1.06	7.41	18.962	18.814	78.58	0.5287	7.94	1.667	16.21	0.80
9	I	1.06	8.47	18.814	18.666	77.95	0.5287	9.00	1.654	16.08	0.80
10	I	1.06	9.53	18.666	18.518	77.32	0.5287	10.06	1.640	15.96	0.80
11	I	1.06	10.59	18.518	18.369	76.69	0.5287	11.12	1.627	15.84	0.80
12	I	1.06	11.65	18.369	18.221	76.06	0.5287	12.18	1.614	15.71	0.80
13	I	1.06	12.71	18.221	18.073	75.43	0.5287	13.23	1.601	15.59	1.00
14	I	1.06	13.76	18.073	17.925	74.81	0.5287	14.29	1.588	15.47	1.00
15	I	1.06	14.82	17.925	17.776	74.18	0.5287	15.35	1.575	15.34	1.00
16	I	1.06	15.88	17.776	17.628	73.55	0.5287	16.41	1.562	15.22	1.00
17	I	1.06	16.94	17.628	17.480	72.92	0.5287	17.47	1.549	15.10	1.00
18	J	0.50	18.00	17.480	17.410	34.21	0.2498	18.25	0.727	7.09	1.00
19	I	0.50	18.50	17.410	17.340	34.07	0.2498	18.75	0.724	7.06	1.00
20	I	0.50	19.00	17.340	17.270	33.93	0.2498	19.25	0.721	7.03	1.00
						1428					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	1112.50	736.61	0.00	709.82
Section Modulus (in^3)	113.38	86.13	0.00	
Cross-Section Area (in^2)	23.11	20.14	0.00	
Width-Thickness Ratio	53.33	46.61	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	20.948	20.948	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.455
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-21 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.19	0.000	21.98	1.100	4.576	8.05
2	0.450	12.62	22.02	0.000	21.81	1.100	4.576	7.99
3	0.450	12.62	21.86	0.000	21.65	1.100	4.576	7.93
4	0.450	12.62	21.69	0.000	21.49	1.100	4.576	7.87
5	0.450	12.62	21.53	0.000	21.32	1.100	4.576	7.81
6	0.450	12.62	21.36	0.000	21.16	1.100	4.576	7.75
7	0.450	12.62	21.20	0.000	21.00	1.100	4.576	7.69
8	0.450	12.62	21.03	0.001	20.83	1.100	4.576	7.63
9	0.450	12.62	20.87	0.001	20.67	1.100	4.576	7.57
10	0.450	12.62	20.70	0.001	20.51	1.100	4.576	7.51
11	0.450	12.62	20.54	0.001	20.34	1.100	4.576	7.45
12	0.450	12.62	20.37	0.001	20.18	1.100	4.576	7.39
13	0.450	15.77	25.25	0.002	20.02	1.100	4.576	7.33
14	0.450	15.77	25.04	0.002	19.85	1.100	4.576	7.27
15	0.450	15.77	24.84	0.002	19.69	1.100	4.576	7.21
16	0.450	15.77	24.63	0.003	19.52	1.100	4.576	7.15
17	0.450	15.77	24.43	0.003	19.36	1.100	4.576	7.09
18	0.450	15.77	11.46	0.002	9.09	1.100	4.576	3.33
19	0.450	15.77	11.42	0.002	9.05	1.100	4.576	3.31
20	0.450	15.77	11.37	0.002	9.01	1.100	4.576	3.30
Fix. #1	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.056	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-21 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	2.50	0.00	14.000	13.650	90.7	1.2447	1.24	2.880	2.880	28.32
2	I	2.50	2.50	13.650	13.300	88.4	1.2446	3.74	2.807	2.807	27.64
3	I	2.50	5.00	13.300	12.950	86.0	1.2444	6.24	2.734	2.734	26.95
4	I	2.50	7.50	12.950	12.600	83.7	1.2443	8.74	2.661	2.661	26.26
5	I	2.50	10.00	12.600	12.250	81.3	1.2441	11.24	2.589	2.589	25.57
6	I	2.50	12.50	12.250	11.900	79.0	1.2440	13.74	2.516	2.516	24.89
7	I	2.50	15.00	11.900	11.550	76.7	1.2438	16.24	2.443	2.443	24.20
8	I	2.50	17.50	11.550	11.200	74.3	1.2436	18.74	2.370	2.370	23.51
9	I	2.50	20.00	11.200	10.850	72.0	1.2434	21.24	2.297	2.297	22.83
10	I	2.50	22.50	10.850	10.500	69.7	1.2432	23.74	2.224	2.224	22.14
11	I	2.50	25.00	10.500	10.150	67.3	1.2429	26.24	2.151	2.151	21.45
12	I	2.50	27.50	10.150	9.800	65.0	1.2427	28.74	2.078	2.078	20.76
13	I	2.50	30.00	9.800	9.450	62.6	1.2424	31.24	2.005	2.005	20.08
14	I	2.50	32.50	9.450	9.100	60.3	1.2421	33.74	1.932	1.932	19.39
15	I	2.50	35.00	9.100	8.750	58.0	1.2418	36.24	1.859	1.859	18.70
16	I	2.50	37.50	8.750	8.400	55.6	1.2415	38.74	1.786	1.786	18.01
17	I	2.50	40.00	8.400	8.050	53.3	1.2411	41.24	1.714	1.714	17.33
18	I	2.50	42.50	8.050	7.700	50.9	1.2407	43.74	1.641	1.641	16.64
19	I	2.50	45.00	7.700	7.350	48.6	1.2403	46.24	1.568	1.568	15.95
20	I	2.50	47.50	7.350	7.000	46.3	1.2398	48.74	1.495	1.495	15.27
		<u>50.00</u>				<u>1370</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	12.50	37.500	1.000	112.50
Fix. #3	105	16.00	13.750	2.000	126.00
Fix. #4	22.5	24.00	7.500	1.000	22.50
Fix. #5	65	27.00	8.700	1.000	78.00
Fix. #6	22	36.00	1.000	1.000	9.00
Fix. #7	22.5	35.00	7.500	1.000	22.50
Fix. #8	65	38.00	8.700	1.000	78.00
Fix. #9	22	47.00	1.000	1.000	9.00
Fix. #10	26.7	46.00	10.500	1.000	31.50
Fix. #11	80	49.00	11.000	1.000	102.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	37.104	0.000
Cross-Section Area (in^2)	10.794	0.000
Width-Thickness Ratio	56.00	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	36.300	0.000
Allow. Shear Stress (ksi)	18.150	0.000



16362-3-21 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000 Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	45.42	36.00	1.100	4.576	13.18	0	0.644	0.00	0.00	
2	1.00	0.450	15.77	44.27	35.09	1.100	4.576	12.85	0	0.666	0.00	0.00	
3	1.00	0.450	15.77	43.12	34.18	1.100	4.576	12.51	0	0.689	0.00	0.00	
4	1.00	0.450	15.77	41.97	33.27	1.100	4.576	12.18	0	0.714	0.00	0.00	
5	1.00	0.450	15.77	40.82	32.36	1.100	4.576	11.85	0	0.740	0.00	0.00	
6	1.00	0.450	15.77	39.67	31.45	1.100	4.576	11.51	0	0.768	0.00	0.00	
7	1.00	0.450	15.77	38.52	30.53	1.100	4.576	11.18	0	0.798	0.00	0.00	
8	1.00	0.450	15.77	37.37	29.62	1.100	4.576	10.84	0	0.830	0.00	0.00	
9	1.00	0.450	15.77	36.22	28.71	1.100	4.576	10.51	0	0.865	0.00	0.00	
10	1.00	0.450	15.77	35.07	27.80	1.100	4.576	10.18	0	0.902	0.00	0.00	
11	1.00	0.450	15.77	33.92	26.89	1.100	4.576	9.84	0	0.942	0.00	0.00	
12	1.00	0.450	15.77	32.77	25.98	1.100	4.576	9.51	0	0.985	0.00	0.00	
13	1.00	0.450	15.77	31.62	25.07	1.100	4.576	9.18	0	1.032	0.00	0.00	
14	1.00	0.450	15.77	30.47	24.15	1.100	4.576	8.84	0	1.083	0.00	0.00	
15	1.00	0.450	15.77	29.32	23.24	1.100	4.576	8.51	1	1.100	0.00	0.00	
16	1.00	0.450	15.77	28.17	22.33	1.100	4.576	8.17	1	1.100	0.00	0.00	
17	1.00	0.471	16.5	28.27	21.42	1.100	4.576	7.84	1	1.100	0.00	0.00	
18	1.00	0.498	17.46	28.65	20.51	1.100	4.576	7.51	1	1.100	0.00	0.00	
19	1.00	0.528	18.52	29.03	19.60	1.100	4.576	7.17	1	1.100	0.00	0.00	
20	1.00	0.562	19.7	29.45	18.68	1.100	4.576	6.84	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



16362-3-21 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

Flange Analysis - Arm #1

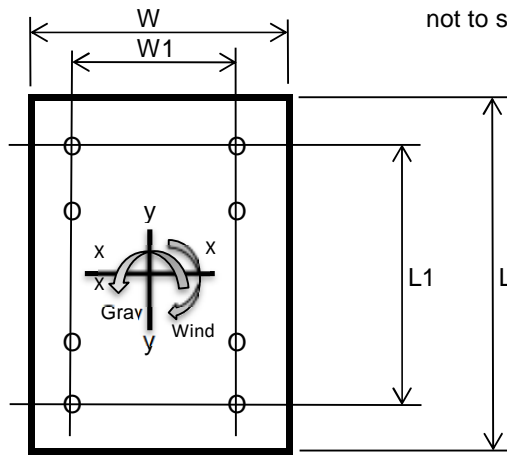
V06-21-16

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1911	2947	-	lbs
Shear (Wind)	5201	2795	-	lbs
Torsion (Arm Rise)	13627	7324	-	ft-lbs
Moment (Gravity)	45745	72547	-	ft-lbs
Moment (Wind)	131913	70114	-	ft-lbs
Nat. Wind Moment	-	-	18208	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	14.00	in
Tube Wall Thick.	0.25	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	14.69	14.00	ksi
Bolt Shear Stress - fv	1.79	1.09	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.35	0.33	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	1.73	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.25	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	8.05	12.77	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	23.61	12.55	ksi
Combined applied stress for interaction (SRSS)	24.94	17.90	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-21 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.3	
Dop - Baseplate center hole diameter	15.25	in
Cop - Center hole to shaft diameter ratio	0.7625	
Kf - Fatigue stress concentration factor for finite life	2.49	
Ki - Fatigue stress concentration factor for infinite life	5.82	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.25	in
Dt - Arm base diameter	14.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.27	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.428571	
Kf - Fatigue stress concentration factor for finite life	1.88	
Ki - Fatigue stress concentration factor for infinite life	3.64	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



## 16362-3-21 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

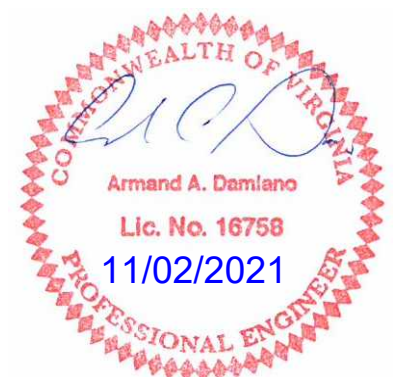
## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	19.57	in
Shaft Thickness	0.375	in
Total Area	27.3136	in <sup>2</sup>
Ix	1143	in <sup>4</sup>
Iy	1250	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	17733	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	7.15	ksi
CSR	0.45	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	1.97	ksi
CSR	0.28	
Therefore	<b>OK</b>	





16362-3-21 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	1911		1911	45745		45746		355	14795		0.41
Gp II	1911	5201	5541	45745	131913	139620	13627	1027	45156	2204	0.96
Gp III	2947	2795	4062	72547	70114	100892	7324	753	32631	1185	0.69
Gp IV Natural		734	734		18208	18208	1923	137	5889	311	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-21 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	3503		45745	0	45745		152		4842		0.14
Gp II	3503	6480	67194	121756	139067	131913	152	561	14719	6981	0.41
Gp III	4996	3614	57638	92860	109294	70114	216	313	11568	3711	0.28
Gp IV Natural			17733	0	17733				1877		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9984										

<b>Shaft At Arm</b>											
Gp I	2013		45745	0	45745		100		6373		0.18
Gp II	2013	5235	13627	45771	47756	131913	100	520	6654	9189	0.31
Gp III	3049	2822	7324	72567	72936	70114	151	281	10162	4884	0.27
Gp IV Natural			1930	0	1930				269		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9984										



16362-3-2A - VA - 90 MPH - MP-3 Std. Loads-Type B1 w/50' Arm  
Weld Analysis

Page S4

**INPUTS**

	<b>Gp II</b>	<b>GpIII</b>		<b>Arm Dimensions</b>		
<b>Applied Loads To Flange Connection</b>						
Vert. Shr	1911	2947	lbs	Diameter (d)	14.0	in
Horz. Shr	5201	2795	lbs	Tube Wall Thk	0.25	in
Torsion Moment	13627	7324	ft-lbs	Plate Thk (D)	2.25	in
Gravity Moment	45745	72547	ft-lbs	Plate Yield (Fy)	50	ksi
Wind Moment	131913	70114	ft-lbs			
<b>Applied Loads To Base Plate Connection</b>				<b>Shaft Dimensions</b>		
Axial	0	0	lbs	Diameter (d)	20.0	in
Shear	0	0	lbs	Tube Wall Thk	<b>0.375</b>	in
Shear	0	0	lbs	Plate Thk (D)	2	in
Bending Moment	0	0	ft-lbs	Plate Yield (Fy)	36	ksi
Bending Moment	0	0	ft-lbs	Arm Attach. Elev.	<b>18.0</b>	ft
Torsion Moment	0	0	ft-lbs			

Additional Load Factor To Apply As Per Signal Plans & Specifications = **1.00**

**Electrodes**

**AASHTO Gp II & III Factor = 1.33**

**E70 Electrodes (Used with plates having Fy = 36 ksi)**

$F_v = 0.27 F_u$  (AASHTO Bridge Spec 10.32.2)

$F_v = 0.27 \times 58000 = 15660$  psi

Allowable =  $F_v \times \text{Gp Factor} = 20828$  psi

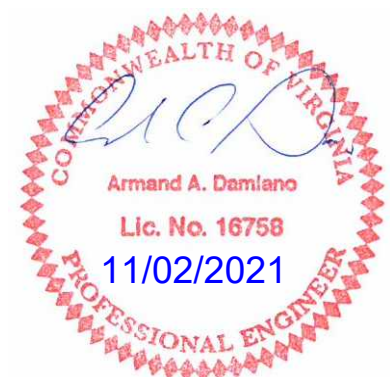
**E70 Electrodes (Used with plates having Fy = 50 ksi)**

$F_v = 0.27 \times 65000 = 17550$  psi

Allowable =  $F_v \times \text{Gp Factor} = 23342$  psi

Reference: *Design of Welded Structures*, Omer W. Blodgett

Method: Weld As A Line

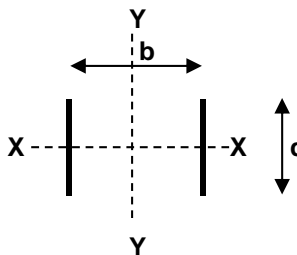


16362-3-2A - VA - 90 MPH - MP-3 Std. Loads-Type B1 w/50' Arm  
Weld Analysis - Continued

**ARM CONNECTING PLATES**

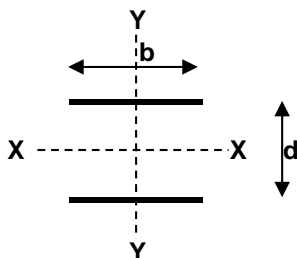
**Side Plates**

Vertical Length (d)	27.00	in
Horz. Dist Between Plates (b)	17.48	in
Thickness	0.5	in
Weld Size	0.375	in
Weld Throat (t <sub>1</sub> )	0.265	in
A <sub>1</sub> = A <sub>w1</sub> * t <sub>1</sub> = 2 * d * t <sub>1</sub>	=	14.32 in <sup>2</sup>
S <sub>x1</sub> = S <sub>wx1</sub> * t <sub>1</sub> = (d <sup>2</sup> / 3) * t <sub>1</sub>	=	64.43 in <sup>3</sup>
S <sub>y1</sub> = S <sub>wy1</sub> * t <sub>1</sub> = b * d * t <sub>1</sub>	=	125.13 in <sup>3</sup>
J <sub>1</sub> = J <sub>w1</sub> * t <sub>1</sub> = t <sub>1</sub> * d(3b <sup>2</sup> + d <sup>2</sup> ) / 6	=	1963.40 in <sup>4</sup>



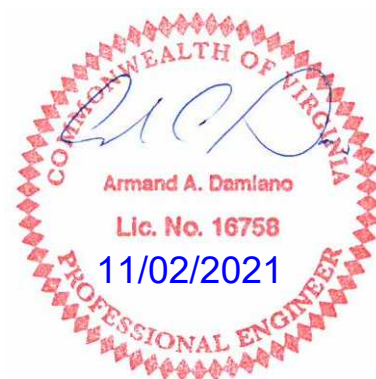
**Top & Bottom Plates**

Vert. Dist Between Plates (d)	27.00	in
Horz. Length (b)	27.46	in
Thickness	0.5	in
Weld Size	0.375	in
Weld Throat (t <sub>2</sub> )	0.265	in
A <sub>2</sub> = A <sub>w2</sub> * t <sub>2</sub> = t <sub>2</sub> * 2 * b	=	14.6 in <sup>2</sup>
S <sub>x2</sub> = S <sub>wx2</sub> * t <sub>2</sub> = t <sub>2</sub> * b * d	=	196.6 in <sup>3</sup>
S <sub>y2</sub> = S <sub>wy2</sub> * t <sub>2</sub> = t <sub>2</sub> * (b <sup>2</sup> / 3)	=	66.6 in <sup>3</sup>
J <sub>2</sub> = J <sub>w2</sub> * t <sub>2</sub> = t <sub>2</sub> * (b <sup>3</sup> + 3bd <sup>2</sup> ) / 6	=	3568.2 in <sup>4</sup>



**Combined Analysis**

σ <sub>1</sub> = Gravity Mom / (S <sub>x1</sub> + S <sub>x2</sub> )	=	2104.0	Gp II	3336.0	psi
σ <sub>2</sub> = Wind Mom / (S <sub>y1</sub> + S <sub>y2</sub> )	=	8255.0	Gp III	4388.0	psi
σ <sub>2</sub> = [Tor. Mom * C / (J <sub>1</sub> + J <sub>2</sub> )] + [Res. Shr / (A <sub>1</sub> + A <sub>2</sub> )]	=	668.0		397.0	psi
Res. Weld Stress = σ <sub>r</sub> = Sqrt[ (σ <sub>1</sub> + σ <sub>2</sub> ) <sup>2</sup> + σ <sub>3</sub> <sup>2</sup> ]	=	10381		7735	psi
Allowable: E70 Electrodes * AASHTO Gp Factor	=	23341.5		23341.5	psi
<b>Actual Weld Stress vs. Allowable</b>		<b>Passes</b>		<b>Passes</b>	



16362-3-21 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	6480 lbs
Bending Moment	139067 ft-lbs
Torsion Moment	131913 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.00 in

**ANALYSIS - ANCHOR BOLTS**

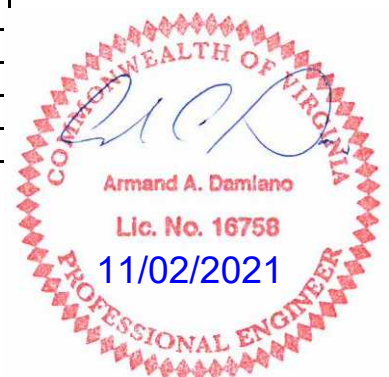
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	12.807 ksi
Bolt Direct Shear Stress	0.353 ksi
Bolt Torsion Shear Stress	6.618 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	12.807 ksi
$f_v =$	6.971 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.48 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3 in
Design Moment	97 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	14.66 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.438 in
Design Moment	47 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	7.45 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-3-21 - VA - 90 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	17733 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	1.64 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.24
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

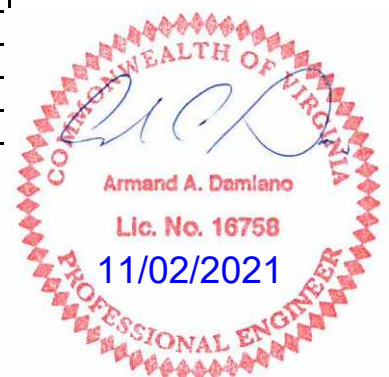
Anchor Bolt Length	60.0 in
Anchor Bolt Max. Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	32018 lbs
Computed Factor-of Safety	1.94 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	32018 lbs
Total Tensile Load	256144 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.84 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	32018 lbs
Total Tensile Load	256144 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	6 Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

11/02/21

**General**

Wind Vel.- mph	90	No	Roadway - mph	55	<b>Fatigue Importance Factors</b>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	1		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	1		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.00	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	0.14	14.00	50.00	18.00	-	2.62	0	55	29000	180
Traffic Arm #2						-		0	55	29000	90
Lum Arm #1	0.3750		2.88	24.00	24.00	-	5	0	36	29000	180
Lum Arm #2						-		0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8	Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes
A.B. Bolt Circle	26.00	in	Foundation Diameter	48
Baseplate Dia.	32.00	in	Concrete Cover	4
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000
B.P. Center Hole	15.25	in	Vertical Reinforcing Bar Size #	8
Weld Type	Full Pen.		Rebar Yield Strength fy	60
				ksi

**Flange Simplex**

	Arm #1	Arm #2
Flange Bolt Qty.	8	NA
Bolt Diameter	1.50	in
Flange Plate Length (V)	27.00	in
Flange Plate Width (H)	27.00	in
Spac. Between Bolt (V)	22.50	in
Spac. Between Bolt (H)	22.50	in
Flange Plate Thk.	2.25	in
Flange Plate Yield (Fy)	50	ksi
Gusset Thk.	0.500	in
Plate Center Hole	6.00	in
Weld Type	Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.14	0.19	0.41								12.53	0.00
GP II CSR	0.46	0.34	0.96				0.95					
GP III CSR	0.30	0.28	0.69				0.69				20.09	
Nat.Wind (psi)	1960	290	5889									

Arm #1 Flange Bolt (Max.) CSR	0.35
Arm #1 Flange Bolt Fatigue CSR	0.25
Arm #1 Flange Plate (Max.) CSR	0.57
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.47
Handhole at Toe (Fatigue) CSR	0.29
Minimum Qty of Vertical Reinf. Bars	7

Fatigue Allowable - Shaft to Baseplate	4.5	ksi
Fatigue Allowable - Arm#1 to Flange	7	ksi
Fatigue Allowable - Arm#2 to Flange	-	
Anchor Bolt Max. CSR	0.52	
Anchor Bolt Max. Fatigue Stress Ratio	0.25	
Base Plate Max. CSR	0.52	
Anchorage Capacity S.F.	1.71	
Concrete Pull Out Capacity S.F.	1.62	

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
6015	7111	157684	133775



16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

Input Loads

**Fixture Input Data**

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1	Cobra Head w/Camera	24	2	1			4.54	9	57	1.00
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	12.5			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	16	13.75	4			2	42	105	1.20
	#4	2.5'x3' Sign	24			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	27	8.7	4			1	26	65	1.20
	#6	Camera	36	1	1			1	3	22	1.20
	#7	2.5'x3' Sign	35			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	38	8.7	4			1	26	65	1.20
	#9	Camera	47	1	1			1	3	22	1.20
	#10	3'x3.5' Sign	46			3	3.5	1	10.5	26.7	1.13
	#11	4 Section Head w/BP	49	11	5			1	34	80	1.20
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1										
	#2										
	#3										
	#4										
	#5										
	#6										
	#7										
	#8										
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										





16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.000	19.852	82.99	0.5288	0.53	1.758	17.07	0.80
2	I	1.06	1.06	19.852	19.704	82.36	0.5288	1.59	1.745	16.95	0.80
3	I	1.06	2.12	19.704	19.555	81.73	0.5287	2.65	1.732	16.82	0.80
4	I	1.06	3.18	19.555	19.407	81.10	0.5287	3.71	1.719	16.70	0.80
5	I	1.06	4.24	19.407	19.259	80.47	0.5287	4.76	1.706	16.58	0.80
6	I	1.06	5.29	19.259	19.111	79.84	0.5287	5.82	1.693	16.45	0.80
7	I	1.06	6.35	19.111	18.962	79.21	0.5287	6.88	1.680	16.33	0.80
8	I	1.06	7.41	18.962	18.814	78.58	0.5287	7.94	1.667	16.21	0.80
9	I	1.06	8.47	18.814	18.666	77.95	0.5287	9.00	1.654	16.08	0.80
10	I	1.06	9.53	18.666	18.518	77.32	0.5287	10.06	1.640	15.96	0.80
11	I	1.06	10.59	18.518	18.369	76.69	0.5287	11.12	1.627	15.84	0.80
12	I	1.06	11.65	18.369	18.221	76.06	0.5287	12.18	1.614	15.71	0.80
13	I	1.06	12.71	18.221	18.073	75.43	0.5287	13.23	1.601	15.59	1.00
14	I	1.06	13.76	18.073	17.925	74.81	0.5287	14.29	1.588	15.47	1.00
15	I	1.06	14.82	17.925	17.776	74.18	0.5287	15.35	1.575	15.34	1.00
16	I	1.06	15.88	17.776	17.628	73.55	0.5287	16.41	1.562	15.22	1.00
17	I	1.06	16.94	17.628	17.480	72.92	0.5287	17.47	1.549	15.10	1.00
18	J	3.00	18.00	17.480	17.060	203.18	1.4939	19.49	4.318	42.10	1.00
19	I	3.00	21.00	17.060	16.640	198.13	1.4938	22.49	4.213	41.12	1.00
20	J	1.00	24.00	16.640	16.500	64.92	0.4993	24.50	1.381	13.49	1.00
						1792					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in <sup>4</sup> )	1112.50	736.61	0.00	617.12
Section Modulus (in <sup>3</sup> )	113.38	86.13	0.00	
Cross-Section Area (in <sup>2</sup> )	23.11	20.14	0.00	
Width-Thickness Ratio	53.33	46.61	0.00	
Compact Limit	68.55	68.55	0.00	
Non-Compact Limit	137.09	137.09	0.00	
Maximum Limit	237.27	237.27	0.00	
Allow. Bending Stress (ksi)	36.300	36.300	0.000	
Allow. Compressive Str (ksi)	14.993	14.993	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

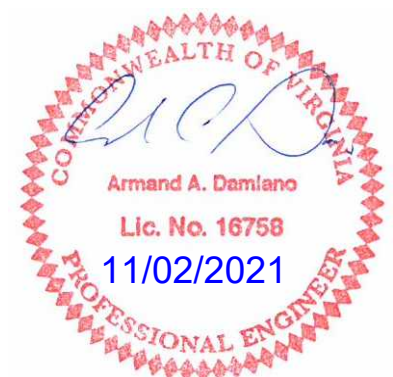
Shaft Deflection From Arm#1 GP I Load (in)	0.455
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

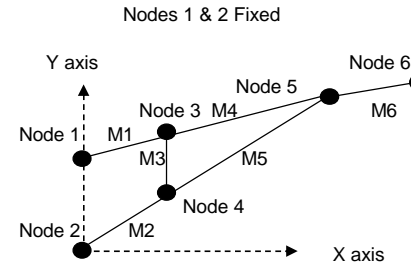
## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.19	0.000	21.98	1.100	4.576	8.05
2	0.450	12.62	22.02	0.000	21.81	1.100	4.576	7.99
3	0.450	12.62	21.86	0.000	21.65	1.100	4.576	7.93
4	0.450	12.62	21.69	0.000	21.49	1.100	4.576	7.87
5	0.450	12.62	21.53	0.000	21.32	1.100	4.576	7.81
6	0.450	12.62	21.36	0.000	21.16	1.100	4.576	7.75
7	0.450	12.62	21.20	0.001	21.00	1.100	4.576	7.69
8	0.450	12.62	21.03	0.001	20.83	1.100	4.576	7.63
9	0.450	12.62	20.87	0.001	20.67	1.100	4.576	7.57
10	0.450	12.62	20.70	0.001	20.51	1.100	4.576	7.51
11	0.450	12.62	20.54	0.002	20.34	1.100	4.576	7.45
12	0.450	12.62	20.37	0.002	20.18	1.100	4.576	7.39
13	0.450	15.77	25.25	0.003	20.02	1.100	4.576	7.33
14	0.450	15.77	25.04	0.003	19.85	1.100	4.576	7.27
15	0.450	15.77	24.84	0.003	19.69	1.100	4.576	7.21
16	0.450	15.77	24.63	0.004	19.52	1.100	4.576	7.15
17	0.450	15.77	24.43	0.004	19.36	1.100	4.576	7.09
18	0.450	15.77	68.09	0.015	53.97	1.100	4.576	19.76
19	0.450	15.77	66.43	0.018	52.66	1.100	4.576	19.28
20	0.450	15.77	21.78	0.007	17.26	1.100	4.576	6.32
Fix. #1	1.200	33.65	80.76	0.006	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.006	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.077	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm - Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-44.01	-40.6	0	0	0
Node #2	0	0	0	0	-46.58	-42.9	0	0	0
Node #3	100	59.5	0	0	-87	-84.8	0	0	0
Node #4	100	48.8	0	0	-90.64	-88.2	0	0	0
Node #5	200	79	0	0	-123.35	-125	0	0	0
Node #6	288	87	0	0	-93.99	-114.6	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-88.02	1.1	1	-81.07	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-93.14	1.1	1	-85.79	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.95	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-85.28	1.1	1.1	-86.40	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-87.44	1.1	1.1	-88.59	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-73.97	1.1	1.1	-74.94	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-77.10					

AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2629.3	lbs
P1y	-827.0	lbs
P1z	294.4	lbs
M1x	10996.1	in-lbs
M1y	-41528.6	in-lbs
M1z	-716.1	in-lbs
P2x	2629.3	lbs
P2y	1312.5	lbs
P2z	201.7	lbs
M2x	11346.6	in-lbs
M2y	-33776.2	in-lbs
M2z	-770.7	in-lbs

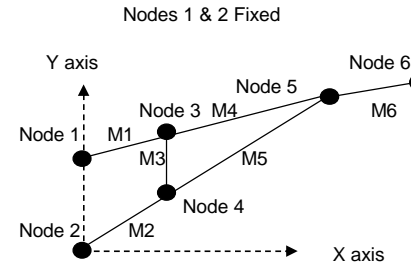
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-939	173	26099	-644	0.76
#2	989	109	21500	-1250	0.95
#3	1807	572	11253	-534	0.45
#4	-919	78	10031	-29	0.28
#5	936	91	11105	-380	0.58
#6	3	101	7955	-1	0.24

V09.19.15



16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm - Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-51.2	-20.3	0	0	0
Node #2	0	0	0	0	-54.18	-21.5	0	0	0
Node #3	100	59.5	0	0	-101.41	-42.4	0	0	0
Node #4	100	48.8	0	0	-105.65	-44.1	0	0	0
Node #5	200	79	0	0	-143.49	-62.5	0	0	0
Node #6	288	87	0	0	-124.03	-57.3	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.375	105.15	2.10	2.952	-102.39	1.1	1	-40.53	2.367	2.367	4.734	11000000	29000000
Member #2	2.88	0.375	111.27	2.23	2.952	-108.35	1.1	1	-42.89	2.367	2.367	4.734	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.98	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.375	101.88	2.04	2.952	-99.21	1.1	1.1	-43.20	2.367	2.367	4.734	11000000	29000000
Member #5	2.88	0.375	104.46	2.09	2.952	-101.72	1.1	1.1	-44.29	2.367	2.367	4.734	11000000	29000000
Member #6	2.88	0.375	88.36	1.77	2.952	-86.04	1.1	1.1	-37.47	2.367	2.367	4.734	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-38.55					

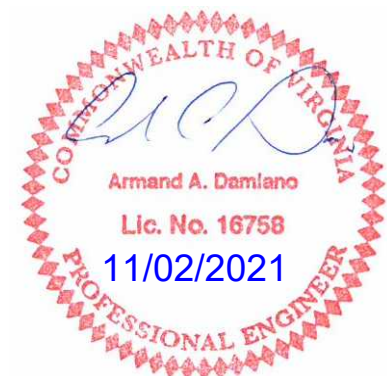
AASHTO Gp	3
Mntg Hght =	29.00
Datum =	1

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	2409 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2734 psi
Fa Member 6	3821 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-3247.7	lbs
P1y	-1031.5	lbs
P1z	147.2	lbs
M1x	5498.0	in-lbs
M1y	-20764.3	in-lbs
M1z	-1257.5	in-lbs
P2x	3247.7	lbs
P2y	1611.4	lbs
P2z	100.9	lbs
M2x	5673.3	in-lbs
M2y	-16888.1	in-lbs
M2z	-1306.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1160	88	13070	-322	0.36
#2	1221	57	10777	-625	0.69
#3	2226	425	8530	-267	0.39
#4	-1137	47	5068	-15	0.12
#5	1159	52	5600	-190	0.48
#6	4	93	7320	-1	0.23

V09.19.15



16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	2.50	0.00	14.000	13.650	90.7	1.2447	1.24	2.880	2.880	28.32
2	I	2.50	2.50	13.650	13.300	88.4	1.2446	3.74	2.807	2.807	27.64
3	I	2.50	5.00	13.300	12.950	86.0	1.2444	6.24	2.734	2.734	26.95
4	I	2.50	7.50	12.950	12.600	83.7	1.2443	8.74	2.661	2.661	26.26
5	I	2.50	10.00	12.600	12.250	81.3	1.2441	11.24	2.589	2.589	25.57
6	I	2.50	12.50	12.250	11.900	79.0	1.2440	13.74	2.516	2.516	24.89
7	I	2.50	15.00	11.900	11.550	76.7	1.2438	16.24	2.443	2.443	24.20
8	I	2.50	17.50	11.550	11.200	74.3	1.2436	18.74	2.370	2.370	23.51
9	I	2.50	20.00	11.200	10.850	72.0	1.2434	21.24	2.297	2.297	22.83
10	I	2.50	22.50	10.850	10.500	69.7	1.2432	23.74	2.224	2.224	22.14
11	I	2.50	25.00	10.500	10.150	67.3	1.2429	26.24	2.151	2.151	21.45
12	I	2.50	27.50	10.150	9.800	65.0	1.2427	28.74	2.078	2.078	20.76
13	I	2.50	30.00	9.800	9.450	62.6	1.2424	31.24	2.005	2.005	20.08
14	I	2.50	32.50	9.450	9.100	60.3	1.2421	33.74	1.932	1.932	19.39
15	I	2.50	35.00	9.100	8.750	58.0	1.2418	36.24	1.859	1.859	18.70
16	I	2.50	37.50	8.750	8.400	55.6	1.2415	38.74	1.786	1.786	18.01
17	I	2.50	40.00	8.400	8.050	53.3	1.2411	41.24	1.714	1.714	17.33
18	I	2.50	42.50	8.050	7.700	50.9	1.2407	43.74	1.641	1.641	16.64
19	I	2.50	45.00	7.700	7.350	48.6	1.2403	46.24	1.568	1.568	15.95
20	I	2.50	47.50	7.350	7.000	46.3	1.2398	48.74	1.495	1.495	15.27
		<u>50.00</u>				<u>1370</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	12.50	37.500	1.000	112.50
Fix. #3	105	16.00	13.750	2.000	126.00
Fix. #4	22.5	24.00	7.500	1.000	22.50
Fix. #5	65	27.00	8.700	1.000	78.00
Fix. #6	22	36.00	1.000	1.000	9.00
Fix. #7	22.5	35.00	7.500	1.000	22.50
Fix. #8	65	38.00	8.700	1.000	78.00
Fix. #9	22	47.00	1.000	1.000	9.00
Fix. #10	26.7	46.00	10.500	1.000	31.50
Fix. #11	80	49.00	11.000	1.000	102.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	37.104	0.000
Cross-Section Area (in^2)	10.794	0.000
Width-Thickness Ratio	56.00	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	36.300	0.000
Allow. Shear Stress (ksi)	18.150	0.000



16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

Arm #1 Analysis Continued

Sec. Num.	Kz	Truck Induced Gust											
		Group 2			Group 3	Natural Wind Gust			Hght Corr. Factor = 1.000				Gallop
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	Loads (lbs)
1	1.00	0.450	15.77	45.42	36.00	1.100	4.576	13.18	0	0.644	0.00	0.00	
2	1.00	0.450	15.77	44.27	35.09	1.100	4.576	12.85	0	0.666	0.00	0.00	
3	1.00	0.450	15.77	43.12	34.18	1.100	4.576	12.51	0	0.689	0.00	0.00	
4	1.00	0.450	15.77	41.97	33.27	1.100	4.576	12.18	0	0.714	0.00	0.00	
5	1.00	0.450	15.77	40.82	32.36	1.100	4.576	11.85	0	0.740	0.00	0.00	
6	1.00	0.450	15.77	39.67	31.45	1.100	4.576	11.51	0	0.768	0.00	0.00	
7	1.00	0.450	15.77	38.52	30.53	1.100	4.576	11.18	0	0.798	0.00	0.00	
8	1.00	0.450	15.77	37.37	29.62	1.100	4.576	10.84	0	0.830	0.00	0.00	
9	1.00	0.450	15.77	36.22	28.71	1.100	4.576	10.51	0	0.865	0.00	0.00	
10	1.00	0.450	15.77	35.07	27.80	1.100	4.576	10.18	0	0.902	0.00	0.00	
11	1.00	0.450	15.77	33.92	26.89	1.100	4.576	9.84	0	0.942	0.00	0.00	
12	1.00	0.450	15.77	32.77	25.98	1.100	4.576	9.51	0	0.985	0.00	0.00	
13	1.00	0.450	15.77	31.62	25.07	1.100	4.576	9.18	0	1.032	0.00	0.00	
14	1.00	0.450	15.77	30.47	24.15	1.100	4.576	8.84	0	1.083	0.00	0.00	
15	1.00	0.450	15.77	29.32	23.24	1.100	4.576	8.51	1	1.100	0.00	0.00	
16	1.00	0.450	15.77	28.17	22.33	1.100	4.576	8.17	1	1.100	0.00	0.00	
17	1.00	0.471	16.5	28.27	21.42	1.100	4.576	7.84	1	1.100	0.00	0.00	
18	1.00	0.498	17.46	28.65	20.51	1.100	4.576	7.51	1	1.100	0.00	0.00	
19	1.00	0.528	18.52	29.03	19.60	1.100	4.576	7.17	1	1.100	0.00	0.00	
20	1.00	0.562	19.7	29.45	18.68	1.100	4.576	6.84	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



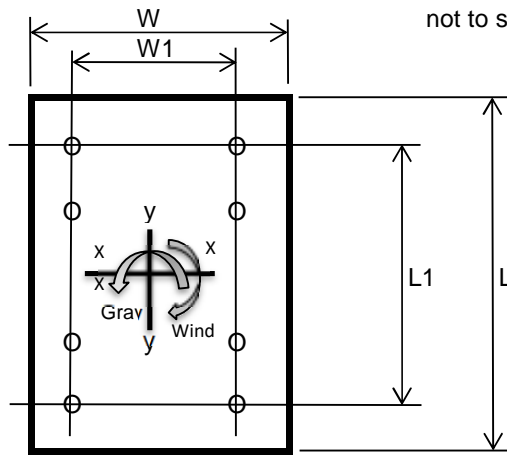
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1911	2947	-	lbs
Shear (Wind)	5201	2795	-	lbs
Torsion (Arm Rise)	13627	7324	-	ft-lbs
Moment (Gravity)	45745	72547	-	ft-lbs
Moment (Wind)	131913	70114	-	ft-lbs
Nat. Wind Moment	-	-	18208	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	14.00	in
Tube Wall Thick.	0.25	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	14.69	14.00	ksi
Bolt Shear Stress - fv	1.79	1.09	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.35	0.33	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	1.73	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.25	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	8.05	12.77	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	23.61	12.55	ksi
Combined applied stress for interaction (SRSS)	24.94	17.90	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.3	
Dop - Baseplate center hole diameter	15.25	in
Cop - Center hole to shaft diameter ratio	0.7625	
Kf - Fatigue stress concentration factor for finite life	2.49	
Ki - Fatigue stress concentration factor for infinite life	5.82	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.25	in
Dt - Arm base diameter	14.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.27	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.428571	
Kf - Fatigue stress concentration factor for finite life	1.88	
Ki - Fatigue stress concentration factor for infinite life	3.64	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle





## 16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	19.57	in
Shaft Thickness	0.375	in
Total Area	27.3136	in <sup>2</sup>
Ix	1143	in <sup>4</sup>
Iy	1250	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	18520	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	7.46	ksi
CSR	0.47	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.06	ksi
CSR	0.29	
Therefore	<b>OK</b>	



16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear (ft-lbs)	Shear (psi)	Bending (psi)	Torsion (psi)	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	1911		1911	45745		45746		355	14795		0.41
Gp II	1911	5201	5541	45745	131913	139620	13627	1027	45156	2204	0.96
Gp III	2947	2795	4062	72547	70114	100892	7324	753	32631	1185	0.69
Gp IV Natural		734	734		18208	18208	1923	137	5889	311	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	4353		45745	0	45745		188		4842		0.14
Gp II	4353	7111	67194	142651	157684	133775	188	616	16690	7080	0.46
Gp III	6015	3965	57638	104103	118994	71045	260	344	12595	3760	0.30
Gp IV Natural			18520	0	18520				1960		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9981										

<b>Shaft At Arm</b>											
Gp I	2863		45745	0	45745		142		6373		0.19
Gp II	2863	5853	13627	55539	57186	133775	142	582	7968	9319	0.34
Gp III	3993	3167	7324	77603	77948	71045	198	315	10860	4949	0.28
Gp IV Natural			2080	0	2080				290		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9981										



16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	7111 lbs
Bending Moment	157684 ft-lbs
Torsion Moment	133775 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.00 in

**ANALYSIS - ANCHOR BOLTS**

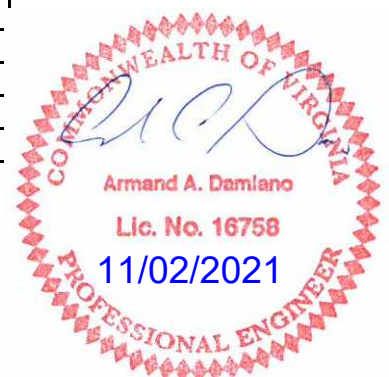
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	14.522 ksi
Bolt Direct Shear Stress	0.387 ksi
Bolt Torsion Shear Stress	6.712 ksi
Combined Bolt Stress	
Fv = .3 Fy * Allowable Increase Factor	21.945 ksi
Ft = .5Fy * Allowable Increase Factor	36.575 ksi
ft =	14.522 ksi
fv =	7.099 ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.52 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3 in
Design Moment	109 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	16.47 ksi
Allowable Plate Stress = .66Fy*Allow.Incr.	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.438 in
Design Moment	53 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	8.4 ksi
Allowable Plate Stress = .66Fy*Allow.Incr.	31.6 ksi
Therefore	<b>OK</b>



16362-3-22 - VA - 90 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	18520 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	1.71 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.25
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

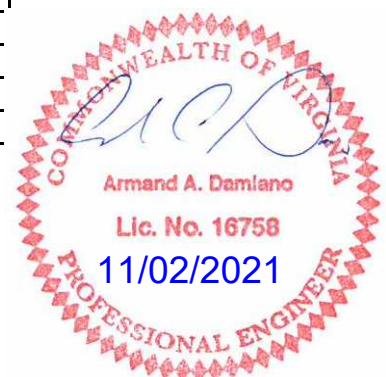
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	36305 lbs
Computed Factor-of Safety	1.71 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	36305 lbs
Total Tensile Load	290440 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.62 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	36305 lbs
Total Tensile Load	290440 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	7 Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

11/02/21

**General**

Wind Vel. - mph	90		Roadway - mph	55		<b>Fatigue Importance Factors</b>	
Natural Wind	11.2		Plate Yield (ksi)	36		Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870		Galloping	0.65 No
Fatigue Cat.	2		Vel. Conver. Cv	0.930		Vortex Shedding	0.00 No
Recurrence (yr)	25		Gust Effect G	1.300		Natural Wind Gust	0.80 Yes
Hurricane Region	0	No	Elev. Pole Bot.(ft)	1		Truck Gust	0.85 No
# Traffic Arms	2		<b>AASHTO Editon</b>	<b>6TH</b>		Wind Pressure - Appendix C	Yes
# Lum. Arms	0		State	VA			

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.50	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.3130	0.14	17.50	25.00	18.00	-	3.67	0	55	29000	180
	0.1880	0.14	14.79	47.92	-	2.92		0	55	29000	
Traffic Arm #2	0.2190	0.14	14.00	40.00	18.00	-	2.10	0	55	29000	270
								0	55	29000	
Lum Arm #1								0	36	29000	180
Lum Arm #2								0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8		Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes	
A.B. Bolt Circle	26.00	in	Foundation Diameter	48	in
Baseplate Dia.	32.00	in	Concrete Cover	4	in
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	15.75	in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.		Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1		Arm #2	
Flange Bolt Qty.	8		8	
Bolt Diameter	1.50	in	1.50	in
Flange Plate Length (V)	27.00	in	27.00	in
Flange Plate Width (H)	27.00	in	27.00	in
Spac. Between Bolt (V)	22.50	in	22.50	in
Spac. Between Bolt (H)	22.50	in	22.50	in
Flange Plate Thk.	2.25	in	2.25	in
Flange Plate Yield (Fy)	50	ksi	50	ksi
Gusset Thk.	0.500	in	0.500	in
Plate Center Hole	6.00	in	6.00	in
Weld Type	Full Pen.		Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1		Lum#2		Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Root	Root	Arm #1	Arm #2
GP I CSR	0.27	0.35	0.41	0.41	0.30						24.47	5.37
GP II CSR	0.72	0.75	0.84	0.97	0.69							
GP III CSR	0.53	0.57	0.65	0.71	0.50						39.96	8.84
Nat.Wind (psi)	2633	490	5419	5792	4333							

Arm #1 Flange Bolt (Max.) CSR	0.61
Arm #1 Flange Bolt Fatigue CSR	0.45
Arm #1 Flange Plate (Max.) CSR	0.89
Arm #2 Flange Bolt (Max.) CSR	0.22
Arm #2 Flange Bolt Fatigue CSR	0.16
Arm #2 Flange Plate (Max.) CSR	0.36
Handhole at Root (Fatigue) CSR	0.63
Handhole at Toe (Fatigue) CSR	0.39
Minimum Qty of Vertical Reinf. Bars	9

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	7 ksi
Anchor Bolt Max. CSR	0.78
Anchor Bolt Max. Fatigue Stress Ratio	0.35
Base Plate Max. CSR	0.63
Anchorage Capacity S.F.	1.29
Concrete Pull Out Capacity S.F.	1.23

**Ground Line Reactions**

Axial (lbs)	8847	Shear (lbs)	7510	Bending (ft-lbs)	208242	Torsion (ft-lbs)	238735
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16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft.)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.2
	#2	Ped Head	10.5	2.4	1			1	6	30	1.2
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.2
	#4										
Lum #1	#1										
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	12	13.75	4	15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	25	13.75	4			2	42	105	1.20
	#4	2.5'x3' Sign	29			2.5	3	1	7.5	22.5	1.13
	#5	3 Section Head w/BP	36	8.7	4			1	26	65	1.20
	#6	Camera	40	1	1			1	3	22	1.20
	#7	2.5'x3' Sign	44			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	47	8.7	4			1	26	65	1.20
	#9	2.5'x3' Sign	55			2.5	3	1	7.5	22.5	1.13
	#10	3 Section Head w/BP	58	8.7	4			1	26	65	1.20
	#11	Camera	62	1	1			1	3	22	1.20
	#12	3'x3.5' Sign	66			3	3.5	1	10.5	26.7	1.13
	#13	4 Section Head w/BP	69	11	5			1	34	80	1.20
#14											
#15											
#16											
#17											
#18											
#19											
#20											
For Arm #2	#1	Camera	4	1	1			1	3	22	1.20
	#2	12'x2.5' Sign	8	13.75	4	12	2.5	1	30	66	1.20
	#3	5 Section Head w/BP	17	13.75	4			2	42	105	1.20
	#4	Camera	20	1	1			1	3	22	1.20
	#5	2.5'x3' Sign	25			2.5	3	1	7.5	22.5	1.13
	#6	3 Section Head w/BP	28	8.7	4			1	26	65	1.20
	#7	Camera	30	1	1			1	3	22	1.20
	#8	3'x3.5' Sign	36			3	3.5	1	10.5	26.7	1.13
	#9	4 Section Head w/BP	39	11	5			1	34	80	1.20
	#10										
	#11										
	#12										
	#13										
#14											
#15											
#16											
#17											
#18											
#19											
#20											



16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.500	20.352	85.11	0.5288	0.53	1.802	17.48	0.80
2	I	1.06	1.06	20.352	20.204	84.48	0.5288	1.59	1.789	17.36	0.80
3	I	1.06	2.12	20.204	20.055	83.85	0.5288	2.65	1.776	17.24	0.80
4	I	1.06	3.18	20.055	19.907	83.22	0.5288	3.71	1.763	17.12	0.80
5	I	1.06	4.24	19.907	19.759	82.59	0.5288	4.76	1.750	16.99	0.80
6	I	1.06	5.29	19.759	19.611	81.96	0.5287	5.82	1.737	16.87	0.80
7	I	1.06	6.35	19.611	19.462	81.33	0.5287	6.88	1.724	16.75	0.80
8	I	1.06	7.41	19.462	19.314	80.70	0.5287	7.94	1.711	16.62	0.80
9	I	1.06	8.47	19.314	19.166	80.07	0.5287	9.00	1.698	16.50	0.80
10	I	1.06	9.53	19.166	19.018	79.44	0.5287	10.06	1.685	16.38	0.80
11	I	1.06	10.59	19.018	18.869	78.82	0.5287	11.12	1.671	16.25	0.80
12	I	1.06	11.65	18.869	18.721	78.19	0.5287	12.18	1.658	16.13	0.80
13	I	1.06	12.71	18.721	18.573	77.56	0.5287	13.23	1.645	16.01	1.00
14	I	1.06	13.76	18.573	18.425	76.93	0.5287	14.29	1.632	15.88	1.00
15	I	1.06	14.82	18.425	18.276	76.30	0.5287	15.35	1.619	15.76	1.00
16	I	1.06	15.88	18.276	18.128	75.67	0.5287	16.41	1.606	15.64	1.00
17	I	1.06	16.94	18.128	17.980	75.04	0.5287	17.47	1.593	15.51	1.00
18	J	0.50	18.00	17.980	17.910	35.22	0.2498	18.25	0.748	7.28	1.00
19	I	0.50	18.50	17.910	17.840	35.08	0.2498	18.75	0.745	7.26	1.00
20	I	0.50	19.00	17.840	17.770	34.94	0.2498	19.25	0.742	7.23	1.00
						1467					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in <sup>4</sup> )	1199.72	803.12	803.12	774.72
Section Modulus (in <sup>3</sup> )	119.23	91.24	91.24	
Cross-Section Area (in <sup>2</sup> )	23.70	20.73	20.73	
Width-Thickness Ratio	54.67	47.95	47.95	
Compact Limit	68.55	68.55	68.55	
Non-Compact Limit	137.09	137.09	137.09	
Maximum Limit	237.27	237.27	237.27	
Allow. Bending Stress (ksi)	36.300	36.300	36.300	
Allow. Compressive Str (ksi)	21.411	21.411	21.411	
Allow. Shear Stress (ksi)	18.150	18.150	18.150	

Shaft Deflection From Arm#1 GP I Load (in)	0.811
Shaft Deflection From Arm#2 GP I Load (in)	0.265

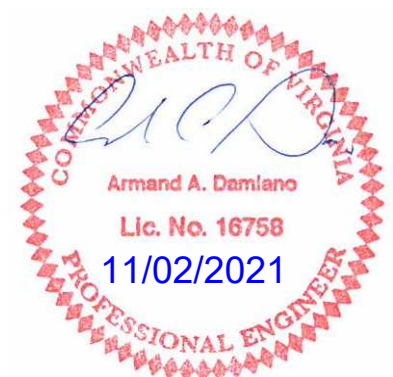




16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.74	0.000	22.53	1.100	4.576	8.25
2	0.450	12.62	22.58	0.000	22.37	1.100	4.576	8.19
3	0.450	12.62	22.41	0.000	22.20	1.100	4.576	8.13
4	0.450	12.62	22.25	0.000	22.04	1.100	4.576	8.07
5	0.450	12.62	22.08	0.000	21.87	1.100	4.576	8.01
6	0.450	12.62	21.92	0.000	21.71	1.100	4.576	7.95
7	0.450	12.62	21.75	0.000	21.55	1.100	4.576	7.89
8	0.450	12.62	21.59	0.001	21.38	1.100	4.576	7.83
9	0.450	12.62	21.42	0.001	21.22	1.100	4.576	7.77
10	0.450	12.62	21.26	0.001	21.06	1.100	4.576	7.71
11	0.450	12.62	21.09	0.001	20.89	1.100	4.576	7.65
12	0.450	12.62	20.93	0.001	20.73	1.100	4.576	7.59
13	0.450	15.77	25.95	0.002	20.57	1.100	4.576	7.53
14	0.450	15.77	25.74	0.002	20.40	1.100	4.576	7.47
15	0.450	15.77	25.53	0.002	20.24	1.100	4.576	7.41
16	0.450	15.77	25.33	0.003	20.08	1.100	4.576	7.35
17	0.450	15.77	25.12	0.003	19.91	1.100	4.576	7.29
18	0.450	15.77	11.79	0.001	9.35	1.100	4.576	3.42
19	0.450	15.77	11.75	0.002	9.31	1.100	4.576	3.41
20	0.450	15.77	11.70	0.002	9.27	1.100	4.576	3.39
Fix. #1	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.052	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70/40' Arms

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	3.68	0.00	17.500	16.985	208.5	1.8308	1.83	5.288	5.288	51.57
2	I	3.68	3.68	16.985	16.470	202.1	1.8306	5.51	5.130	5.130	50.08
3	I	3.68	7.36	16.470	15.954	195.8	1.8303	9.19	4.972	4.972	48.59
4	I	3.68	11.04	15.954	15.439	189.4	1.8299	12.87	4.814	4.814	47.10
5	I	3.68	14.72	15.439	14.924	183.1	1.8296	16.55	4.656	4.656	45.61
6	I	3.68	18.40	14.924	14.409	176.7	1.8292	20.23	4.498	4.498	44.12
7	J	2.92	22.08	14.790	14.381	220.3	1.4532	23.53	3.549	3.549	34.83
8	O	3.46	25.00	14.381	13.897	97.1	1.7209	26.72	4.079	4.079	40.07
9	O	3.46	28.46	13.897	13.412	93.7	1.7205	30.18	3.939	3.939	38.75
10	O	3.46	31.92	13.412	12.927	90.3	1.7202	33.64	3.799	3.799	37.43
11	O	3.46	35.38	12.927	12.443	86.9	1.7197	37.10	3.659	3.659	36.12
12	O	3.46	38.85	12.443	11.958	83.6	1.7193	40.57	3.519	3.519	34.80
13	O	3.46	42.31	11.958	11.474	80.2	1.7188	44.03	3.380	3.380	33.48
14	O	3.46	45.77	11.474	10.989	76.8	1.7183	47.49	3.240	3.240	32.16
15	O	3.46	49.23	10.989	10.504	73.5	1.7178	50.95	3.100	3.100	30.85
16	O	3.46	52.69	10.504	10.020	70.1	1.7171	54.41	2.960	2.960	29.53
17	O	3.46	56.15	10.020	9.535	66.7	1.7165	57.87	2.820	2.820	28.21
18	O	3.46	59.62	9.535	9.050	63.3	1.7157	61.33	2.681	2.681	26.89
19	O	3.46	63.08	9.050	8.566	60.0	1.7149	64.79	2.541	2.541	25.58
20	O	3.46	66.54	8.566	8.081	56.6	1.7140	68.25	2.401	2.401	24.26
		<u>70.00</u>				<u>2375</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	12.00	37.500	1.000	112.50
Fix. #3	105	25.00	13.750	2.000	126.00
Fix. #4	22.5	29.00	7.500	1.000	22.50
Fix. #5	65	36.00	8.700	1.000	78.00
Fix. #6	22	40.00	1.000	1.000	9.00
Fix. #7	22.5	44.00	7.500	1.000	22.50
Fix. #8	65	47.00	8.700	1.000	78.00
Fix. #9	22.5	55.00	7.500	1.000	22.50
Fix. #10	65	58.00	8.700	1.000	78.00
Fix. #11	22	62.00	1.000	1.000	9.00
Fix. #12	26.7	66.00	10.500	1.000	31.50
Fix. #13	80	69.00	11.000	1.000	102.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	72.580	31.467
Cross-Section Area (in^2)	16.892	8.620
Width-Thickness Ratio	55.91	78.67
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	34.389
Allow. Shear Stress (ksi)	18.150	17.040



16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000 Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	83.39	66.10	1.100	4.576	24.20	0	0.484	0.00	0.00	
2	1.00	0.450	15.77	80.89	64.12	1.100	4.576	23.47	0	0.503	0.00	0.00	
3	1.00	0.450	15.77	78.40	62.15	1.100	4.576	22.75	0	0.524	0.00	0.00	
4	1.00	0.450	15.77	75.91	60.17	1.100	4.576	22.03	0	0.546	0.00	0.00	
5	1.00	0.450	15.77	73.42	58.20	1.100	4.576	21.30	0	0.571	0.00	0.00	
6	1.00	0.450	15.77	70.93	56.22	1.100	4.576	20.58	0	0.597	0.00	0.00	
7	1.00	0.450	15.77	55.97	44.36	1.100	4.576	16.24	0	0.601	0.00	0.00	
8	1.00	0.450	15.77	64.32	50.98	1.100	4.576	18.66	0	0.626	0.00	0.00	
9	1.00	0.450	15.77	62.11	49.23	1.100	4.576	18.02	0	0.655	0.00	0.00	
10	1.00	0.450	15.77	59.91	47.49	1.100	4.576	17.38	0	0.686	0.00	0.00	
11	1.00	0.450	15.77	57.70	45.74	1.100	4.576	16.74	0	0.721	0.00	0.00	
12	1.00	0.450	15.77	55.50	43.99	1.100	4.576	16.10	0	0.758	0.00	0.00	
13	1.00	0.450	15.77	53.30	42.24	1.100	4.576	15.46	0	0.799	0.00	0.00	
14	1.00	0.450	15.77	51.09	40.50	1.100	4.576	14.83	0	0.844	0.00	0.00	
15	1.00	0.450	15.77	48.89	38.75	1.100	4.576	14.19	0	0.894	0.00	0.00	
16	1.00	0.450	15.77	46.68	37.00	1.100	4.576	13.55	0	0.949	0.00	0.00	
17	1.00	0.450	15.77	44.48	35.25	1.100	4.576	12.91	1	1.011	0.00	0.00	
18	1.00	0.450	15.77	42.27	33.51	1.100	4.576	12.27	1	1.080	0.00	0.00	
19	1.00	0.450	15.77	40.07	31.76	1.100	4.576	11.63	1	1.100	0.00	0.00	
20	1.00	0.463	16.25	39.02	30.01	1.100	4.576	10.99	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70/40' Arms

Flange Analysis - Arm #1

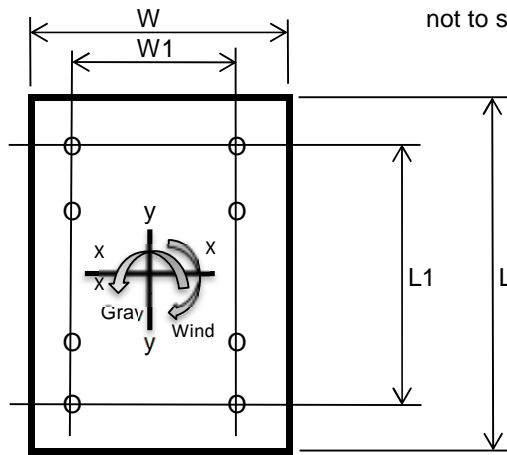
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Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	3003	4444	-	lbs
Shear (Wind)	6345	3518	-	lbs
Torsion (Arm Rise)	23274	12905	-	ft-lbs
Moment (Gravity)	88170	139536	-	ft-lbs
Moment (Wind)	223585	122410	-	ft-lbs
Nat. Wind Moment	-	-	32774	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	17.50	in
Tube Wall Thick.	0.313	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)

	Results GpII	Results GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	25.90	26.39	ksi
Bolt Shear Stress - fv	2.84	1.76	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.6	0.61	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	3.1	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.45	<b>OK</b>	

Plate Analysis

Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	14.17	22.43	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	36.56	20.02	ksi
Combined applied stress for interaction (SRSS)	39.21	30.07	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70/40' Arms

Arm #2 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	2.00	0.00	14.000	13.720	63.9	0.9966	1.00	2.310	2.310	22.71
2	I	2.00	2.00	13.720	13.440	62.6	0.9966	3.00	2.263	2.263	22.27
3	I	2.00	4.00	13.440	13.160	61.2	0.9965	5.00	2.217	2.217	21.83
4	I	2.00	6.00	13.160	12.880	59.9	0.9964	7.00	2.170	2.170	21.39
5	I	2.00	8.00	12.880	12.600	58.6	0.9963	9.00	2.123	2.123	20.95
6	I	2.00	10.00	12.600	12.320	57.3	0.9963	11.00	2.077	2.077	20.51
7	I	2.00	12.00	12.320	12.040	56.0	0.9962	13.00	2.030	2.030	20.07
8	I	2.00	14.00	12.040	11.760	54.7	0.9961	15.00	1.983	1.983	19.63
9	I	2.00	16.00	11.760	11.480	53.4	0.9960	17.00	1.937	1.937	19.19
10	I	2.00	18.00	11.480	11.200	52.1	0.9959	19.00	1.890	1.890	18.76
11	I	2.00	20.00	11.200	10.920	50.8	0.9958	21.00	1.843	1.843	18.32
12	I	2.00	22.00	10.920	10.640	49.4	0.9957	23.00	1.797	1.797	17.88
13	I	2.00	24.00	10.640	10.360	48.1	0.9956	25.00	1.750	1.750	17.44
14	I	2.00	26.00	10.360	10.080	46.8	0.9954	27.00	1.703	1.703	17.00
15	I	2.00	28.00	10.080	9.800	45.5	0.9953	29.00	1.657	1.657	16.56
16	I	2.00	30.00	9.800	9.520	44.2	0.9952	31.00	1.610	1.610	16.12
17	I	2.00	32.00	9.520	9.240	42.9	0.9950	33.00	1.563	1.563	15.68
18	I	2.00	34.00	9.240	8.960	41.6	0.9949	34.99	1.517	1.517	15.24
19	I	2.00	36.00	8.960	8.680	40.3	0.9947	36.99	1.470	1.470	14.80
20	I	2.00	38.00	8.680	8.400	39.0	0.9945	38.99	1.423	1.423	14.36
		40.00				1028					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	66	8.00	30.000	1.000	90.00
Fix. #3	105	17.00	13.750	2.000	126.00
Fix. #4	22	20.00	1.000	1.000	9.00
Fix. #5	22.5	25.00	7.500	1.000	22.50
Fix. #6	65	28.00	8.700	1.000	78.00
Fix. #7	22	30.00	1.000	1.000	9.00
Fix. #8	26.7	36.00	10.500	1.000	31.50
Fix. #9	80	39.00	11.000	1.000	102.00
Fix. #10	0	0.00	0.000	0.000	0.00
Fix. #11	0	0.00	0.000	0.000	0.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#2 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	32.649	0.000
Cross-Section Area (in^2)	9.477	0.000
Width-Thickness Ratio	63.93	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	36.300	0.000
Allow. Shear Stress (ksi)	18.150	0.000



16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

Arm #2 Analysis Continued

Sec. Num.	Kz	Truck Induced Gust											Gallop Loads (lbs)
		Group 2			Group 3	Natural Wind Gust			Hght Corr. Factor = 1.00				
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	36.43	28.88	1.100	4.576	10.57	0	0.642	0.00	0.00	0.00
2	1.00	0.450	15.77	35.69	28.29	1.100	4.576	10.36	0	0.660	0.00	0.00	0.00
3	1.00	0.450	15.77	34.96	27.71	1.100	4.576	10.14	0	0.678	0.00	0.00	0.00
4	1.00	0.450	15.77	34.22	27.13	1.100	4.576	9.93	0	0.697	0.00	0.00	0.00
5	1.00	0.450	15.77	33.48	26.54	1.100	4.576	9.72	0	0.717	0.00	0.00	0.00
6	1.00	0.450	15.77	32.75	25.96	1.100	4.576	9.50	0	0.738	0.00	0.00	0.00
7	1.00	0.450	15.77	32.01	25.38	1.100	4.576	9.29	0	0.760	0.00	0.00	0.00
8	1.00	0.450	15.77	31.28	24.79	1.100	4.576	9.08	0	0.783	0.00	0.00	0.00
9	1.00	0.450	15.77	30.54	24.21	1.100	4.576	8.86	0	0.808	0.00	0.00	0.00
10	1.00	0.450	15.77	29.81	23.63	1.100	4.576	8.65	0	0.834	0.00	0.00	0.00
11	1.00	0.450	15.77	29.07	23.04	1.100	4.576	8.44	0	0.861	0.00	0.00	0.00
12	1.00	0.450	15.77	28.33	22.46	1.100	4.576	8.22	0	0.890	0.00	0.00	0.00
13	1.00	0.450	15.77	27.60	21.88	1.100	4.576	8.01	1	0.921	0.00	0.00	0.00
14	1.00	0.450	15.77	26.86	21.29	1.100	4.576	7.79	1	0.954	0.00	0.00	0.00
15	1.00	0.450	15.77	26.13	20.71	1.100	4.576	7.58	1	0.990	0.00	0.00	0.00
16	1.00	0.450	15.77	25.39	20.13	1.100	4.576	7.37	1	1.027	0.00	0.00	0.00
17	1.00	0.450	15.77	24.65	19.54	1.100	4.576	7.15	1	1.067	0.00	0.00	0.00
18	1.00	0.450	15.77	23.92	18.96	1.100	4.576	6.94	1	1.100	0.00	0.00	0.00
19	1.00	0.450	15.77	23.18	18.38	1.100	4.576	6.73	1	1.100	0.00	0.00	0.00
20	1.00	0.450	15.77	22.45	17.79	1.100	4.576	6.51	1	1.100	0.00	0.00	0.00
Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	42.03	1260.90	630.45	1.199	4.990	149.70	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #5	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #9	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #11	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



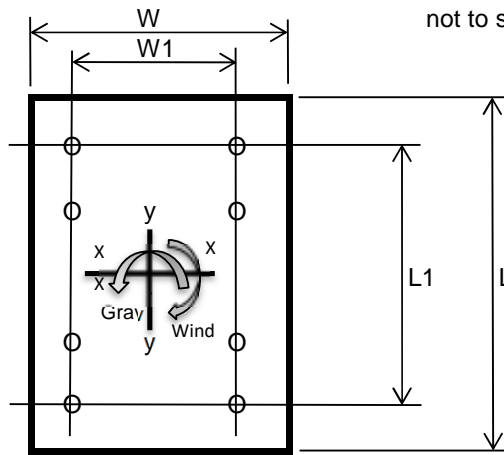
Flange Analysis - Arm #2

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1460	2307	-	lbs
Shear (Wind)	4097	2221	-	lbs
Torsion (Arm Rise)	8588	4656	-	ft-lbs
Moment (Gravity)	28783	46817	-	ft-lbs
Moment (Wind)	83716	45017	-	ft-lbs
Nat. Wind Moment	-	-	11788	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	14.00	in
Tube Wall Thick.	0.219	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	9.30	9.03	ksi
Bolt Shear Stress - fv	1.21	0.75	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.22	0.21	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	1.12	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.16	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	5.08	8.26	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	15.03	8.08	ksi
Combined applied stress for interaction (SRSS)	15.87	11.55	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



## 16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

## Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.268293	
Dop - Baseplate center hole diameter	15.75	in
Cop - Center hole to shaft diameter ratio	0.768293	
Kf - Fatigue stress concentration factor for finite life	2.43	
Ki - Fatigue stress concentration factor for infinite life	5.66	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.313	in
Dt - Arm base diameter	17.50	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	1.82	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.342857	
Kf - Fatigue stress concentration factor for finite life	1.85	
Ki - Fatigue stress concentration factor for infinite life	3.77	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle

**ARM 2 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.219	in
Dt - Arm base diameter	14.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.272843	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.428571	
Kf - Fatigue stress concentration factor for finite life	1.83	
Ki - Fatigue stress concentration factor for infinite life	3.40	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle





## 16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	20.07	in
Shaft Thickness	0.375	in
Total Area	27.9058	in <sup>2</sup>
Ix	1226	in <sup>4</sup>
Iy	1349	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	26161	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	10.09	ksi
CSR	0.63	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.76	ksi
CSR	0.39	
Therefore	<b>OK</b>	



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Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear	Shear	Bending	Torsion	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	3003		3003	88170		88171		356	14578		0.41
Gp II	3003	6345	7020	88170	223585	240342	23274	832	39738	1925	0.84
Gp III	4444	3518	5668	139536	122410	185619	12905	672	30690	1067	0.65
Gp IV Natural		956	956		32774	32774	3507	114	5419	290	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	1737		1737	36326		36326		404	13853		0.41
Gp II	1737	4255	4596	36326	105504	111583	15607	1067	42553	2976	0.97
Gp III	2769	2338	3624	60449	57281	83278	8575	841	31759	1636	0.71
Gp IV Natural		628	628		15186	15186	2305	146	5792	440	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	1460		1460	28783		28783		309	10579		0.30
Gp II	1460	4097	4350	28783	83716	88526	8588	919	32537	1579	0.69
Gp III	2307	2221	3203	46817	45017	64949	4656	676	23872	856	0.50
Gp IV Natural		587	587		11788	11788	1232	124	4333	227	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#1 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#2 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

<b>Shaft Base</b>											
Gp I	6094		88170	28783	92749		257		9335		0.27
Gp II	6094	7510	121660	169008	208242	238735	257	634	20959	12014	0.72
Gp III	8847	4277	97825	181589	206263	130412	373	361	20760	6563	0.53
Gp IV Natural			23347	11803	26161				2633		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9969										

<b>Shaft At Arm</b>											
Gp I	4568		88170	28783	92749		220		12199		0.35
Gp II	4568	6380	47612	93244	104696	238735	220	616	13770	15700	0.75
Gp III	6856	3546	56407	142672	153418	130412	331	343	20178	8576	0.57
Gp IV Natural			3514	1231	3723				490		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9969										



16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	7510 lbs
Bending Moment	208242 ft-lbs
Torsion Moment	238735 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.50 in

**ANALYSIS - ANCHOR BOLTS**

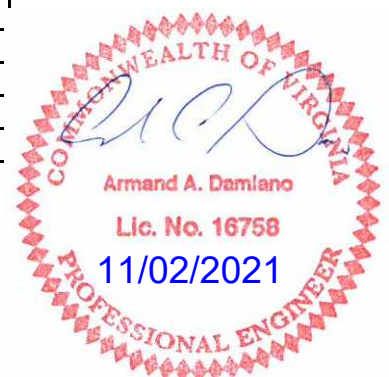
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	19.178 ksi
Bolt Direct Shear Stress	0.409 ksi
Bolt Torsion Shear Stress	11.977 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	19.178 ksi
$f_v =$	12.386 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.78 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	2.75 in
Design Moment	132 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	19.94 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.188 in
Design Moment	57 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	9.04 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-1-23 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	26161 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	2.41 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.35
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

Anchor Bolt Length	60.0 in
Anchor Bolt Max. Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	47945 lbs
Computed Factor-of Safety	1.29 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	47945 lbs
Total Tensile Load	383560 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.23 <b>OK</b>

**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	47945 lbs
Total Tensile Load	383560 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	<b>9</b> Qty.



**MAST ARM POLE ANALYSIS TO AASHTO**

16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/30' Arms

11/02/21

**General**

Wind Vel. - mph	90	No	Roadway - mph	55	<b>Fatigue Importance Factors</b>	
Natural Wind	11.2		Plate Yield (ksi)	36	Cantilevered	Traffic
Truck Gust	65		Wind Import. Ir	0.870	Galloping	0.65
Fatigue Cat.	2		Vel. Conver. Cv	0.930	Vortex Shedding	0.00
Recurrence (yr)	25		Gust Effect G	1.300	Natural Wind Gust	0.80
Hurricane Region	0		Elev. Pole Bot.(ft)	1	Truck Gust	0.85
# Traffic Arms	2		<b>AASHTO Editon</b>	<b>6TH</b>	Wind Pressure - Appendix C	
# Lum. Arms	0		State	VA		

[Basic Shapes: 0=Round, 8=8 Sided, 12=12 Sided, 16=16 Sided]

[Fluted Shapes: 16F=16 Flat, 16S=16 Sharp, 8F=8 Flat, 8S=8 Sharp]

**Pole Variables**

	Wall (in)	Taper (in/ft)	Dia. (in)	Length (ft)	Attach. (ft)	Overlap (ft)	Arm Rise (ft)	Member Shape	Member Fy (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.3750	0.14	20.50	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.3130	0.14	17.50	25.00	18.00	-	3.67	0	55	29000	180
	0.1880	0.14	14.79	47.92	-	2.93	-	0	55	29000	-
Traffic Arm #2	0.2190	0.14	14.00	30.00	18.00	-	1.57	0	55	29000	270
					-			0	55	29000	-
Lum Arm #1								0	36	29000	180
Lum Arm #2								0	36	29000	90

**Anchor Bolt, Baseplate & Foundation**

Anchor Bolt Qty.	8		Anchor Bolt Length	60	in
Anchor Bolt Dia.	2.00	in	Double Top Nuts	Yes	
A.B. Bolt Circle	26.00	in	Foundation Diameter	48	in
Baseplate Dia.	32.00	in	Concrete Cover	4	in
Baseplate Thk.	2.00	in	f'c = 28 Day Concrete Comp. Strength	3000	psi
B.P. Center Hole	15.75	in	Vertical Reinforcing Bar Size #	8	
Weld Type	Full Pen.		Rebar Yield Strength fy	60	ksi

**Flange Simplex**

	Arm #1		Arm #2	
Flange Bolt Qty.	8		8	
Bolt Diameter	1.50	in	1.50	in
Flange Plate Length (V)	27.00	in	27.00	in
Flange Plate Width (H)	27.00	in	27.00	in
Spac. Between Bolt (V)	22.50	in	22.50	in
Spac. Between Bolt (H)	22.50	in	22.50	in
Flange Plate Thk.	2.25	in	2.25	in
Flange Plate Yield (Fy)	50	ksi	50	ksi
Gusset Thk.	0.500	in	0.500	in
Plate Center Hole	6.00	in	6.00	in
Weld Type	Full Pen.		Full Pen.	

**Hand Hole**

Handhole Width	6.00	in
Handhole Height	24.50	in
Height To C.L.	37	in
Radial Orientation	0	Deg.
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in

**Results**

	Shaft At		Arm#1		Arm#2		Lum#1	Lum#2	Tip Deflection (in)	
	Base	Flange	Root	Joint	Root	Joint	Root	Root	Arm #1	Arm #2
GP I CSR	0.26	0.34	0.41	0.41	0.19				24.46	1.96
GP II CSR	0.68	0.71	0.84	0.97	0.46					
GP III CSR	0.50	0.54	0.65	0.71	0.33				39.95	3.25
Nat.Wind (psi)	2555	474	5419	5793	2888					

Arm #1 Flange Bolt (Max.) CSR	0.61
Arm #1 Flange Bolt Fatigue CSR	0.45
Arm #1 Flange Plate (Max.) CSR	0.89
Arm #2 Flange Bolt (Max.) CSR	0.15
Arm #2 Flange Bolt Fatigue CSR	0.11
Arm #2 Flange Plate (Max.) CSR	0.24
Handhole at Root (Fatigue) CSR	0.61
Handhole at Toe (Fatigue) CSR	0.38
Minimum Qty of Vertical Reinf. Bars	8

Fatigue Allowable - Shaft to Baseplate	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	7 ksi
Anchor Bolt Max. CSR	0.74
Anchor Bolt Max. Fatigue Stress Ratio	0.34
Base Plate Max. CSR	0.60
Anchorage Capacity S.F.	1.36
Concrete Pull Out Capacity S.F.	1.30

**Ground Line Reactions**

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
8420	7509	197079	230611



16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70/30' Arms

Input Loads

Fixture Input Data

Member	Fixture	Load Type	Location (ft)	Front Area (sq.ft.)	Side Area (sq.ft)	Sign Width (ft)	Sign Length (ft)	Bottom Area (sq.ft.)	Ice Area (sq.ft.)	Weight (lbs)	Cd
For Shaft	#1	Ped Head	10.5	2.4	1			1	6	30	1.20
	#2	Ped Head	10.5	2.4	1			1	6	30	1.20
	#3	5 Section Head w/BP	15	13.75	4			2	42	105	1.20
	#4										
Lum #1	#1										
Lum #2	#1										
For Arm #1	#1	Camera	4	1	1			1	3	22	1.20
	#2	15'x2.5' Sign	12			15	2.5	1	37.5	88.5	1.21
	#3	5 Section Head w/BP	25	13.75	4			2	42	105	1.20
	#4		2.5'x3' Sign			29		1	7.5	22.5	1.13
	#5	3 Section Head w/BP	36	8.7	4			1	26	65	1.20
	#6	Camera	40	1	1			1	3	22	1.20
	#7	2.5'x3' Sign	44			2.5	3	1	7.5	22.5	1.13
	#8	3 Section Head w/BP	47	8.7	4			1	26	65	1.20
	#9	2.5'x3' Sign	55			2.5	3	1	7.5	22.5	1.13
	#10	3 Section Head w/BP	58	8.7	4			1	26	65	1.20
	#11	Camera	62	1	1			1	3	22	1.20
	#12	3'x3.5' Sign	66			3	3.5	1	10.5	26.7	1.13
	#13	4 Section Head w/BP	69	11	5			1	34	80	1.20
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										
For Arm #2	#1	Camera	4	1	1			1	3	22	1.20
	#2	12'x2.5' Sign	7			12	2.5	1	30	66	1.20
	#3	Camera	10	1	1			1	3	22	1.20
	#4	2.5'x3' Sign	15			2.5	3	1	7.5	22.5	1.13
	#5	5 Section Head w/BP	19	13.75	4			2	42	105	1.20
	#6		Camera			21	1	1	3	3.5	1
	#7	3'x3.5' Sign	26					1	34	80	1.20
	#8	4 Section Head w/BP	29	11	5			1			
	#9										
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										



16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/30' Arms

Shaft Analysis

Sect. Num.	Mem Type	Sect. Lgth (ft)	Cumm. Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Cent. Loc. (ft)	Mom. Arm (ft)	Projected Area Vert (sq.ft.)	Ice Wght (lbs)	Kz
1	I	1.06	0.00	20.500	20.352	85.11	0.5288	0.53	1.802	17.48	0.80
2	I	1.06	1.06	20.352	20.204	84.48	0.5288	1.59	1.789	17.36	0.80
3	I	1.06	2.12	20.204	20.055	83.85	0.5288	2.65	1.776	17.24	0.80
4	I	1.06	3.18	20.055	19.907	83.22	0.5288	3.71	1.763	17.12	0.80
5	I	1.06	4.24	19.907	19.759	82.59	0.5288	4.76	1.750	16.99	0.80
6	I	1.06	5.29	19.759	19.611	81.96	0.5287	5.82	1.737	16.87	0.80
7	I	1.06	6.35	19.611	19.462	81.33	0.5287	6.88	1.724	16.75	0.80
8	I	1.06	7.41	19.462	19.314	80.70	0.5287	7.94	1.711	16.62	0.80
9	I	1.06	8.47	19.314	19.166	80.07	0.5287	9.00	1.698	16.50	0.80
10	I	1.06	9.53	19.166	19.018	79.44	0.5287	10.06	1.685	16.38	0.80
11	I	1.06	10.59	19.018	18.869	78.82	0.5287	11.12	1.671	16.25	0.80
12	I	1.06	11.65	18.869	18.721	78.19	0.5287	12.18	1.658	16.13	0.80
13	I	1.06	12.71	18.721	18.573	77.56	0.5287	13.23	1.645	16.01	1.00
14	I	1.06	13.76	18.573	18.425	76.93	0.5287	14.29	1.632	15.88	1.00
15	I	1.06	14.82	18.425	18.276	76.30	0.5287	15.35	1.619	15.76	1.00
16	I	1.06	15.88	18.276	18.128	75.67	0.5287	16.41	1.606	15.64	1.00
17	I	1.06	16.94	18.128	17.980	75.04	0.5287	17.47	1.593	15.51	1.00
18	J	0.50	18.00	17.980	17.910	35.22	0.2498	18.25	0.748	7.28	1.00
19	I	0.50	18.50	17.910	17.840	35.08	0.2498	18.75	0.745	7.26	1.00
20	I	0.50	19.00	17.840	17.770	34.94	0.2498	19.25	0.742	7.23	1.00
						1467					

Fix. #1	30	10.50	2.40	18.00	0.80
Fix. #2	30	10.50	2.40	18.00	0.80
Fix. #3	105	15.00	13.75	126.00	1.00
Fix. #4	0	0.00	0.00	0.00	0.80

Shaft Section Values	At Shaft Base	18.00 Lower Arm	18.00 Upper Arm	Shaft Top
Moment of Inertia (in^4)	1199.72	803.12	803.12	774.72
Section Modulus (in^3)	119.23	91.24	91.24	
Cross-Section Area (in^2)	23.70	20.73	20.73	
Width-Thickness Ratio	54.67	47.95	47.95	
Compact Limit	68.55	68.55	68.55	
Non-Compact Limit	137.09	137.09	137.09	
Maximum Limit	237.27	237.27	237.27	
Allow. Bending Stress (ksi)	36.300	36.300	36.300	
Allow. Compressive Str (ksi)	21.411	21.411	21.411	
Allow. Shear Stress (ksi)	18.150	18.150	18.150	

Shaft Deflection From Arm#1 GP I Load (in)	0.811
Shaft Deflection From Arm#2 GP I Load (in)	0.167

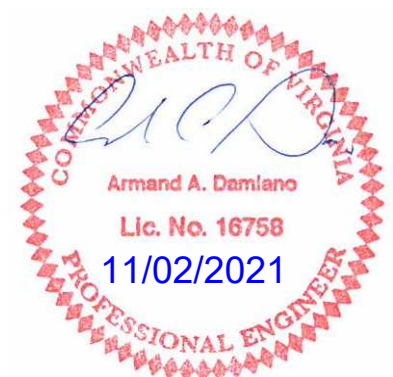




16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/30' Arms

## Shaft Analysis Continued

Sect. Num.	Group 2 Analysis				Group 3	Natural Wind		
	Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Tip Deflect (in)	Wind Load (lbs)	Drag Coeff	Press. (psf)	Load (lbs)
1	0.450	12.62	22.74	0.000	22.53	1.100	4.576	8.25
2	0.450	12.62	22.58	0.000	22.37	1.100	4.576	8.19
3	0.450	12.62	22.41	0.000	22.20	1.100	4.576	8.13
4	0.450	12.62	22.25	0.000	22.04	1.100	4.576	8.07
5	0.450	12.62	22.08	0.000	21.87	1.100	4.576	8.01
6	0.450	12.62	21.92	0.000	21.71	1.100	4.576	7.95
7	0.450	12.62	21.75	0.000	21.55	1.100	4.576	7.89
8	0.450	12.62	21.59	0.001	21.38	1.100	4.576	7.83
9	0.450	12.62	21.42	0.001	21.22	1.100	4.576	7.77
10	0.450	12.62	21.26	0.001	21.06	1.100	4.576	7.71
11	0.450	12.62	21.09	0.001	20.89	1.100	4.576	7.65
12	0.450	12.62	20.93	0.001	20.73	1.100	4.576	7.59
13	0.450	15.77	25.95	0.002	20.57	1.100	4.576	7.53
14	0.450	15.77	25.74	0.002	20.40	1.100	4.576	7.47
15	0.450	15.77	25.53	0.002	20.24	1.100	4.576	7.41
16	0.450	15.77	25.33	0.003	20.08	1.100	4.576	7.35
17	0.450	15.77	25.12	0.003	19.91	1.100	4.576	7.29
18	0.450	15.77	11.79	0.001	9.35	1.100	4.576	3.42
19	0.450	15.77	11.75	0.002	9.31	1.100	4.576	3.41
20	0.450	15.77	11.70	0.002	9.27	1.100	4.576	3.39
Fix. #1	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #2	1.200	33.65	80.76	0.004	40.38	1.200	4.992	11.98
Fix. #3	1.200	42.06	578.33	0.052	289.16	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/30' Arms

Arm #1 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	3.68	0.00	17.500	16.985	208.4	1.8300	1.83	5.285	5.285	51.55
2	I	3.68	3.68	16.985	16.470	202.0	1.8297	5.51	5.127	5.127	50.06
3	I	3.68	7.36	16.470	15.955	195.7	1.8294	9.19	4.970	4.970	48.57
4	I	3.68	11.04	15.955	15.440	189.3	1.8291	12.86	4.812	4.812	47.08
5	I	3.68	14.71	15.440	14.925	183.0	1.8288	16.54	4.654	4.654	45.59
6	I	3.68	18.39	14.925	14.410	176.7	1.8284	20.22	4.496	4.496	44.11
7	J	2.93	22.07	14.790	14.380	221.0	1.4581	23.53	3.561	3.561	34.94
8	O	3.46	25.00	14.380	13.895	97.0	1.7205	26.72	4.077	4.077	40.06
9	O	3.46	28.46	13.895	13.411	93.7	1.7202	30.18	3.938	3.938	38.74
10	O	3.46	31.92	13.411	12.926	90.3	1.7198	33.64	3.798	3.798	37.42
11	O	3.46	35.38	12.926	12.442	86.9	1.7194	37.10	3.658	3.658	36.11
12	O	3.46	38.84	12.442	11.957	83.5	1.7189	40.56	3.518	3.518	34.79
13	O	3.46	42.30	11.957	11.473	80.2	1.7185	44.02	3.379	3.379	33.47
14	O	3.46	45.76	11.473	10.988	76.8	1.7179	47.48	3.239	3.239	32.16
15	O	3.46	49.23	10.988	10.504	73.4	1.7174	50.94	3.099	3.099	30.84
16	O	3.46	52.69	10.504	10.019	70.1	1.7168	54.40	2.959	2.959	29.52
17	O	3.46	56.15	10.019	9.535	66.7	1.7161	57.86	2.820	2.820	28.21
18	O	3.46	59.61	9.535	9.050	63.3	1.7153	61.32	2.680	2.680	26.89
19	O	3.46	63.07	9.050	8.566	60.0	1.7145	64.78	2.540	2.540	25.57
20	O	3.46	66.53	8.566	8.081	56.6	1.7136	68.24	2.400	2.400	24.25
		<u>69.99</u>				<u>2375</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	88.5	12.00	37.500	1.000	112.50
Fix. #3	105	25.00	13.750	2.000	126.00
Fix. #4	22.5	29.00	7.500	1.000	22.50
Fix. #5	65	36.00	8.700	1.000	78.00
Fix. #6	22	40.00	1.000	1.000	9.00
Fix. #7	22.5	44.00	7.500	1.000	22.50
Fix. #8	65	47.00	8.700	1.000	78.00
Fix. #9	22.5	55.00	7.500	1.000	22.50
Fix. #10	65	58.00	8.700	1.000	78.00
Fix. #11	22	62.00	1.000	1.000	9.00
Fix. #12	26.7	66.00	10.500	1.000	31.50
Fix. #13	80	69.00	11.000	1.000	102.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#1 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	72.580	31.467
Cross-Section Area (in^2)	16.892	8.620
Width-Thickness Ratio	55.91	78.67
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	36.300	34.389
Allow. Shear Stress (ksi)	18.150	17.040



16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/30' Arms

Arm #1 Analysis Continued

Sec. Num.	Kz	Group 2			Group 3	Natural Wind Gust			Truck Induced Gust				Gallop Loads (lbs)
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Hght Corr. Factor = 1.000 Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	83.35	66.07	1.100	4.576	24.19	0	0.484	0.00	0.00	
2	1.00	0.450	15.77	80.86	64.09	1.100	4.576	23.46	0	0.503	0.00	0.00	
3	1.00	0.450	15.77	78.37	62.12	1.100	4.576	22.74	0	0.524	0.00	0.00	
4	1.00	0.450	15.77	75.88	60.15	1.100	4.576	22.02	0	0.546	0.00	0.00	
5	1.00	0.450	15.77	73.39	58.17	1.100	4.576	21.30	0	0.571	0.00	0.00	
6	1.00	0.450	15.77	70.90	56.20	1.100	4.576	20.57	0	0.597	0.00	0.00	
7	1.00	0.450	15.77	56.16	44.51	1.100	4.576	16.30	0	0.601	0.00	0.00	
8	1.00	0.450	15.77	64.30	50.97	1.100	4.576	18.66	0	0.626	0.00	0.00	
9	1.00	0.450	15.77	62.09	49.22	1.100	4.576	18.02	0	0.655	0.00	0.00	
10	1.00	0.450	15.77	59.89	47.47	1.100	4.576	17.38	0	0.686	0.00	0.00	
11	1.00	0.450	15.77	57.69	45.73	1.100	4.576	16.74	0	0.721	0.00	0.00	
12	1.00	0.450	15.77	55.48	43.98	1.100	4.576	16.10	0	0.758	0.00	0.00	
13	1.00	0.450	15.77	53.28	42.23	1.100	4.576	15.46	0	0.799	0.00	0.00	
14	1.00	0.450	15.77	51.08	40.49	1.100	4.576	14.82	0	0.844	0.00	0.00	
15	1.00	0.450	15.77	48.87	38.74	1.100	4.576	14.18	0	0.894	0.00	0.00	
16	1.00	0.450	15.77	46.67	36.99	1.100	4.576	13.54	0	0.949	0.00	0.00	
17	1.00	0.450	15.77	44.47	35.25	1.100	4.576	12.90	1	1.011	0.00	0.00	
18	1.00	0.450	15.77	42.26	33.50	1.100	4.576	12.26	1	1.080	0.00	0.00	
19	1.00	0.450	15.77	40.06	31.75	1.100	4.576	11.62	1	1.100	0.00	0.00	
20	1.00	0.463	16.25	39.01	30.01	1.100	4.576	10.98	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	42.27	1585.13	792.56	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	42.06	365.92	182.96	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



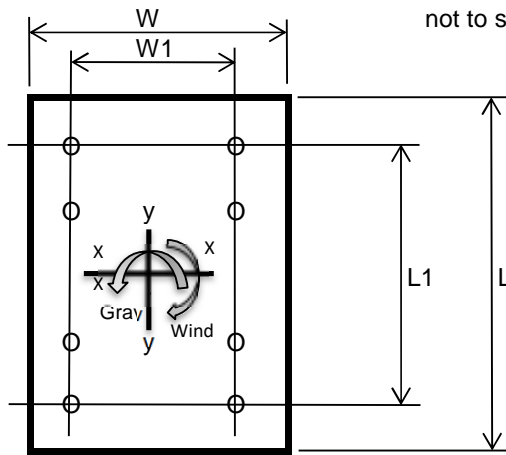
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	3003	4444	-	lbs
Shear (Wind)	6345	3518	-	lbs
Torsion (Arm Rise)	23270	12902	-	ft-lbs
Moment (Gravity)	88159	139518	-	ft-lbs
Moment (Wind)	223573	122401	-	ft-lbs
Nat. Wind Moment	-	-	32771	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	17.50	in
Tube Wall Thick.	0.313	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	25.90	26.38	ksi
Bolt Shear Stress - fv	2.84	1.76	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.6	0.61	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	3.1	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.45	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	14.17	22.43	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	36.55	20.01	ksi
Combined applied stress for interaction (SRSS)	39.20	30.06	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70/30' Arms

Arm #2 Analysis

Sec. Num.	Mem Type	Sect. Lgth (ft)	Cumm Lgth (ft)	Bottom Dia. (in)	Top Dia. (in)	Wght (lbs)	Centroid Loc. (ft)	Mom. Arm (ft)	Projected Area		Ice Wght (lbs)
									In Elev (sq.ft.)	In Plan (sq.ft.)	
1	I	1.50	0.00	14.000	13.790	48.0	0.7481	0.75	1.737	1.737	17.08
2	I	1.50	1.50	13.790	13.580	47.3	0.7481	2.25	1.711	1.711	16.83
3	I	1.50	3.00	13.580	13.370	46.6	0.7481	3.75	1.684	1.684	16.58
4	I	1.50	4.50	13.370	13.160	45.8	0.7480	5.25	1.658	1.658	16.33
5	I	1.50	6.00	13.160	12.950	45.1	0.7480	6.75	1.632	1.632	16.09
6	I	1.50	7.50	12.950	12.740	44.3	0.7480	8.25	1.606	1.606	15.84
7	I	1.50	9.00	12.740	12.530	43.6	0.7479	9.75	1.579	1.579	15.59
8	I	1.50	10.50	12.530	12.320	42.9	0.7479	11.25	1.553	1.553	15.34
9	I	1.50	12.00	12.320	12.110	42.1	0.7479	12.75	1.527	1.527	15.10
10	I	1.50	13.50	12.110	11.900	41.4	0.7478	14.25	1.501	1.501	14.85
11	I	1.50	15.00	11.900	11.690	40.7	0.7478	15.75	1.474	1.474	14.60
12	I	1.50	16.50	11.690	11.480	39.9	0.7477	17.25	1.448	1.448	14.35
13	I	1.50	18.00	11.480	11.270	39.2	0.7477	18.75	1.422	1.422	14.11
14	I	1.50	19.50	11.270	11.060	38.4	0.7476	20.25	1.396	1.396	13.86
15	I	1.50	21.00	11.060	10.850	37.7	0.7476	21.75	1.369	1.369	13.61
16	I	1.50	22.50	10.850	10.640	37.0	0.7476	23.25	1.343	1.343	13.37
17	I	1.50	24.00	10.640	10.430	36.2	0.7475	24.75	1.317	1.317	13.12
18	I	1.50	25.50	10.430	10.220	35.5	0.7475	26.25	1.291	1.291	12.87
19	I	1.50	27.00	10.220	10.010	34.8	0.7474	27.75	1.264	1.264	12.62
20	I	1.50	28.50	10.010	9.800	34.0	0.7473	29.25	1.238	1.238	12.38
		<u>30.00</u>				<u>820</u>					

Fix. #1	22	4.00	1.000	1.000	9.00
Fix. #2	66	7.00	30.000	1.000	90.00
Fix. #3	22	10.00	1.000	1.000	9.00
Fix. #4	22.5	15.00	7.500	1.000	22.50
Fix. #5	105	19.00	13.750	2.000	126.00
Fix. #6	22	21.00	1.000	1.000	9.00
Fix. #7	26.7	26.00	10.500	1.000	31.50
Fix. #8	80	29.00	11.000	1.000	102.00
Fix. #9	0	0.00	0.000	0.000	0.00
Fix. #10	0	0.00	0.000	0.000	0.00
Fix. #11	0	0.00	0.000	0.000	0.00
Fix. #12	0	0.00	0.000	0.000	0.00
Fix. #13	0	0.00	0.000	0.000	0.00
Fix. #14	0	0.00	0.000	0.000	0.00
Fix. #15	0	0.00	0.000	0.000	0.00
Fix. #16	0	0.00	0.000	0.000	0.00
Fix. #17	0	0.00	0.000	0.000	0.00
Fix. #18	0	0.00	0.000	0.000	0.00
Fix. #19	0	0.00	0.000	0.000	0.00
Fix. #20	0	0.00	0.000	0.000	0.00

Arm#2 Section Values		
Property	Inboard	Outboard
Section Modulus (in^3)	32.649	0.000
Cross-Section Area (in^2)	9.477	0.000
Width-Thickness Ratio	63.93	0.00
Compact Limit	68.55	0.00
Non-Compact Limit	137.09	0.00
Maximum Limit	237.27	0.00
Allow. Bending Stress (ksi)	36.300	0.000
Allow. Shear Stress (ksi)	18.150	0.000



16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/30' Arms

Arm #2 Analysis Continued

Sec. Num.	Kz	Truck Induced Gust											Gallop Loads (lbs)
		Group 2			Group 3	Natural Wind Gust			Hght Corr. Factor = 1.00				
		Drag Coeff	Vel. Press. (psf)	Wind Load (lbs)	Wind Load (lbs)	Drag Coeff.	Press. (psf)	Load (lbs)	Used 1=Yes 0=No	Drag Coeff	Press. (psf)	Load (lbs)	
1	1.00	0.450	15.77	27.39	21.71	1.100	4.576	7.95	0	0.640	0.00	0.00	
2	1.00	0.450	15.77	26.98	21.38	1.100	4.576	7.83	0	0.653	0.00	0.00	
3	1.00	0.450	15.77	26.56	21.05	1.100	4.576	7.71	0	0.666	0.00	0.00	
4	1.00	0.450	15.77	26.15	20.73	1.100	4.576	7.59	0	0.680	0.00	0.00	
5	1.00	0.450	15.77	25.73	20.40	1.100	4.576	7.47	0	0.694	0.00	0.00	
6	1.00	0.450	15.77	25.32	20.07	1.100	4.576	7.35	0	0.709	0.00	0.00	
7	1.00	0.450	15.77	24.91	19.74	1.100	4.576	7.23	0	0.724	0.00	0.00	
8	1.00	0.450	15.77	24.49	19.41	1.100	4.576	7.11	0	0.740	0.00	0.00	
9	1.00	0.450	15.77	24.08	19.09	1.100	4.576	6.99	0	0.757	0.00	0.00	
10	1.00	0.450	15.77	23.66	18.76	1.100	4.576	6.87	0	0.774	0.00	0.00	
11	1.00	0.450	15.77	23.25	18.43	1.100	4.576	6.75	1	0.792	0.00	0.00	
12	1.00	0.450	15.77	22.84	18.10	1.100	4.576	6.63	1	0.811	0.00	0.00	
13	1.00	0.450	15.77	22.42	17.77	1.100	4.576	6.51	1	0.830	0.00	0.00	
14	1.00	0.450	15.77	22.01	17.45	1.100	4.576	6.39	1	0.851	0.00	0.00	
15	1.00	0.450	15.77	21.60	17.12	1.100	4.576	6.27	1	0.872	0.00	0.00	
16	1.00	0.450	15.77	21.18	16.79	1.100	4.576	6.15	1	0.894	0.00	0.00	
17	1.00	0.450	15.77	20.77	16.46	1.100	4.576	6.03	1	0.917	0.00	0.00	
18	1.00	0.450	15.77	20.35	16.13	1.100	4.576	5.91	1	0.942	0.00	0.00	
19	1.00	0.450	15.77	19.94	15.80	1.100	4.576	5.79	1	0.967	0.00	0.00	
20	1.00	0.450	15.77	19.53	15.48	1.100	4.576	5.67	1	0.994	0.00	0.00	
Fix. #1	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	42.03	1260.90	630.45	1.199	4.990	149.70	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	39.74	298.05	149.03	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	42.06	578.33	289.16	1.200	4.992	68.64	1	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	42.06	42.06	21.03	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.132	39.66	416.43	208.22	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #8	1.00	1.200	42.06	462.66	231.33	1.200	4.992	54.91	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #10	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #11	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #12	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #13	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #14	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #15	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #16	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #17	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #18	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #19	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00
Fix. #20	1.00	0.000	0.00	0.00	0.00	0.000	0.000	0.00	0	0.000	0.00	0.00	0.00



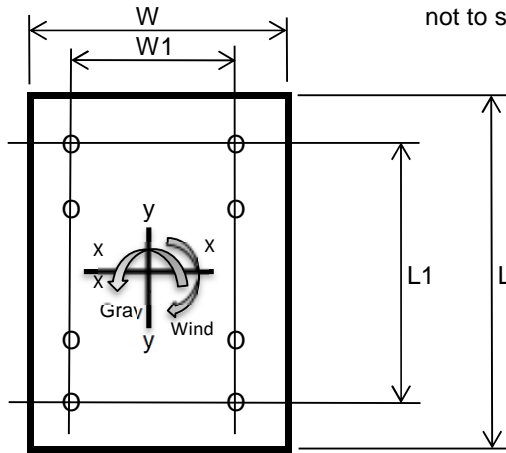
Flange Analysis - Arm #2

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1187	1880	-	lbs
Shear (Wind)	3612	1943	-	lbs
Torsion (Arm Rise)	5678	3055	-	ft-lbs
Moment (Gravity)	18147	29771	-	ft-lbs
Moment (Wind)	56625	30251	-	ft-lbs
Nat. Wind Moment	-	-	7857	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	14.00	in
Tube Wall Thick.	0.219	in
A325 Bolt Dia.	1.50	in
Plate Yield (Fy)	50	ksi
Number of Bolts	8	
GpII & GpIII Allow. Increase	1.33	
Tube-To-Plate Fit Check	OK	

Note: Sketch not to scale

ITEM	PLATE DIM. (in)
Thk.(t)	2.25
W	27
W1	22.50
L	27
L1	22.50
L2 - Dist. between bolts (Typ.)	7.50



Worst Bolt Load (Corner Bolt P1)	Results	Results	
	GpII	GpIII	
Bolt Tensile Stress Area	1.41	1.41	in <sup>2</sup>
Bolt Shear Stress Area	1.29	1.29	in <sup>2</sup>
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in <sup>4</sup>
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in <sup>4</sup>
Bolt Tensile Stress - ft	6.18	5.82	ksi
Bolt Shear Stress - fv	0.88	0.55	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.15	0.14	CSR
Therefore	<b>OK</b>	<b>OK</b>	
Natural Wind Bolt Tensile Stress	0.75	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.11	<b>OK</b>	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	3.21	5.26	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	10.17	5.43	ksi
Combined applied stress for interaction (SRSS)	10.66	7.56	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	<b>OK</b>	<b>OK</b>	



## 16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/30' Arms

## Fatigue Allowable - Shaft to Baseplate Weld &amp; Arms to Simplex Plate Weld

**SHAFT TO BASEPLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.268293	
Dop - Baseplate center hole diameter	15.75	in
Cop - Center hole to shaft diameter ratio	0.768293	
Kf - Fatigue stress concentration factor for finite life	2.43	
Ki - Fatigue stress concentration factor for infinite life	5.66	
Fatigue Allowable	4.5	ksi

**ARM 1 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.313	in
Dt - Arm base diameter	17.50	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	1.82	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.342857	
Kf - Fatigue stress concentration factor for finite life	1.85	
Ki - Fatigue stress concentration factor for infinite life	3.77	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle

**ARM 2 TO SIMPLEX PLATE**

Full Penetration groove welded tube-to-transverse-plate connection

Tt - Thickness of arm inboard	0.219	in
Dt - Arm base diameter	14.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.272843	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.428571	
Kf - Fatigue stress concentration factor for finite life	1.83	
Ki - Fatigue stress concentration factor for infinite life	3.40	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle





## 16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/30' Arms

## Hand Hole Stresses

**INPUTS**

Handhole Width	6.00	in
Handhole Height	24.50	in
Distance From Base Plate To Hand Hole Center Line	37	in
Radial Orientation	0	Degrees
Rim Thickness	0.75	in
Rim Depth	5.00	in
Rim Projection	1.00	in
Shaft Diameter (At hand hole location)	20.07	in
Shaft Thickness	0.375	in
Total Area	27.9058	in <sup>2</sup>
Ix	1226	in <sup>4</sup>
Iy	1349	in <sup>4</sup>
Controlling Moment - Natural Wind Gust	25383	ft-lbs

**CHECK**

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	9.79	ksi
CSR	0.61	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.68	ksi
CSR	0.38	
Therefore	<b>OK</b>	



16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70'/30' Arms

Summary

Location	LOADS							STRESSES			CSR
	Direct Shear			Bending Moments			Torsional Shear	Shear	Bending	Torsion	
	Vert Shr (lbs)	Horz Shr (lbs)	Resultant Shr (lbs)	Grav Mom (ft-lbs)	Wind Mom (ft-lbs)	Resultant Mom (ft-lbs)					

Arm#1 Base											
Gp I	3003		3003	88159		88160		356	14576		0.41
Gp II	3003	6345	7020	88159	223573	240327	23270	832	39735	1924	0.84
Gp III	4444	3518	5668	139518	122401	185600	12902	672	30687	1067	0.65
Gp IV Natural		956	956		32771	32771	3506	114	5419	290	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

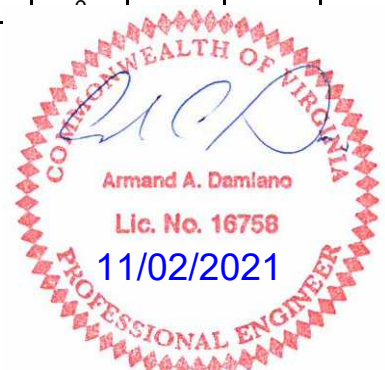
Arm#1 Joint											
Gp I	1738		1738	36332		36333		404	13856		0.41
Gp II	1738	4255	4596	36332	105539	111618	15605	1067	42567	2976	0.97
Gp III	2770	2338	3625	60461	57299	83299	8573	842	31767	1635	0.71
Gp IV Natural		628	628		15191	15191	2305	146	5793	440	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	1187		1187	18147		18148		251	6670		0.19
Gp II	1187	3612	3802	18147	56625	59462	5678	803	21855	1044	0.46
Gp III	1880	1943	2704	29771	30251	42444	3055	571	15600	562	0.33
Gp IV Natural		509	509		7857	7857	801	108	2888	148	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#1 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Lum#2 Base											
Gp I	0		0	0		0		0	0		0
Gp II	0	0	0	0	0	0	0	0	0	0	0
Gp III	0	0	0	0	0	0	0	0	0	0	0
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-



16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70/30' Arms

**Summary - Continued**

Location	ENVELOPED LOADS (Wind Around The Pole)						STRESSES				CSR
	Axial (lbs)	Shear Resultant (lbs)	Bending			Torsion Mz Mom. (ft-lbs)	Axial (psi)	Shear (psi)	Bending (psi)	Torsion (psi)	
			Mx Mom (ft-lbs)	My Mom (ft-lbs)	Resultant (ft-lbs)						

**Shaft Base**

Gp I	5821		88159	18147	90007		246		9059		0.26
Gp II	5821	7509	110003	163522	197079	230611	246	634	19836	11605	0.68
Gp III	8420	4277	80776	176666	194257	126059	355	361	19552	6344	0.50
Gp IV Natural			23345	9966	25383				2555		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9971										

**Shaft At Arm**

Gp I	4295		88159	18147	90007		207		11838		0.34
Gp II	4295	6380	38300	91024	98754	230611	207	616	12989	15166	0.71
Gp III	6429	3546	39655	141502	146954	126059	310	343	19328	8290	0.54
Gp IV Natural			3513	800	3603				474		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9971										



16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70/30' Arms

## Anchor Bolt &amp; Base Plate Analysis

**INPUTS**

Shear Force	7509 lbs
Bending Moment	197079 ft-lbs
Torsion Moment	230611 ft-lbs
Num. Anchor Bolts	8
Bolt Circle	26 in
Bolt Diameter	2.00 in
Bolt Yield Stress	55 ksi
Baseplate Width or Diameter	32 in
Baseplate Thickness	2.00 in
Baseplate Shape	Circular
Baseplate Yield Stress	36 ksi
Pole Shaft Base Diameter	20.50 in

**ANALYSIS - ANCHOR BOLTS**

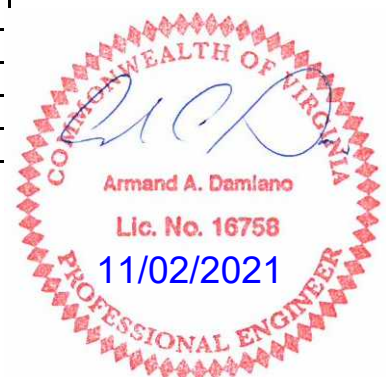
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Bolt Shear Stress Area	2.3 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	18.15 ksi
Bolt Direct Shear Stress	0.409 ksi
Bolt Torsion Shear Stress	11.57 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	18.15 ksi
$f_v =$	11.979 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.74 CSR
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case I)**

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	2.75 in
Design Moment	125 in-kip
Section Modulus of Failure Plane	6.62 in <sup>3</sup>
Applied Plate Stress	18.89 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>

**ANALYSIS - BASEPLATE (Case II)**

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.188 in
Design Moment	54 in-kip
Section Modulus of Failure Plane	6.31 in <sup>3</sup>
Applied Plate Stress	8.56 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	<b>OK</b>



16362-1-24 - VA - 90 MPH - MP-3 Standard Loads - Type C - 70/30' Arms

## Anchor Bolt &amp; Base Plate Analysis

**ANALYSIS - ANCHOR BOLTS - FATIGUE**

Bending Moment	25383 ft-lbs
Bolt Tensile Stress Area	2.5 in <sup>2</sup>
Mom. Inertia Bolt Grouping	1693.98 in <sup>4</sup>
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	2.34 ksi
<b>Bolt Stress</b>	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.34
Therefore	<b>OK</b>

**ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation**

Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A <sub>b</sub> = Net Bearing Area	4.528 in <sup>2</sup>
D <sub>w</sub> = Diameter of anchorage device (or) Flat-to-flat of nut	3.125 in
D = Diameter of Bolt	2 in
C' = Clear Cover To Bolt	10 in
T Reduced For Group Action	62115 lbs
Maximum Applied Tensile Load	45375 lbs
Computed Factor-of Safety	1.36 <b>OK</b>

**CONCRETE PULL OUT CAPACITY**

Maximum Applied Tensile Load Per Bolt	45375 lbs
Total Tensile Load	363000 lbs
Concrete Failure Surface Area	4310.27 in <sup>2</sup>
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.3 <b>OK</b>

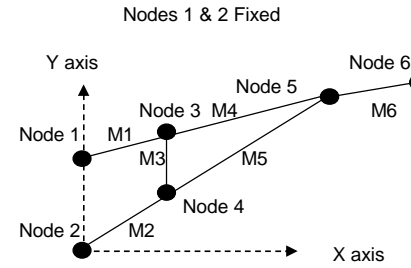
**LOAD TRANSFER TO REINFORCEMENT CAGE**

Maximum Applied Tensile Load Per Bolt	45375 lbs
Total Tensile Load	363000 lbs
Reinforcing Development Length	32.86 in
Anchor Bolt Embedment For Full Devel.(Min.)	44.65 in
Tensile Capacity per Bar	47123 lbs
Minimum Qty. of Vertical Reinforcement Bars	<b>8</b> Qty.



16362-3 - Northern Virginia, VA - On-Call Signal - VDOT - MP-3 Std. Loads - 12' Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-8.15	-17	0	0	0
Node #2	0	0	0	0	-10.01	-20.9	0	0	0
Node #3	48	50.5	0	0	-15.82	-33.2	0	0	0
Node #4	48	44.8	0	0	-17.92	-37.5	0	0	0
Node #5	96	61	0	0	-22.63	-47.2	0	0	0
Node #6	144	69	0	0	-64.42	-85.6	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.375	0.154	53.44	0.88	1.075	-16.29	1.1	1	-33.98	0.666	0.666	1.332	11000000	29000000
Member #2	2.375	0.154	65.66	1.08	1.075	-20.01	1.1	1	-41.74	0.666	0.666	1.332	11000000	29000000
Member #3	0.682	0.1296	5.70	0.03	0.225	-0.36	1.1	1	-1.04	0.01	0.01	0.02	11000000	29000000
Member #4	2.375	0.154	49.14	0.81	1.075	-14.98	1.1	1	-31.24	0.666	0.666	1.332	11000000	29000000
Member #5	2.375	0.154	50.66	0.84	1.075	-15.44	1.1	1	-32.21	0.666	0.666	1.332	11000000	29000000
Member #6	2.375	0.154	48.66	0.80	1.075	-14.83	1.1	1	-30.94	0.666	0.666	1.332	11000000	29000000
Fixture Node 6				2		-57.00	1	1	-70.09					

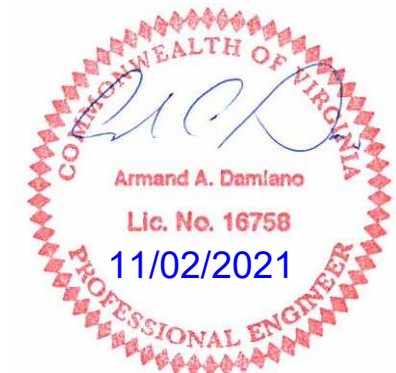
AASHTO Gp	2
Mntg Hght =	28.5
Datum =	0

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	5347 psi
Fa Member 3	16999 psi
Fa Member 4	21600 psi
Fa Member 5	8982 psi
Fa Member 6	9720 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-589.5	lbs
P1y	-354.8	lbs
P1z	181.4	lbs
M1x	4571.8	in-lbs
M1y	-12784.7	in-lbs
M1z	-1505.3	in-lbs
P2x	589.5	lbs
P2y	493.7	lbs
P2z	60.0	lbs
M2x	3131.4	in-lbs
M2y	-7466.5	in-lbs
M2z	-1343.3	in-lbs

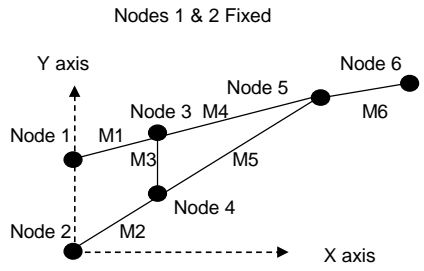
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-641	331	24208	-1271	0.71
#2	708	117	13753	-2353	0.53
#3	961	1581	17925	-486	0.59
#4	-715	106	9383	-101	0.26
#5	737	142	10578	-253	0.38
#6	10	199	9250	-1	0.28

V09.19.15



16362-3 - Northern Virginia, VA - On-Call Signal - VDOT - MP-3 Std. Loads - 12' Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-11.27	-8.5	0	0	0
Node #2	0	0	0	0	-13.85	-10.5	0	0	0
Node #3	48	50.5	0	0	-21.96	-16.6	0	0	0
Node #4	48	44.8	0	0	-24.85	-18.8	0	0	0
Node #5	96	61	0	0	-31.3	-23.6	0	0	0
Node #6	144	69	0	0	-91.26	-42.8	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.375	0.154	53.44	0.88	1.075	-22.53	1.1	1	-16.99	0.666	0.666	1.332	11000000	29000000
Member #2	2.375	0.154	65.66	1.08	1.075	-27.69	1.1	1	-20.87	0.666	0.666	1.332	11000000	29000000
Member #3	0.682	0.1296	5.70	0.03	0.225	-0.65	1.1	1	-0.52	0.01	0.01	0.02	11000000	29000000
Member #4	2.375	0.154	49.14	0.81	1.075	-20.72	1.1	1	-15.62	0.666	0.666	1.332	11000000	29000000
Member #5	2.375	0.154	50.66	0.84	1.075	-21.36	1.1	1	-16.10	0.666	0.666	1.332	11000000	29000000
Member #6	2.375	0.154	48.66	0.80	1.075	-20.52	1.1	1	-15.47	0.666	0.666	1.332	11000000	29000000
Fixture Node 6				2		-81.00	1	1	-35.04					

AASHTO Gp	3
Mntg Hght =	28.5
Datum =	0

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	5347 psi
Fa Member 3	16999 psi
Fa Member 4	21600 psi
Fa Member 5	8982 psi
Fa Member 6	9720 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-830.5	lbs
P1y	-500.5	lbs
P1z	90.7	lbs
M1x	2286.6	in-lbs
M1y	-6393.9	in-lbs
M1z	-2130.1	in-lbs
P2x	830.5	lbs
P2y	695.0	lbs
P2z	30.1	lbs
M2x	1566.3	in-lbs
M2y	-3734.1	in-lbs
M2z	-1900.4	in-lbs

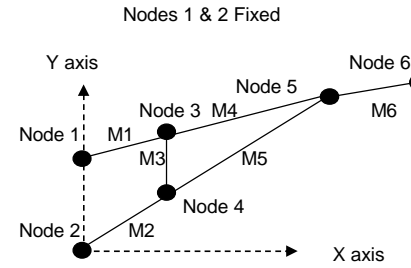
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-904	233	12618	-636	0.36
#2	998	133	7574	-1177	0.37
#3	1352	2059	22819	-243	0.76
#4	-1009	53	6016	-51	0.15
#5	1039	72	6225	-127	0.27
#6	14	186	8649	-1	0.27

V09.19.15



16362-3 - Northern Virginia, VA - On-Call Signal - VDOT - MP-3 Std. Loads - 15' Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-9.94	-20.8	0	0	0
Node #2	0	0	0	0	-11.04	-23.1	0	0	0
Node #3	60	52.47	0	0	-19.56	-41.1	0	0	0
Node #4	60	40.5	0	0	-21.08	-44.3	0	0	0
Node #5	120	61	0	0	-28.13	-58.7	0	0	0
Node #6	180	69	0	0	-66.23	-89.4	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.375	0.154	65.18	1.08	1.075	-19.87	1.1	1	-41.44	0.666	0.666	1.332	11000000	29000000
Member #2	2.375	0.154	72.39	1.19	1.075	-22.07	1.1	1	-46.02	0.666	0.666	1.332	11000000	29000000
Member #3	0.682	0.1296	11.97	0.06	0.225	-0.76	1.1	1	-2.19	0.01	0.01	0.02	11000000	29000000
Member #4	2.375	0.154	60.60	1.00	1.075	-18.47	1.1	1	-38.53	0.666	0.666	1.332	11000000	29000000
Member #5	2.375	0.154	63.41	1.05	1.075	-19.33	1.1	1	-40.31	0.666	0.666	1.332	11000000	29000000
Member #6	2.375	0.154	60.53	1.00	1.075	-18.45	1.1	1	-38.48	0.666	0.666	1.332	11000000	29000000
Fixture Node 6				2		-57.00	1	1	-70.09					

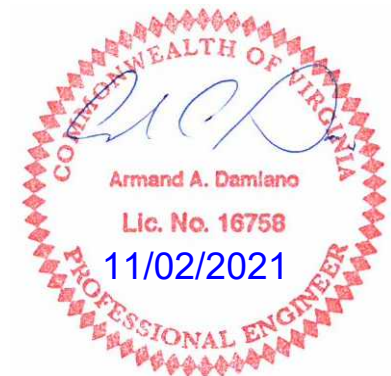
AASHTO Gp	2
Mntg Hght =	28.5
Datum =	0

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	4399 psi
Fa Member 3	11129 psi
Fa Member 4	21600 psi
Fa Member 5	5734 psi
Fa Member 6	6291 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-709.4	lbs
P1y	-312.8	lbs
P1z	182.0	lbs
M1x	4940.7	in-lbs
M1y	-16469.0	in-lbs
M1z	-719.5	in-lbs
P2x	709.4	lbs
P2y	468.8	lbs
P2z	95.4	lbs
M2x	4408.0	in-lbs
M2y	-11791.0	in-lbs
M2z	-698.3	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-725	303	30500	-1583	0.9
#2	786	139	21859	-2468	0.81
#3	934	519	11734	-603	0.42
#4	-699	140	12374	132	0.35
#5	719	153	13554	-595	0.5
#6	9	207	11971	-1	0.37

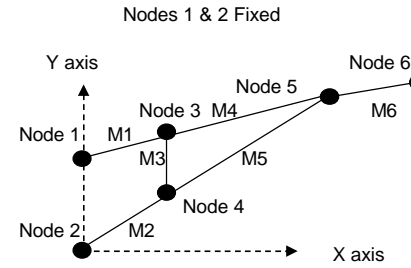
V09.19.15





16362-3 - Northern Virginia, VA - On-Call Signal - VDOT - MP-3 Std. Loads - 15' Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-13.75	-10.4	0	0	0
Node #2	0	0	0	0	-15.27	-11.6	0	0	0
Node #3	60	52.47	0	0	-27.21	-20.6	0	0	0
Node #4	60	40.5	0	0	-29.32	-22.2	0	0	0
Node #5	120	61	0	0	-38.91	-29.4	0	0	0
Node #6	180	69	0	0	-93.77	-44.7	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.375	0.154	65.18	1.08	1.075	-27.48	1.1	1	-20.72	0.666	0.666	1.332	11000000	29000000
Member #2	2.375	0.154	72.39	1.19	1.075	-30.52	1.1	1	-23.01	0.666	0.666	1.332	11000000	29000000
Member #3	0.682	0.1296	11.97	0.06	0.225	-1.37	1.1	1	-1.09	0.01	0.01	0.02	11000000	29000000
Member #4	2.375	0.154	60.60	1.00	1.075	-25.55	1.1	1	-19.27	0.666	0.666	1.332	11000000	29000000
Member #5	2.375	0.154	63.41	1.05	1.075	-26.74	1.1	1	-20.16	0.666	0.666	1.332	11000000	29000000
Member #6	2.375	0.154	60.53	1.00	1.075	-25.52	1.1	1	-19.24	0.666	0.666	1.332	11000000	29000000
Fixture Node 6				2		-81.00	1	1	-35.04					

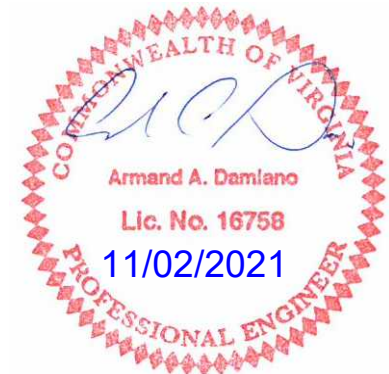
AASHTO Gp	3
Mntg Hght =	28.5
Datum =	0

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	4399 psi
Fa Member 3	11129 psi
Fa Member 4	21600 psi
Fa Member 5	5734 psi
Fa Member 6	6291 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-998.7	lbs
P1y	-441.1	lbs
P1z	91.1	lbs
M1x	2473.0	in-lbs
M1y	-8241.6	in-lbs
M1z	-1027.6	in-lbs
P2x	998.7	lbs
P2y	659.3	lbs
P2z	47.8	lbs
M2x	2206.4	in-lbs
M2y	-5900.4	in-lbs
M2z	-996.5	in-lbs

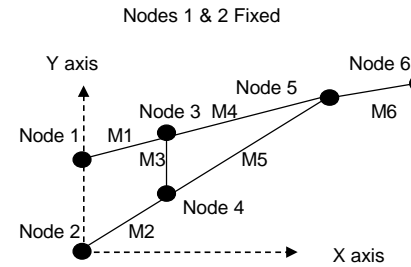
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1021	160	15360	-792	0.43
#2	1106	82	11065	-1235	0.52
#3	1314	439	10017	-302	0.39
#4	-984	97	6263	66	0.16
#5	1013	98	6843	-298	0.34
#6	12	192	11132	-1	0.34

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16362-3 - Northern Virginia, VA - On-Call Signal - VDOT - MP-3 Std. Loads - 18' Luminaire Arm - Group II

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-10.52	-16	0	0	0
Node #2	0	0	0	0	-11.4	-17.3	0	0	0
Node #3	48	41.7	0	0	-31.56	-48.6	0	0	0
Node #4	48	25.6	0	0	-33.36	-51.3	0	0	0
Node #5	144	61	0	0	-57.15	-86.7	0	0	0
Node #6	216	69	0	0	-72.19	-93.2	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



Member #3 is a bar computed as equivalent pipe section to the weak axis

	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.375	0.218	50.20	0.83	1.478	-21.04	1.1	1	-31.92	0.868	0.868	1.736	11000000	29000000
Member #2	2.375	0.218	54.40	0.90	1.478	-22.80	1.1	1	-34.59	0.868	0.868	1.736	11000000	29000000
Member #3	0.682	0.1296	16.10	0.08	0.225	-1.03	1.1	1	-2.94	0.01	0.01	0.02	11000000	29000000
Member #4	2.375	0.218	97.92	1.62	1.478	-41.04	1.1	1	-62.26	0.868	0.868	1.736	11000000	29000000
Member #5	2.375	0.218	102.32	1.69	1.478	-42.88	1.1	1	-65.05	0.868	0.868	1.736	11000000	29000000
Member #6	2.375	0.218	72.44	1.19	1.478	-30.36	1.1	1	-46.06	0.868	0.868	1.736	11000000	29000000
Fixture Node 6				2		-57.00	1	1	-70.09					

AASHTO Gp	2
Mntg Hght =	28.5
Datum =	0

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	7384 psi
Fa Member 3	6379 psi
Fa Member 4	21600 psi
Fa Member 5	2087 psi
Fa Member 6	4164 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-1070.4	lbs
P1y	-341.8	lbs
P1z	205.3	lbs
M1x	4867.3	in-lbs
M1y	-21241.0	in-lbs
M1z	-991.2	in-lbs
P2x	1070.4	lbs
P2y	557.9	lbs
P2z	107.8	lbs
M2x	5080.7	in-lbs
M2y	-16170.2	in-lbs
M2z	-969.9	in-lbs

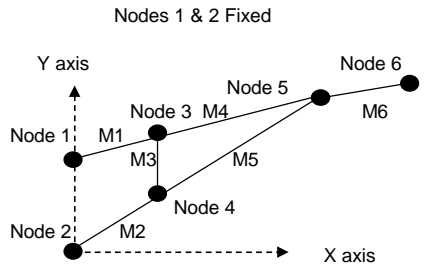
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-763	259	29767	-984	0.88
#2	814	126	22830	-1964	0.78
#3	611	439	13200	-513	0.47
#4	-756	134	17003	-7	0.49
#5	780	120	16627	-713	0.77
#6	6	160	11657	1	0.36

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16362-3 - Northern Virginia, VA - On-Call Signal - VDOT - MP-3 Std. Loads - 18' Luminaire Arm - Group III

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-10.59	-8	0	0	0
Node #2	0	0	0	0	-11.47	-8.7	0	0	0
Node #3	48	41.7	0	0	-32.15	-24.3	0	0	0
Node #4	48	25.6	0	0	-33.96	-25.7	0	0	0
Node #5	144	61	0	0	-57.49	-43.4	0	0	0
Node #6	216	69	0	0	-96.28	-46.6	0	0	0
K Node #1	300	150	0						
K Node #2	120	10	0						
Fixture EPA	2	sq.ft.							
Fixture Wght	-57	lbs							



	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Ch	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.375	0.154	50.20	0.83	1.075	-21.17	1.1	1	-15.96	0.666	0.666	1.332	11000000	29000000
Member #2	2.375	0.154	54.40	0.90	1.075	-22.94	1.1	1	-17.29	0.666	0.666	1.332	11000000	29000000
Member #3	0.682	0.1296	16.10	0.08	0.225	-1.84	1.1	1	-1.47	0.01	0.01	0.02	11000000	29000000
Member #4	2.375	0.154	97.92	1.62	1.075	-41.29	1.1	1	-31.13	0.666	0.666	1.332	11000000	29000000
Member #5	2.375	0.154	102.32	1.69	1.075	-43.14	1.1	1	-32.53	0.666	0.666	1.332	11000000	29000000
Member #6	2.375	0.154	72.44	1.19	1.075	-30.55	1.1	1	-23.03	0.666	0.666	1.332	11000000	29000000
Fixture Node 6				2		-81.00	1	1	-35.04					

AASHTO Gp	3
Mntg Hght =	28.5
Datum =	0

ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	7789 psi
Fa Member 3	6379 psi
Fa Member 4	21600 psi
Fa Member 5	2202 psi
Fa Member 6	4392 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-1302.0	lbs
P1y	-426.4	lbs
P1z	104.7	lbs
M1x	2435.0	in-lbs
M1y	-10678.0	in-lbs
M1z	-1476.2	in-lbs
P2x	1302.0	lbs
P2y	668.4	lbs
P2z	52.0	lbs
M2x	2488.3	in-lbs
M2y	-8037.2	in-lbs
M2z	-1430.1	in-lbs

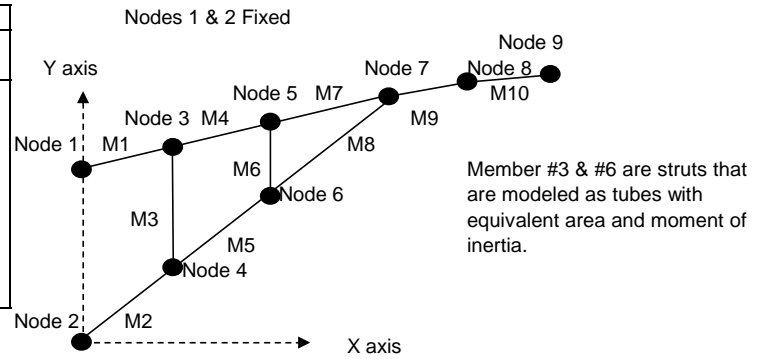
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1278	193	19654	-670	0.55
#2	1357	102	14952	-1331	0.58
#3	732	382	11644	-339	0.44
#4	-1275	110	11017	-5	0.29
#5	1315	101	10916	-471	0.76
#6	10	199	13749	-1	0.42

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16' Luminaire Arm

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X	Y	Z	Fx	Fy grav.	Fz wind	Mx	My	Mz
90	(in)	(in)	(in)	(lbs)	(lbs)	(lbs)	(in-lbs)	(in-lbs)	(in-lbs)
Node #1	0	27	0	0	-7.78	-16.3	0	0	0
Node #2	0	0	0	0	-8.3	-17.4	0	0	0
Node #3	48	43.94	0	0	-17.67	-37	0	0	0
Node #4	48	25.5	0	0	-18.61	-38.96	0	0	0
Node #5	96	63.05	0	0	-16.54	-34.58	0	0	0
Node #6	96	51.04	0	0	-17.1	-35.76	0	0	0
Node #7	144	61	0	0	-18.55	-38.68	0	0	0
Node #8	168	65	0	0	-14.94	-33.04	0	0	0
Node #9	192	69	0	0	-60.72	-77.9	0	0	0
K Node #1	36	240	0						
K Node #2	360	360	0						
K Node #3	300	0	0						



	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.38	0.154	50.90	0.84	1.077	-15.55	1.1	-32.44	0.671	0.671	1.342	11000000	29000000
Member #2	2.38	0.154	54.35	0.90	1.077	-16.6	1.1	-34.63	0.671	0.671	1.342	11000000	29000000
Member #3	1.75	0.1525	18.44	0.22	0.766	-4.01	1.1	-8.64	0.247	0.247	0.494	11000000	29000000
Member #4	2.38	0.154	51.66	0.85	1.077	-15.78	1.1	-32.92	0.671	0.671	1.342	11000000	29000000
Member #5	2.38	0.154	54.37	0.90	1.077	-16.61	1.1	-34.65	0.671	0.671	1.342	11000000	29000000
Member #6	1.75	0.1525	12.01	0.15	0.766	-2.61	1.1	-5.63	0.247	0.247	0.494	11000000	29000000
Member #7	2.38	0.154	48.04	0.79	1.077	-14.68	1.1	-30.61	0.671	0.671	1.342	11000000	29000000
Member #8	2.38	0.154	49.02	0.81	1.077	-14.98	1.1	-31.24	0.671	0.671	1.342	11000000	29000000
Member #9	2.38	0.154	24.33	0.40	1.077	-7.44	1.1	-15.51	0.671	0.671	1.342	11000000	29000000
Member #10	2.38	0.154	24.33	0.40	1.077	-7.44	1.1	-15.51	0.671	0.671	1.342	11000000	29000000
Camera Node 8				1		-15	1	-35.05					
Fixture Node 9				2		-57	1	-70.09					

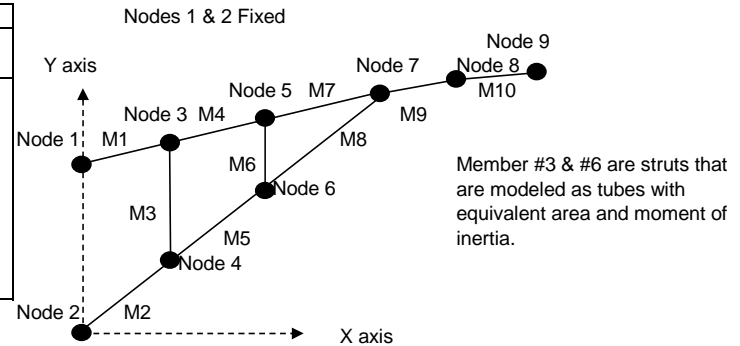
ALLOWABLES	
Fy =	36000 psi
Fa = .60 Fy	21600 psi
Fa Comp.=	7847 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Gp II Increase	1.4

ITEM	RESULTS						
	LOCAL AXIS		AASHTO STRESSES		GLOBAL AXIS		
P1x	-435.2	lbs	Axial	405	psi	-425.2	lbs
P1y	44.3	lbs	Shear	247	psi	-103.0	lbs
P1z	125.1	lbs	Bending	7890	in-lbs	125.1	lbs
M1x	-1036.0	in-lbs	Torsion	865	in-lbs	459.8	in-lbs
M1y	-4317.1	in-lbs	CSR	0.26		-4415.8	in-lbs
M1z	1073.1	in-lbs				1073.1	in-lbs
P2x	476.3	lbs	Axial	443	psi	425.2	lbs
P2y	-9.6	lbs	Shear	117	psi	215.0	lbs
P2z	61.8	lbs	Bending	6592	in-lbs	61.8	lbs
M2x	-1443.2	in-lbs	Torsion	1205	in-lbs	468.3	in-lbs
M2y	-3714.7	in-lbs	CSR	0.25		-3957.6	in-lbs
M2z	115.6	in-lbs				115.6	in-lbs



24' Luminaire Arm

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
90									
Node #1	0	27	0	0	-16.4	-19.5	0	0	0
Node #2	0	0	0	0	-16.88	-20.1	0	0	0
Node #3	50	34.29	0	0	-35.64	-43.8	0	0	0
Node #4	50	14.34	0	0	-36.55	-44.86	0	0	0
Node #5	100	41.58	0	0	-51.11	-61.7	0	0	0
Node #6	100	28.06	0	0	-52.45	-63.29	0	0	0
Node #7	200	56.12	0	0	-79.63	-94.62	0	0	0
Node #8	240	62.56	0	0	-33.79	-48.77	0	0	0
Node #9	280	69	0	0	-70.15	-85.8	0	0	0
K Node #1	36	240	0						
K Node #2	360	360	0						
K Node #3	300	0	0						

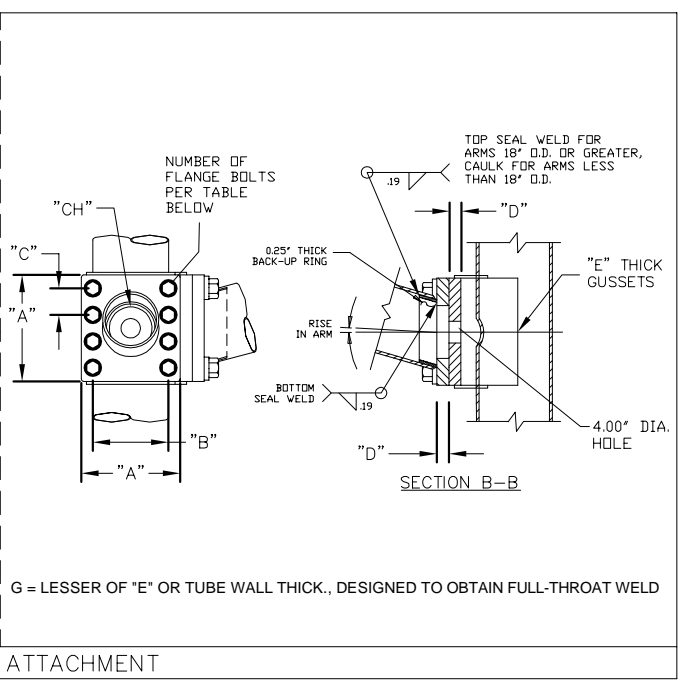
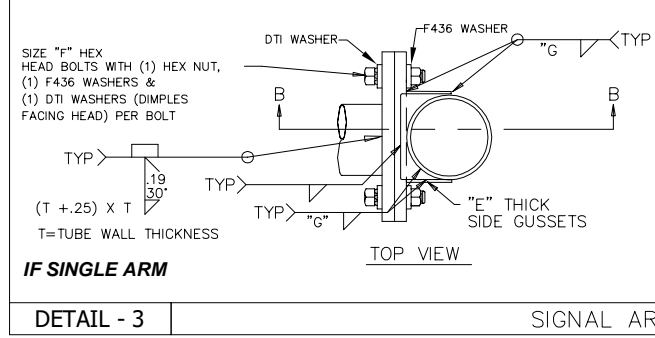
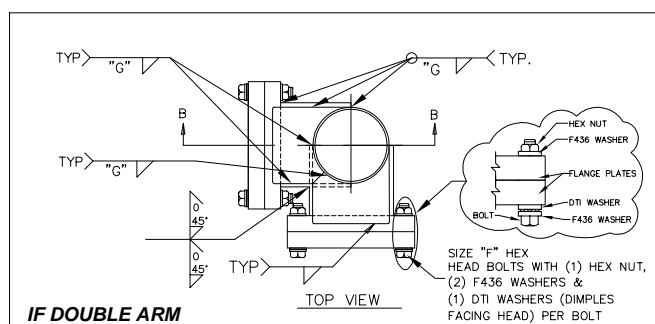
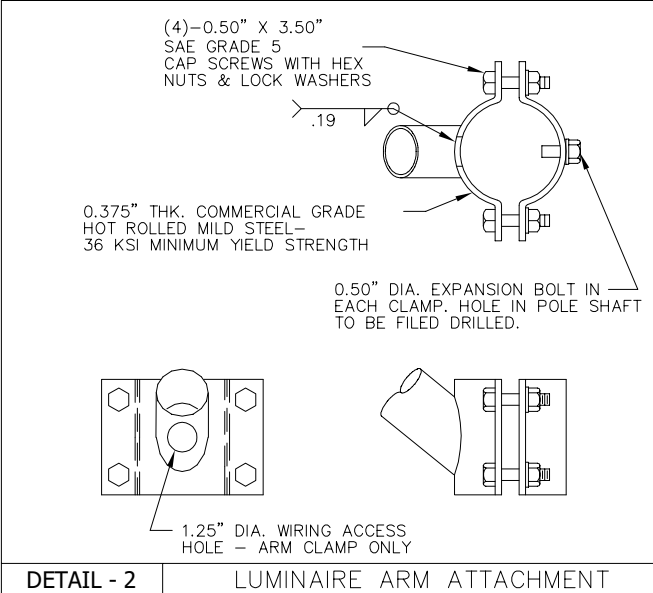
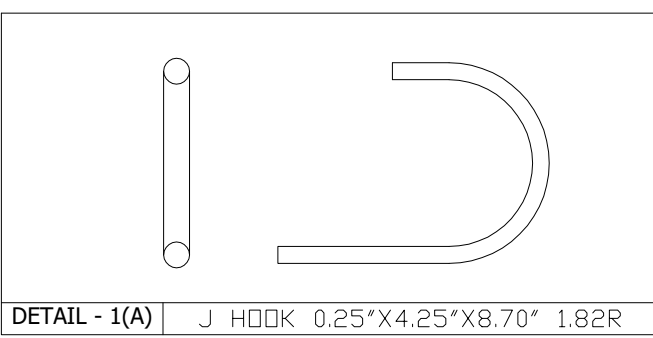
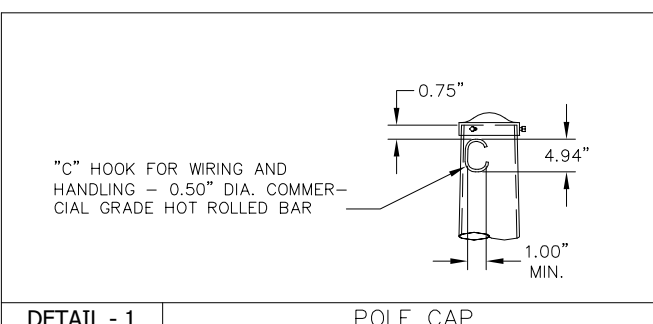
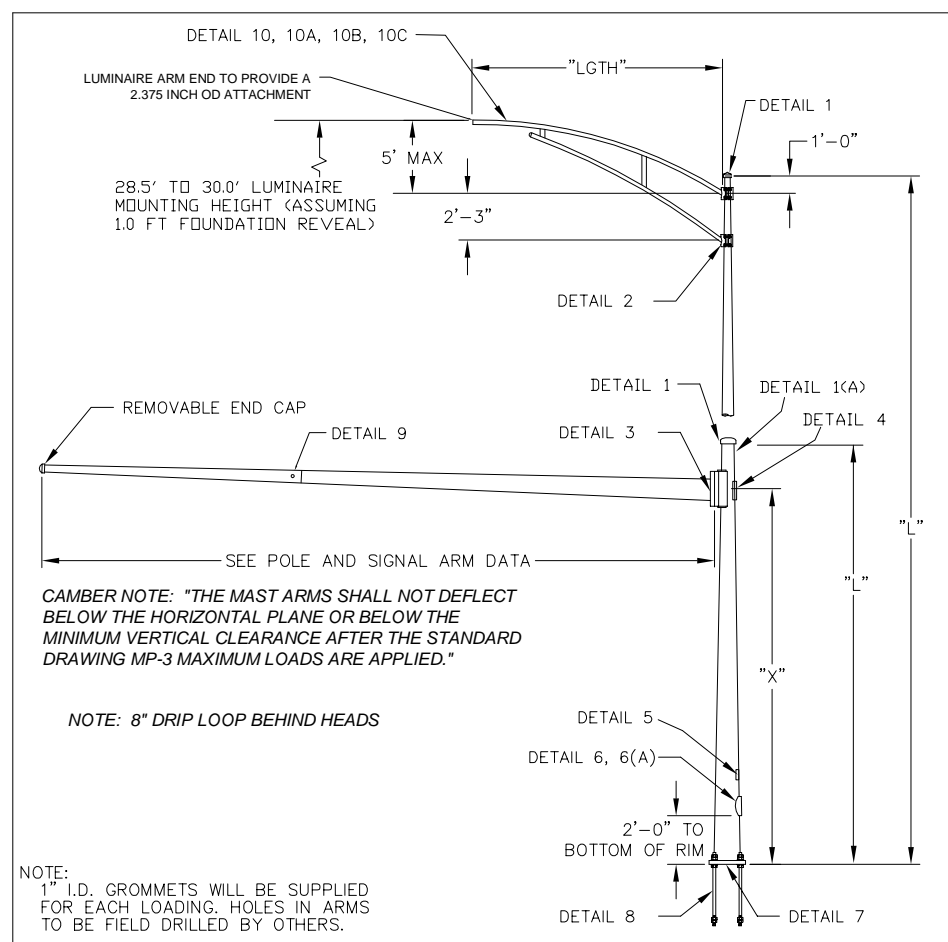


	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.28	50.53	1.01	2.288	-32.79	1.1	-38.96	1.955	1.955	3.91	11000000	29000000
Member #2	2.88	0.28	52.02	1.04	2.288	-33.75	1.1	-40.11	1.955	1.955	3.91	11000000	29000000
Member #3	1.8	0.2	19.95	0.25	1.006	-5.7	1.1	-9.62	0.327	0.327	0.654	11000000	29000000
Member #4	2.88	0.28	50.53	1.01	2.288	-32.79	1.1	-38.96	1.955	1.955	3.91	11000000	29000000
Member #5	2.88	0.28	51.85	1.04	2.288	-33.64	1.1	-39.98	1.955	1.955	3.91	11000000	29000000
Member #6	1.8	0.2	13.52	0.17	1.006	-3.86	1.1	-6.52	0.327	0.327	0.654	11000000	29000000
Member #7	2.88	0.28	101.05	2.02	2.288	-65.57	1.1	-77.91	1.955	1.955	3.91	11000000	29000000
Member #8	2.88	0.28	103.86	2.08	2.288	-67.39	1.1	-80.08	1.955	1.955	3.91	11000000	29000000
Member #9	2.88	0.28	40.52	0.81	2.288	-26.29	1.1	-31.24	1.955	1.955	3.91	11000000	29000000
Member #10	2.88	0.28	40.52	0.81	2.288	-26.29	1.1	-31.24	1.955	1.955	3.91	11000000	29000000
Camera Node 8				1		-15	1	-35.05					
Fixture Node 9				2		-57	1	-70.09					

ALLOWABLES	
Fy =	36000 psi
Fa = .60 Fy	21600 psi
Fa Comp.=	11751 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Gp II Increase	1.4

ITEM	RESULTS						
	LOCAL AXIS		AASHTO STRESSES		GLOBAL AXIS		
P1x	-875.9	lbs	Axial	383	psi	-880.6	lbs
P1y	96.0	lbs	Shear	178	psi	-31.3	lbs
P1z	178.4	lbs	Bending	5221	in-lbs	178.4	lbs
M1x	-1729.4	in-lbs	Torsion	582	in-lbs	-755.0	in-lbs
M1y	-6628.8	in-lbs	CSR	0.18		-6808.9	in-lbs
M1z	2506.9	in-lbs				2506.9	in-lbs
P2x	903.7	lbs	Axial	395	psi	880.6	lbs
P2y	-43.3	lbs	Shear	55	psi	207.5	lbs
P2z	44.9	lbs	Bending	4426	in-lbs	44.9	lbs
M2x	-2198.2	in-lbs	Torsion	740	in-lbs	-457.0	in-lbs
M2y	-6007.2	in-lbs	CSR	0.16		-6380.4	in-lbs
M2z	101.2	in-lbs				101.2	in-lbs





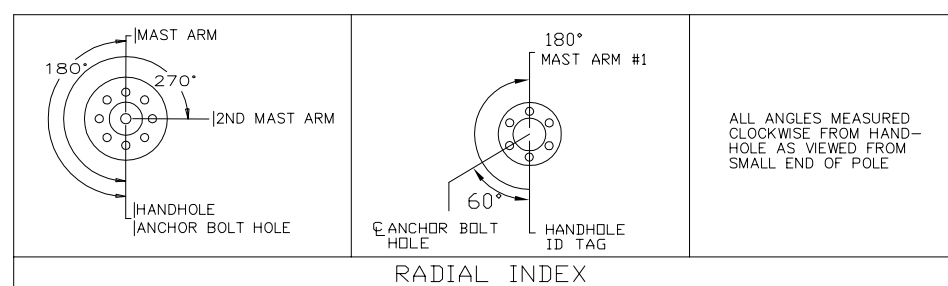
**MATERIAL DATA**

COMPONENT	ASTM DESIGNATION	MIN. YIELD (KSI)	COMPONENT	ASTM DESIGNATION	MIN. YIELD (KSI)
POLE SHAFT - 11,7,5,3 GA	A595 GR. A	55	* ARM CONNECTING BOLTS (GALV.)	F3125 GR. A325 OR A449	
POLE SHAFT - ALL OTHERS	A572 GR.55	55	GALVANIZING - POLES	A123	
POLE BASE	A36	36	GALVANIZING - HARDWARE	A153	
ARM SHAFT - 11,7,5,3 GA	A595 GR. A	55	LUM ARM ATTACHMENT	A27 65-35	
ARM SHAFT - ALL OTHERS	A572 GR.55	55	LUM ARM CONNECTING BOLTS	SAE GR. 5	
ARM CONNECTION	A572 GR.50	50	LUM TRUSS ARM	SEE DETAIL 10	
ANCHOR BOLTS	F1554 GR. 55	55			36
POLYURETHANE SEALANT	C920				

**FINISH: GALVANIZED ONLY OR**

**FINISH: POWDER COATED OVER BARE METAL OR POWDER COATED OVER GALV. (AS REQUESTED/REQUIRED)**

\* LUBRICATE IN THE FIELD IF NECESSARY.



DESIGN BASED ON:

- AASHTO 6TH EDITION
- 90 MPH (APPENDIX C) WIND
- 25 YEAR RECURRENCE
- FATIGUE CATEGORY II FOR 50' ARMS OR LONGER
- NO FATIGUE REQUIREMENTS FOR ARMS 49' LONG OR SMALLER
- NO GALLOPING LOADS
- NO TRUCK GUST
- MP-3 STANDARD LOADS

NOTE: DRAWING NOT TO SCALE

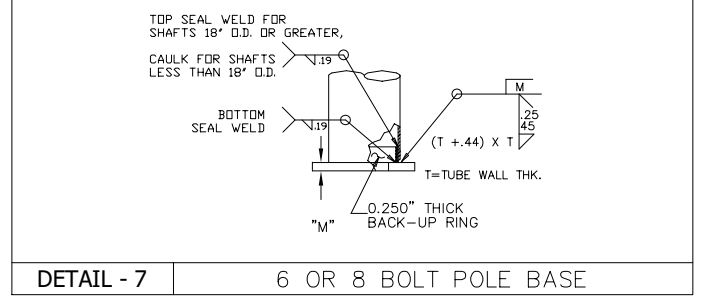
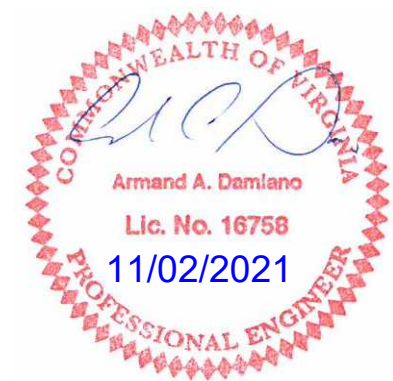
VIRGINIA DEPARTMENT OF TRANSPORTATION  
C.O. STRUCTURE AND BRIDGE  
REVIEW OF WORKING DRAWINGS

Working drawings have been reviewed in accordance with Section 105.10 of the Specifications with the following comments.

Reviewed  Revise and Resubmit

Reviewed as Noted

Reviewed by: Karl Larson 11/30/2021



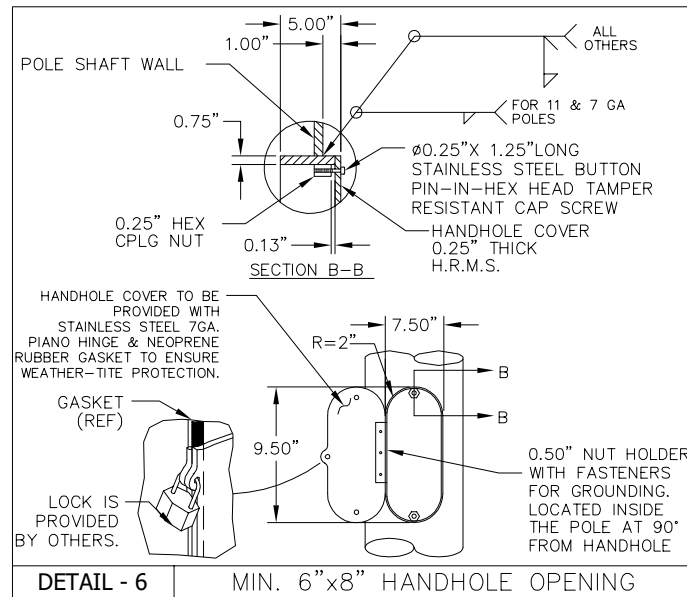
REV.	DATE	REVISION
A	08/08/19	VDDT REVIEW COMMENTS
B	10/02/19	VDDT REVIEW COMMENTS
C	11/02/21	VDDT REVIEW COMMENTS

CUSTOMER: **ATS-SALES**

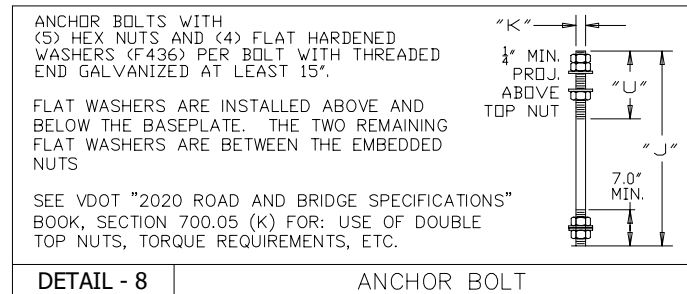
Valmont Valley, NE 68064 POLES (402) 359-2201

DATE: 04/04/19

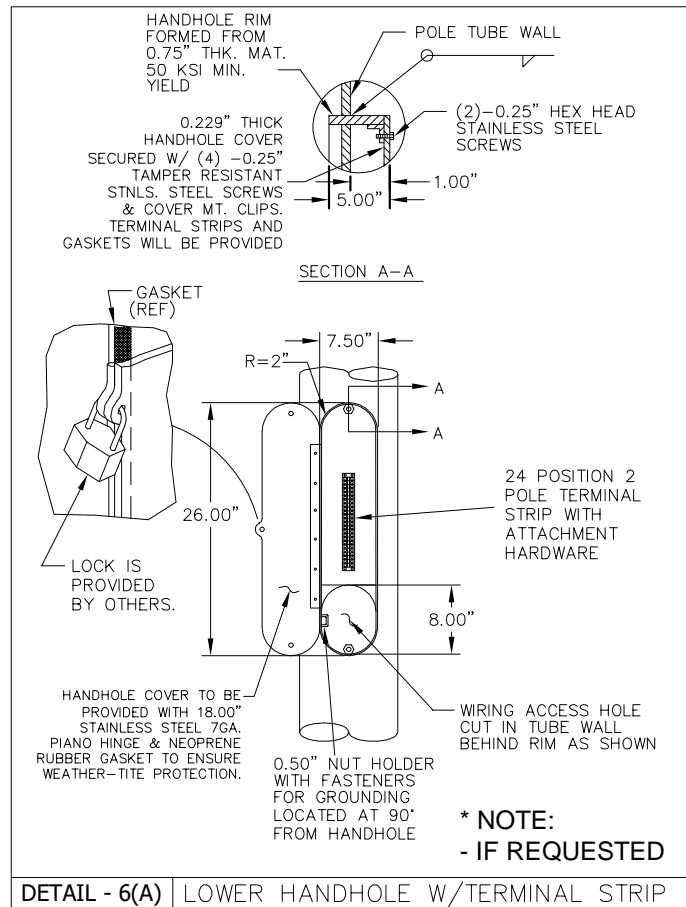
DRAWING: 16362-3(A) C



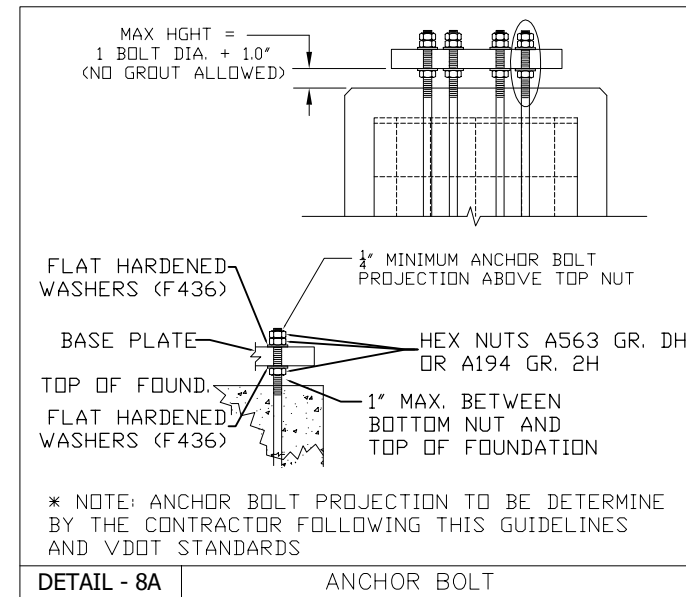
DETAIL - 6 MIN. 6"x8" HANDHOLE OPENING



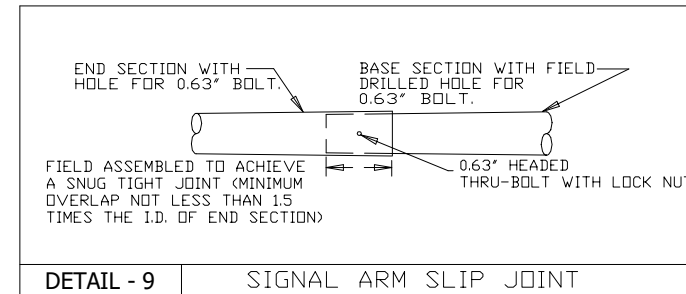
DETAIL - 8 ANCHOR BOLT



DETAIL - 6(A) LOWER HANDHOLE W/TERMINAL STRIP



DETAIL - 8A ANCHOR BOLT



DETAIL - 9 SIGNAL ARM SLIP JOINT

VIRGINIA DEPARTMENT OF TRANSPORTATION  
C.O. STRUCTURE AND BRIDGE  
REVIEW OF WORKING DRAWINGS

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Reviewed  Revise and Resubmit  
 Reviewed as Noted

Reviewed by: Karl Larson 11/30/2021



REV.	DATE	REVISION		
A:08/08/19:		VDOT REVIEW COMMENTS	ATS-SALES	
B:10/02/19:		VDOT REVIEW COMMENTS		
C:11/02/21:		VDOT REVIEW COMMENTS		
CUSTOMER:			valmont	
MAST ARM POLE DETAILS 90 MPH - MP-3 STANDARDS VIRGINIA			Valley, NE 68064 POLES (402) 359-2201	
			DATE: 04/04/19	REV
			DRAWING:	
			16362-3(B)	C

NOTE: DRAWING NOT TO SCALE

SHAFT																			
POLE TYPE	QTY.	SHAFT					BASE PLATE					ANCHOR BOLT			ARM	LUMINAIRE ARM		FLANGE	
		BASE DIA. (IN)	TOP DIA. (IN)	LGTH. "L" (FT)	WALL THICK (IN)	ARM ATTACH ELEV "X" (FT)	DIA. "S" (IN)	BOLT CIRCLE "Y" (IN)	CENTER HOLE DIA. "W" (IN)	THK. "M" (IN)	HOLE "Z" (IN)	QTY.	DIA. "K" (IN)	LGTH. "J" (IN)	THREAD LENGTH "U" (IN)	MAX ARM SPAN (FT)	MAX LUM. ARM SPAN (FT)	MAX LUM. ARM RISE (FT)	FLANGE ID NO.
A	-	17.00	14.27	19.5	0.250	18.0	30.0	24.0	12.50	2.00	2.25	6 OR 8	2.00	60.0	14.0	49	NA	NA	F1
B1	-	20.00	17.27	19.5	0.375	18.0	32.0	26.0	15.25	2.00	2.25	8	2.00	60.0	14.0	75 Case 1	NA	NA	F2
B2	-	22.50	19.77	19.5	0.375	18.0	35.0	29.0	17.75	2.00	2.25	8	2.00	60.0	14.0	75 Case 2	NA	NA	F3
C	-	20.50	17.77	19.5	0.375	18.0	32.0	26.0	15.25	2.00	2.25	8	2.00	60.0	14.0	70/60	NA	NA	F2
D	-	17.50	14.00	25.0	0.250	18.0	30.0	24.0	12.50	2.00	2.25	6 OR 8	2.00	60.0	14.0	49	24.0	5.0	F1
E1	-	20.00	16.50	25.0	0.375	18.0	32.0	26.0	15.25	2.00	2.25	8	2.00	60.0	14.0	75 Case 1	24.0	5.0	F2
E2	-	22.50	19.00	25.0	0.375	18.0	35.0	29.0	17.75	2.00	2.25	8	2.00	60.0	14.0	75 Case 2	24.0	5.0	F3
F	-	21.00	17.50	25.0	0.375	18.0	35.0	29.0	15.25	2.00	2.25	8	2.00	60.0	14.0	70/60	24.0	5.0	F2

VIRGINIA DEPARTMENT OF TRANSPORTATION  
 C.O. STRUCTURE AND BRIDGE  
 REVIEW OF WORKING DRAWINGS

Working drawings have been reviewed in accordance with Section 105.10 of the Specifications with the following comments.

Reviewed  Revise and Resubmit  
 Reviewed as Noted

Reviewed by: Karl Larson 11/30/2021



REV. DATE	REVISION	ATS-SALES
A:08/08/19:	VDDT REVIEW COMMENTS	
B:10/02/19:	VDDT REVIEW COMMENTS	
C:11/02/21:	VDDT REVIEW COMMENTS	
CUSTOMER:		 Valley, NE 68064 POLES (402) 359-2201
MAST ARM POLE DETAILS 90 MPH - MP-3 STANDARDS VIRGINIA		
DATE:	04/04/19	REV:
DRAWING:	16362-3(C)	C



SIGNAL ARM DATA								
QTY.	ARM SPAN (FT)	SIGNAL ARM TUBE					FLANGE	
		FIXED END DIA. (IN)	FREE END DIA. (IN)	GAUGE OR THK (IN)	SEC. LGTH. (FT)	CENTER HOLE "CH" (IN)	QTY.	FLANGE ID NO.
-	30.0 OPTION A	12.00	7.80	0.179	30.00	6.00	-	F1
-	30.0 OPTION B	14.00	9.80	0.219	30.00	6.00	-	F2
-	40.0 OPTION A	13.00	7.40	0.179	40.00	6.00	-	F1
-	40.0 OPTION B	14.00	8.40	0.219	40.00	6.00	-	F2
-	49.0	14.00	7.14	0.219	49.00	6.00	-	F1
-		-	-	-	-	-	-	F2
-	50.0	14.00	7.00	0.250	50.00	6.00	-	F2
-		-	-	-	-	-	-	F3
-	60.0	15.58	12.27	0.250	23.69	6.00	-	F2
-		13.00	7.54	0.179	39.00		-	F3
-	65.0	16.28	12.27	0.313	28.69	6.00	-	F2
-		13.00	7.54	0.179	39.00		-	F3
-	70.0	17.50	14.00	0.313	25.00	6.00	-	F2
-		14.79	8.09	0.188	47.92		-	F3
-	75.0 - Case 1	18.50	14.58	0.313	28.00	6.00	-	F2
-		15.37	8.38	0.188	49.99		-	F3
-	75.0 - Case 2	19.00	14.94	0.375	29.00	6.00	-	F2
-		15.87	9.01	0.250	49.04		-	F3

FLANGE CONNECTION DATA								
FLANGE PLATES								
ID NO.	NUM OF BOLTS	WIDTH & LENGTH "A" (IN)	BOLT DIST. "B" (IN)	BOLT SPACING "C" (IN)	FLANGE THK. "D" (IN)	GUSSET THK. "E" (IN)	CENTER HOLE "CH" (IN)	BOLT "F" (DIA.X MIN.LGTH.) (IN)
F1	8	24.00	19.50	6.50	2.00	0.375	SEE ARM TABLE	1.50" X 7.00"
F2	8	27.00	22.50	7.50	2.25	0.500	SEE ARM TABLE	1.50" X 7.00"
F3	8	29.50	25.00	8.33	2.75	0.500	SEE ARM TABLE	1.50" X 7.75"

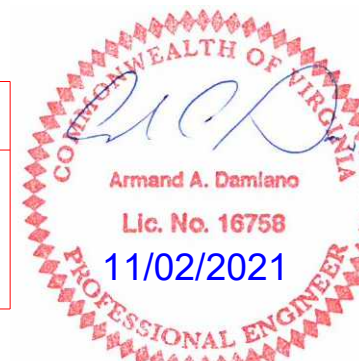
**NOTES:**  
 - ARMS BETWEEN STANDARD LENGTHS MAY BE SUBSTITUTED WITH THE NEXT LONGER ARM AND TRIMMED TO THE CORRECT LENGTH IF THE FLANGE SIZE CORRESPONDS TO WHAT IS REQUIRED BY THE SHAFT.  
 - ACTUAL LENGTH OF FLANGE BOLTS MAY BE ADJUSTED TO ACCOMMODATE CUSTOMIZED WASHERS ASSEMBLY.

VIRGINIA DEPARTMENT OF TRANSPORTATION  
 C.O. STRUCTURE AND BRIDGE  
 REVIEW OF WORKING DRAWINGS

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Reviewed  Revise and Resubmit  
 Reviewed as Noted

Reviewed by: Karl Larson 11/30/2021



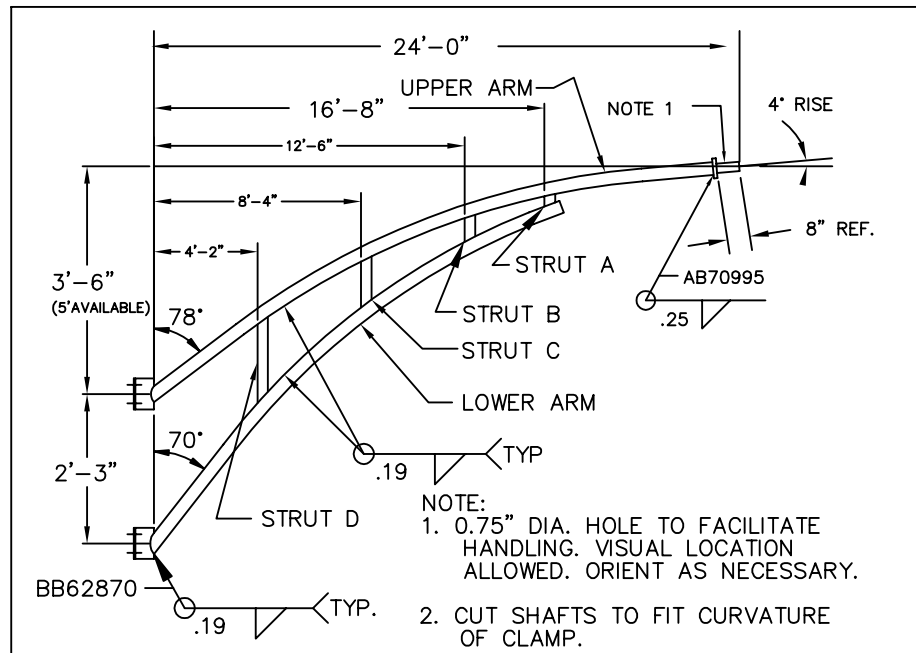
REV.	DATE	REVISION
A	08/08/19	VDDT REVIEW COMMENTS
B	10/02/19	VDDT REVIEW COMMENTS
C	11/02/21	VDDT REVIEW COMMENTS

CUSTOMER: **ATS-SALES**

**valmont**  
 Valley, NE 68064 POLES  
 (402) 359-2201

DATE: 04/04/19 REV:   
 DRAWING: 16362-3(D) C

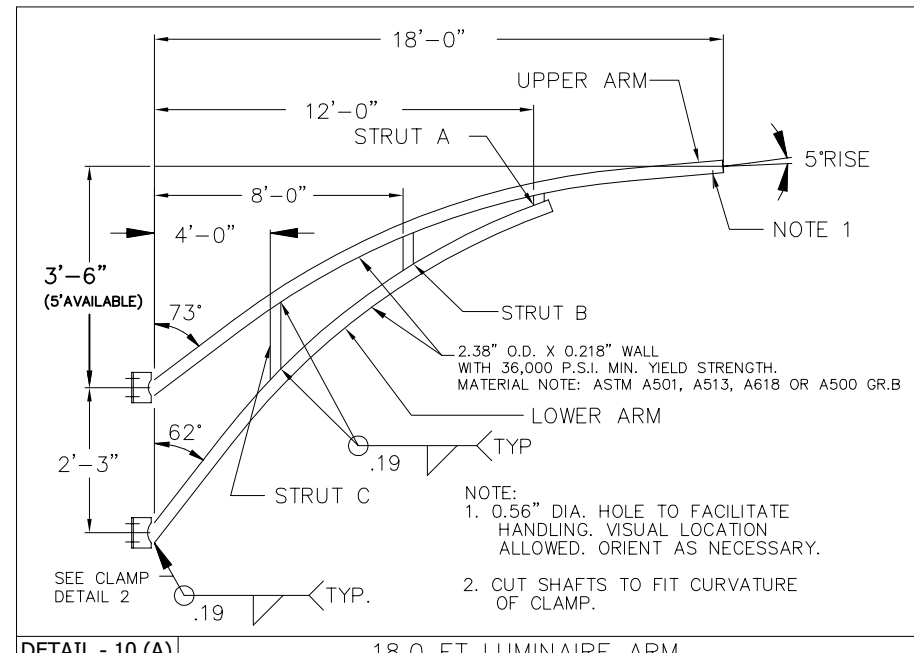
MAST ARM POLE DETAILS  
 90 MPH - MP-3 STANDARDS  
 VIRGINIA



DETAIL - 10 24.0 FT LUMINAIRE ARM

STRUT DATA				
STRUT	THK.	"X"	"Y"	LENGTH
A	0.50"	0.20"	0.43"	0'-2.69"
B	0.50"	0.28"	0.46"	0'-7.11"
C	0.50"	0.36"	0.56"	1'-0.00"
D	0.50"	0.44"	0.67"	1'-5.51"
TOTAL S-70 MATERIAL = 3'-3.31"				

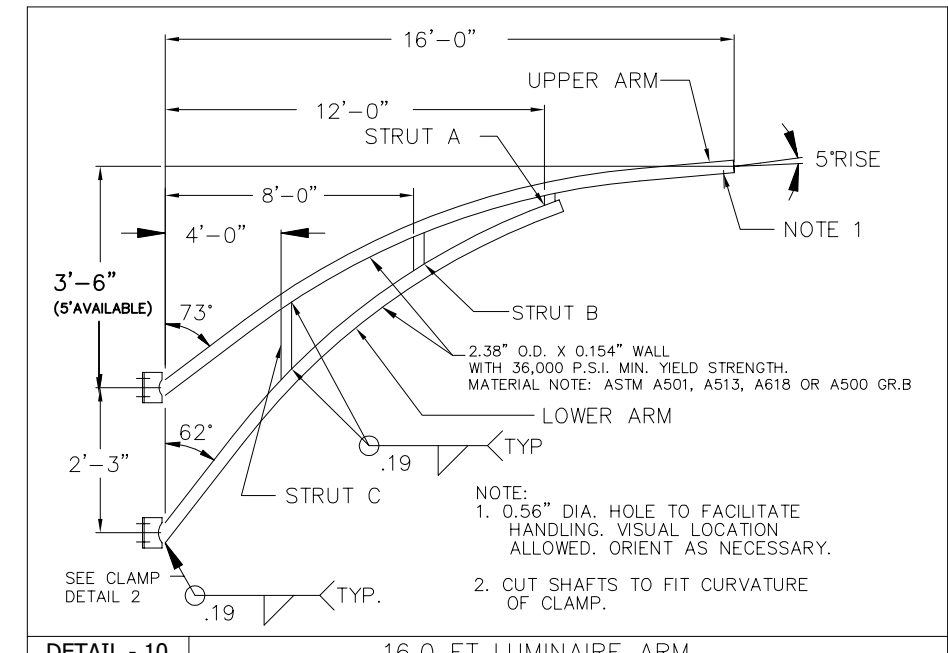
ARM DATA			
ARM	O.D.	WALL	LENGTH
UPPER	2.88"	0.38"	24'- 7.42"
LOWER	2.88"	0.38"	17'- 8.38"
TOTAL S109 MATERIAL= 42'- 3.80"			



DETAIL - 10 (A) 18.0 FT LUMINAIRE ARM

STRUT DATA			
STRUT	THK	WIDTH	LENGTH
A	0.38"	2.00"	4.09"
B	0.38"	2.00"	9.13"
C	0.38"	2.00"	1' - 3.56"
TOTAL A36 MATERIAL= 2'- 4.78"			

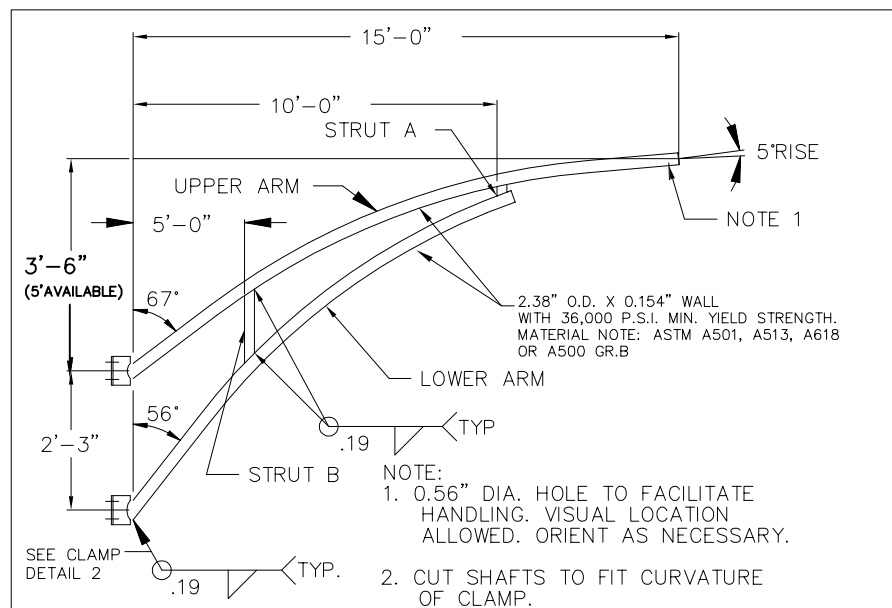
ARM DATA			
ARM	O.D.	WALL	LENGTH
UPPER	2.38"	0.218"	18'- 4.81"
LOWER	2.38"	0.218"	13'- 7.25"
36,000 P.S.I MIN. YIELD STRENGTH			



DETAIL - 10 16.0 FT LUMINAIRE ARM

STRUT DATA			
STRUT	THK	WIDTH	LENGTH
A	0.38"	2.00"	4.09"
B	0.38"	2.00"	9.13"
C	0.38"	2.00"	1' - 3.56"
TOTAL A36 MATERIAL= 2'- 4.78"			

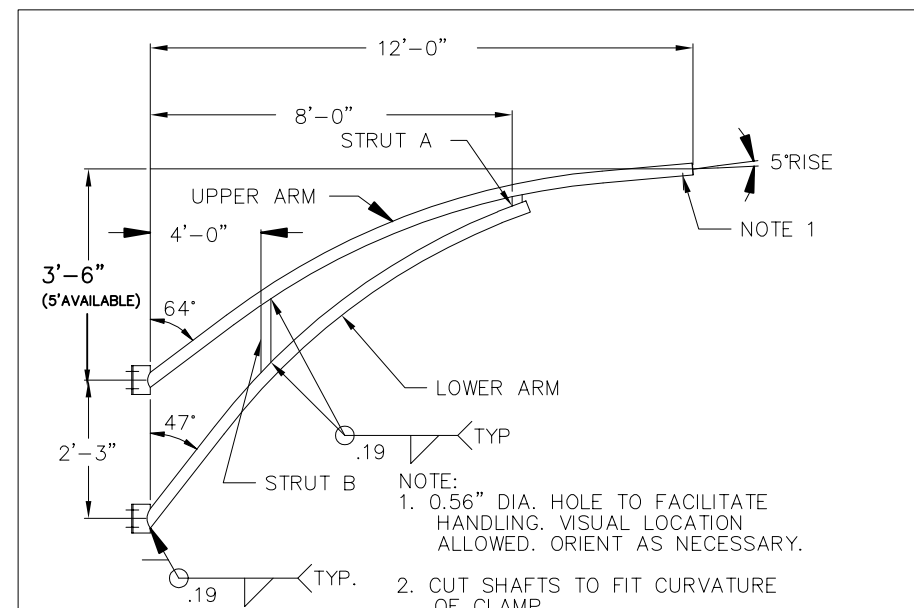
ARM DATA			
ARM	O.D.	WALL	LENGTH
UPPER	2.38"	0.154"	16'- 4.81"
LOWER	2.38"	0.154"	13'- 7.25"
36,000 P.S.I MIN. YIELD STRENGTH			



DETAIL - 10 (B) 15.0 FT LUMINAIRE ARM

STRUT DATA			
STRUT	THK	WIDTH	LENGTH
A	0.38"	2.00"	2.69"
B	0.38"	2.00"	11.13"
TOTAL A36 MATERIAL= 1'- 1.81"			

ARM DATA			
ARM	O.D.	WALL	LENGTH
UPPER	2.38"	0.154"	15'- 6.63"
LOWER	2.38"	0.154"	11'- 7.13"
TOTAL S109 MATERIAL= 27'- 1.75"			



DETAIL - 10 (C) 12.0 FT LUMINAIRE ARM

STRUT DATA			
STRUT	THK	WIDTH	LENGTH
A	0.38"	2.00"	2.38"
B	0.38"	2.00"	9.44"
TOTAL A36 MATERIAL= 0'- 11.82"			

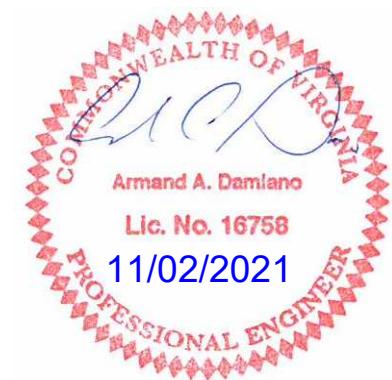
ARM DATA			
ARM	O.D.	WALL	LENGTH
UPPER	2.38"	0.154"	12'- 8.00"
LOWER	2.38"	0.154"	9'- 11.81"
TOTAL S109 MATERIAL= 22'- 7.81"			

VIRGINIA DEPARTMENT OF TRANSPORTATION  
C.O. STRUCTURE AND BRIDGE  
REVIEW OF WORKING DRAWINGS

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Reviewed  Revise and Resubmit  
 Reviewed as Noted

Reviewed by: Karl Larson 11/30/2021



REV.	DATE	REVISION
A	08/08/19	VDDT REVIEW COMMENTS
B	10/02/19	VDDT REVIEW COMMENTS
C	11/02/21	VDDT REVIEW COMMENTS

CUSTOMER: MAST ARM POLE DETAILS  
90 MPH - MP-3 STANDARDS  
VIRGINIA

ATS-SALES  
valmont  
Valley, NE 68064 POLES  
(402) 359-2201

DATE: 04/04/19 REV:  
DRAWING: 16362-3(E) C

**ORDER ENTRY TABLE TO BE COMPLETED AT TIME OF RELEASE FOR: MP-3 90 MPH  
ATS#**

SHAFTS		
QTY	POLE TYPE	QTY OF ANCHOR BOLTS
-	A	-
-	B1	8
-	B2	8
-	C	8
-	D	-
-	E1	8
-	E2	8
-	F	8

TRAFFIC ARMS		
LENGTH (FT)	QTY	FLANGE ID NO.
30.0 Option A	-	F1
30.0 Option B	-	F2
40.0 Option A	-	F1
40.0 Option B	-	F2
49	-	F1
	-	F2

TRAFFIC ARMS		
LENGTH (FT)	QTY	FLANGE ID NO.
50.0	-	F2
	-	F3
60.0	-	F2
	-	F3
65.0	-	F2
	-	F3
70.0	-	F2
	-	F3
75.0 Case 1	-	F2
	-	F3
75.0 Case 2	-	F2
	-	F3

LUMINAIRE ARMS			
LENGTH (FT)	RISE (FT)	QTY	TO FIT SHAFT TYPE
24		-	
		-	
18		-	
		-	
16		-	
		-	
15		-	
		-	
12		-	
		-	

FINISH	
	Galvanized Only
	Powder Coated Over Galv.
	Color:

VIRGINIA DEPARTMENT OF TRANSPORTATION  
C.O. STRUCTURE AND BRIDGE  
REVIEW OF WORKING DRAWINGS

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B	10/02/19	VDDT REVIEW COMMENTS	
C	11/02/21	VDDT REVIEW COMMENTS	
CUSTOMER:			<b>valmont</b> Valley, NE 68064 POLES (402) 359-2201
MAST ARM POLE DETAILS 90 MPH - MP-3 STANDARDS VIRGINIA			
DATE:		04/04/19	REV.
DRAWING:		16362-3(F)	C