

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

703.631.6661(O)
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November 4, 2021

Re: Mast Arm Poles
MP-3 Standard Loads – 80 MPH Wind
Virginia
ATS# 16362-2

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:**
 - **80 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: 16362-2(A) Rev. C, 16362-2(B) Rev. C & 16362-2(C) Rev. C,
16362-2(D) Rev. C, 16362-2(E) Rev. C & 16362-2(F) Rev. C
Calculations Dated: November 4, 2021, Consisting of 371 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 04, 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 - 371	November 4, 2021

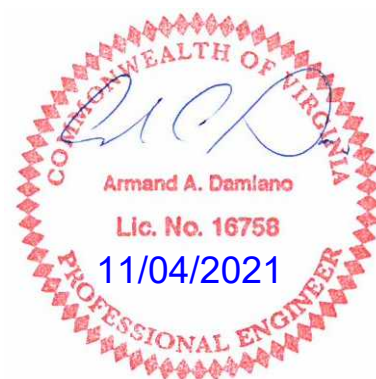


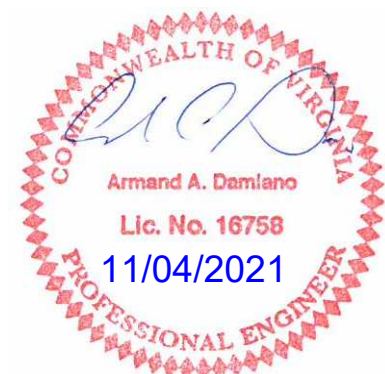
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MP-3 Standard Loads – 80 MPH Wind

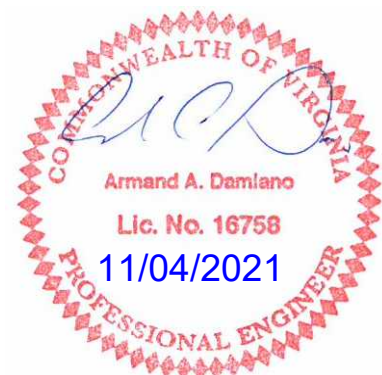
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MAST ARM POLE ANALYSIS TO AASHTO

16362-2-1 - VA - 80 MPH - MP-3 Std. Loads - Type A - 49' Arm

11/04/21

General

Wind Vel. - mph	80		Roadway - mph	55	Fatigue Importance Factors	
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		AASHTO Editon	6TH	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	16.00	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.2391	0.14	13.00	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	11.50	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	0.28	0.39	0.43								17.84	0.00
GP II CSR	0.81	0.81	0.85									
GP III CSR	0.55	0.62	0.67								29.25	

Arm #1 Flange Bolt (Max.) CSR	0.32
Arm #1 Flange Bolt Fatigue CSR	0.00
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	0.00
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	0.51
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.53
Anchorage Capacity S.F.	1.82
Concrete Pull Out Capacity S.F.	2.08

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
3966	4777	105305	93945



16362-2-1 - VA - 80 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	12x2.5' 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										



16362-2-1 - VA - 80 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	16.000	15.852	44.36	0.5286	0.53	1.405	13.74	0.80
2	I	1.06	1.06	15.852	15.704	43.94	0.5286	1.59	1.392	13.62	0.80
3	I	1.06	2.12	15.704	15.555	43.52	0.5286	2.65	1.379	13.50	0.80
4	I	1.06	3.18	15.555	15.407	43.10	0.5286	3.71	1.366	13.37	0.80
5	I	1.06	4.24	15.407	15.259	42.68	0.5286	4.76	1.353	13.25	0.80
6	I	1.06	5.29	15.259	15.111	42.26	0.5286	5.82	1.340	13.13	0.80
7	I	1.06	6.35	15.111	14.962	41.84	0.5285	6.88	1.327	13.00	0.80
8	I	1.06	7.41	14.962	14.814	41.42	0.5285	7.94	1.314	12.88	0.80
9	I	1.06	8.47	14.814	14.666	41.00	0.5285	9.00	1.301	12.76	0.80
10	I	1.06	9.53	14.666	14.518	40.58	0.5285	10.06	1.288	12.63	0.80
11	I	1.06	10.59	14.518	14.369	40.16	0.5285	11.12	1.274	12.51	0.80
12	I	1.06	11.65	14.369	14.221	39.74	0.5285	12.18	1.261	12.39	0.80
13	I	1.06	12.71	14.221	14.073	39.32	0.5285	13.23	1.248	12.26	1.00
14	I	1.06	13.76	14.073	13.925	38.91	0.5285	14.29	1.235	12.14	1.00
15	I	1.06	14.82	13.925	13.776	38.49	0.5285	15.35	1.222	12.02	1.00
16	I	1.06	15.88	13.776	13.628	38.07	0.5285	16.41	1.209	11.89	1.00
17	I	1.06	16.94	13.628	13.480	37.65	0.5284	17.47	1.196	11.77	1.00
18	J	0.50	18.00	13.480	13.410	17.63	0.2498	18.25	0.560	5.52	1.00
19	I	0.50	18.50	13.410	13.340	17.54	0.2498	18.75	0.557	5.49	1.00
20	I	0.50	19.00	13.340	13.270	17.44	0.2498	19.25	0.554	5.46	1.00
						750					

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)	383.37	227.23	0.00	216.58
Section Modulus (in ³)	48.68	34.35	0.00	
Cross-Section Area (in ²)	12.36	10.39	0.00	
Width-Thickness Ratio	64.00	53.92	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)	15.830	15.830	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

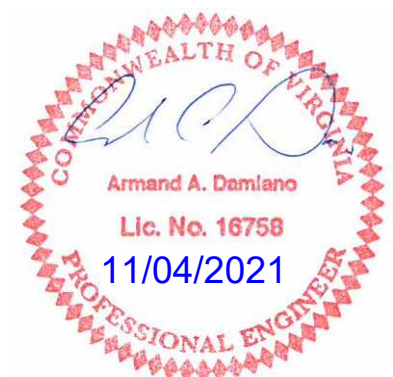
Shaft Deflection From Arm#1 GP I Load (in)	1.175
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-1 - VA - 80 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	9.97	14.01	0.000	17.57	1.100	0.000	0.00
2	0.450	9.97	13.88	0.000	17.40	1.100	0.000	0.00
3	0.450	9.97	13.75	0.000	17.24	1.100	0.000	0.00
4	0.450	9.97	13.62	0.000	17.07	1.100	0.000	0.00
5	0.450	9.97	13.49	0.000	16.91	1.100	0.000	0.00
6	0.450	9.97	13.36	0.001	16.75	1.100	0.000	0.00
7	0.450	9.97	13.23	0.001	16.58	1.100	0.000	0.00
8	0.450	9.97	13.10	0.001	16.42	1.100	0.000	0.00
9	0.450	9.97	12.97	0.001	16.26	1.100	0.000	0.00
10	0.450	9.97	12.84	0.002	16.09	1.100	0.000	0.00
11	0.450	9.97	12.71	0.002	15.93	1.100	0.000	0.00
12	0.450	9.97	12.58	0.002	15.77	1.100	0.000	0.00
13	0.450	12.47	15.57	0.004	15.60	1.100	0.000	0.00
14	0.450	12.47	15.40	0.004	15.44	1.100	0.000	0.00
15	0.450	12.47	15.24	0.005	15.28	1.100	0.000	0.00
16	0.450	12.47	15.08	0.005	15.11	1.100	0.000	0.00
17	0.450	12.47	14.91	0.006	14.95	1.100	0.000	0.00
18	0.450	12.47	6.99	0.003	7.00	1.100	0.000	0.00
19	0.450	12.47	6.95	0.003	6.97	1.100	0.000	0.00
20	0.450	12.47	6.91	0.003	6.93	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.010	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.010	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.131	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-1 - VA - 80 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	13.000	12.657	78.8	1.2195	1.22	2.619	2.619	25.84
2	I	2.45	2.45	12.657	12.314	76.7	1.2194	3.67	2.549	2.549	25.18
3	I	2.45	4.90	12.314	11.971	74.5	1.2192	6.12	2.479	2.479	24.52
4	I	2.45	7.35	11.971	11.628	72.4	1.2191	8.57	2.409	2.409	23.86
5	I	2.45	9.80	11.628	11.285	70.2	1.2189	11.02	2.339	2.339	23.20
6	I	2.45	12.25	11.285	10.942	68.1	1.2187	13.47	2.269	2.269	22.54
7	I	2.45	14.70	10.942	10.599	65.9	1.2185	15.92	2.199	2.199	21.88
8	I	2.45	17.15	10.599	10.256	63.8	1.2183	18.37	2.129	2.129	21.22
9	I	2.45	19.60	10.256	9.913	61.7	1.2181	20.82	2.059	2.059	20.56
10	I	2.45	22.05	9.913	9.570	59.5	1.2178	23.27	1.989	1.989	19.90
11	I	2.45	24.50	9.570	9.227	57.4	1.2175	25.72	1.919	1.919	19.24
12	I	2.45	26.95	9.227	8.884	55.2	1.2173	28.17	1.849	1.849	18.58
13	I	2.45	29.40	8.884	8.541	53.1	1.2170	30.62	1.779	1.779	17.92
14	I	2.45	31.85	8.541	8.198	50.9	1.2166	33.07	1.709	1.709	17.26
15	I	2.45	34.30	8.198	7.855	48.8	1.2163	35.52	1.639	1.639	16.60
16	I	2.45	36.75	7.855	7.512	46.6	1.2159	37.97	1.569	1.569	15.94
17	I	2.45	39.20	7.512	7.169	44.5	1.2155	40.42	1.499	1.499	15.28
18	I	2.45	41.65	7.169	6.826	42.3	1.2150	42.86	1.429	1.429	14.62
19	I	2.45	44.10	6.826	6.483	40.2	1.2145	45.31	1.359	1.359	13.96
20	I	2.45	46.55	6.483	6.140	38.0	1.2139	47.76	1.289	1.289	13.30
		<u>49.00</u>				<u>1169</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)	30.564	0.000
Cross-Section Area (in^2)	9.581	0.000
Width-Thickness Ratio	54.37	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



16362-2-1 - VA - 80 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	12.47	32.66	32.74	1.100	0.000	0.00	0	0.710	0.00	0.00	
2	1.00	0.450	12.47	31.79	31.86	1.100	0.000	0.00	0	0.736	0.00	0.00	
3	1.00	0.450	12.47	30.91	30.99	1.100	0.000	0.00	0	0.763	0.00	0.00	
4	1.00	0.450	12.47	30.04	30.11	1.100	0.000	0.00	0	0.792	0.00	0.00	
5	1.00	0.450	12.47	29.17	29.24	1.100	0.000	0.00	0	0.823	0.00	0.00	
6	1.00	0.450	12.47	28.29	28.36	1.100	0.000	0.00	0	0.856	0.00	0.00	
7	1.00	0.450	12.47	27.42	27.49	1.100	0.000	0.00	0	0.891	0.00	0.00	
8	1.00	0.450	12.47	26.55	26.61	1.100	0.000	0.00	0	0.930	0.00	0.00	
9	1.00	0.450	12.47	25.67	25.74	1.100	0.000	0.00	0	0.971	0.00	0.00	
10	1.00	0.450	12.47	24.80	24.86	1.100	0.000	0.00	0	1.016	0.00	0.00	
11	1.00	0.461	12.78	24.52	23.99	1.100	0.000	0.00	0	1.064	0.00	0.00	
12	1.00	0.484	13.41	24.79	23.11	1.100	0.000	0.00	0	1.100	0.00	0.00	
13	1.00	0.509	14.1	25.08	22.24	1.100	0.000	0.00	0	1.100	0.00	0.00	
14	1.00	0.536	14.85	25.38	21.36	1.100	0.000	0.00	0	1.100	0.00	0.00	
15	1.00	0.566	15.68	25.70	20.48	1.100	0.000	0.00	1	1.100	0.00	0.00	
16	1.00	0.599	16.6	26.04	19.61	1.100	0.000	0.00	1	1.100	0.00	0.00	
17	1.00	0.636	17.62	26.41	18.73	1.100	0.000	0.00	1	1.100	0.00	0.00	
18	1.00	0.677	18.75	26.79	17.86	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.723	20.01	27.19	16.98	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.774	21.44	27.63	16.11	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	33.21	996.30	498.15	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	365.53	182.77	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



16362-2-1 - VA - 80 MPH - MP-3 Std. Loads - Type A - 49' Arm

Flange Analysis - Arm #1

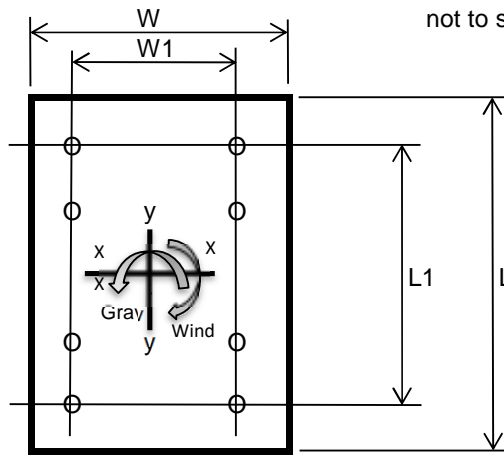
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Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1687	2656	-	lbs
Shear (Wind)	3844	2137	-	lbs
Torsion (Arm Rise)	9869	5487	-	ft-lbs
Moment (Gravity)	39191	63506	-	ft-lbs
Moment (Wind)	93945	51038	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	13.00	in
Tube Wall Thick.	0.2391	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	596.99	596.99	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1073.57	1073.57	in ⁴
Bolt Tensile Stress - ft	12.80	13.64	ksi
Bolt Shear Stress - fv	1.46	0.93	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.3	0.32	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	9.57	15.50	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	23.32	12.67	ksi
Combined applied stress for interaction (SRSS)	25.21	20.02	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-1 - VA - 80 MPH - MP-3 Std. Loads - Type A - 49' 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	1687		1687	39191		39192		353	15388		0.43
Gp II	1687	3844	4198	39191	93945	101793	9869	877	39966	1938	0.85
Gp III	2656	2137	3410	63506	51038	81474	5487	712	31988	1078	0.67
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		-



16362-2-1 - VA - 80 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	2602		39191	0	39191		210		9660		0.28
Gp II	2602	4777	55002	89799	105305	93945	210	773	25957	11579	0.81
Gp III	3966	2780	43950	79201	90578	51038	321	450	22327	6290	0.55
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9961										

Shaft At Arm

Gp I	1740		39191	0	39191		168		13691		0.39
Gp II	1740	3864	9869	39207	40430	93945	168	745	14124	16410	0.81
Gp III	2709	2158	5487	63522	63759	51038	261	416	22274	8915	0.62
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9961										



**Gusset Box Stress Check
For Flange Style F1
Used On Shaft Types A & D
Wind Velocity of 80 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	16.00	in.	
Height To C.L. of Arm Attach.	18.00	ft.	
Shaft Dia. C.L. of Arm Attach.	13.48	in.	Width Between Gussets
Flange Plate Height	24.0	in.	
Flange Plate Width	24.0	in.	
Box Cross-Sectional Area	28.11	sq.in.	

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

Gravity Moment	36,140	ft-lbs
Wind Moment	93,945	ft-lbs
Torsion Moment	9869	ft-lbs
Direct Shear	4143	lbs

Computing Moments of Inertia

For Gravity			For Wind		
d	24	in	d	14.23	in
b	14.23	in	b	24	in
d'	23.25	in	d'	13.48	in
b'	13.48	in	b'	23.25	in
Inertia	2274.82	in ⁴	Inertia	1017.13	in ⁴

Computing Stress

Gravity = $Mc/I =$	2288	psi	
Wind = $Mc/I =$	7886	psi	
Torsion = $M/[2t(a-b)(b-t)] =$	482	psi	Roark's Table 10.1 #16
Shear = $2.25 * V / A =$	332	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 = 0.28 Which is ≤ 1 Therefore OK
To be conservative bending stresses were added not SRSS



16362-2-1 - VA - 80 MPH - MP-3 Std. Loads - Type A - 49' Arm
Weld Analysis

Page S4

INPUTS

	Gp II	GpIII		Arm Dimensions	
Applied Loads To Flange Connection					
Vert. Shr	1545	2514	lbs	Diameter (d)	13.0 in
Horz. Shr	3844	2137	lbs	Tube Wall Thk	0.2093 in
Torsion Moment	9869	5487	ft-lbs	Plate Thk (D)	2 in
Gravity Moment	36140	60455	ft-lbs	Plate Yield (Fy)	50 ksi
Wind Moment	93945	51038	ft-lbs		
Applied Loads To Base Plate Connection				Shaft Dimensions	
Axial	0	0	lbs	Diameter (d)	16.0 in
Shear	0	0	lbs	Tube Wall Thk	0.25 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.	18.0 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

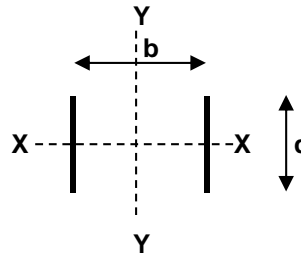


16362-2-1 - VA - 80 MPH - MP-3 Std. Loads - Type A - 49' Arm
Weld Analysis - Continued

ARM CONNECTING PLATES

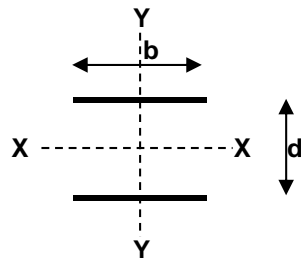
Side Plates

Vertical Length (d)	23.00	in
Horz. Dist Between Plates (b)	13.48	in
Thickness	0.375	in
Weld Size	0.25	in
Weld Throat (t ₁)	0.177	in
$A_1 = A_{w1} * t_1 = 2 * d * t_1$	=	8.13 in ²
$S_{x1} = S_{wx1} * t_1 = (d^2 / 3) * t_1$	=	31.17 in ³
$S_{y1} = S_{wy1} * t_1 = b * d * t_1$	=	54.80 in ³
$J_1 = J_{w1} * t_1 = t_1 * d(3b^2 + d^2) / 6$	=	727.80 in ⁴



Top & Bottom Plates

Vert. Dist Between Plates (d)	23.00	in
Horz. Length (b)	21.17	in
Thickness	0.375	in
Weld Size	0.25	in
Weld Throat (t ₂)	0.177	in
$A_2 = A_{w2} * t_2 = t_2 * 2 * b$	=	7.5 in ²
$S_{x2} = S_{wx2} * t_2 = t_2 * b * d$	=	86.1 in ³
$S_{y2} = S_{wy2} * t_2 = t_2 * (b^2 / 3)$	=	26.4 in ³
$J_2 = J_{w2} * t_2 = t_2 * (b^3 + 3bd^2) / 6$	=	1269.6 in ⁴



Combined Analysis

$\sigma_1 = \text{Gravity Mom} / (S_{x1} + S_{x2})$	=	3699.0	Gp II	6188.0	psi
$\sigma_2 = \text{Wind Mom} / (S_{y1} + S_{y2})$	=	13881.0	Gp III	7541.0	psi
$\sigma_2 = [\text{Tor. Mom} * C / (J_1 + J_2)] + [\text{Res. Shr} / (A_1 + A_2)]$	=	1056.0		651.0	psi
Res. Weld Stress = $\sigma_r = \text{Sqrt}[(\sigma_1 + \sigma_2)^2 + \sigma_3^2]$	=	17612		13745	psi
Allowable: E70 Electrodes * AASHTO Gp Factor	=	23341.5		23341.5	psi
Actual Weld Stress vs. Allowable		Passes		Passes	



16362-2-1 - VA - 80 MPH - MP-3 Std. Loads - Type A - 49' Arm

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	4777 lbs
Bending Moment	105305 ft-lbs
Torsion Moment	93945 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	16.00 in

ANALYSIS - ANCHOR BOLTS

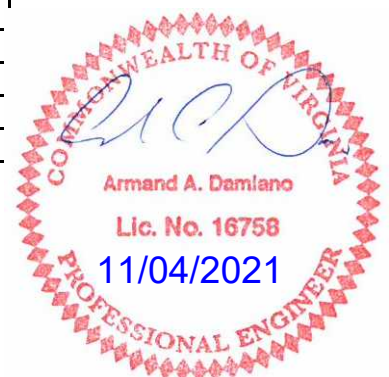
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1082.98 in ⁴
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	14.002 ksi
Bolt Direct Shear Stress	0.347 ksi
Bolt Torsion Shear Stress	6.808 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	14.002 ksi
$f_v =$	7.155 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.51 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	12.701 in
Dist. Shaft Face To Bolt Center	4 in
Design Moment	141 in-kip
Section Modulus of Failure Plane	8.46 in ³
Applied Plate Stress	16.67 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	12.052 in
Dist From Shaft To Nut Face	2.438 in
Design Moment	86 in-kip
Section Modulus of Failure Plane	8.03 in ³
Applied Plate Stress	10.71 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-1 - VA - 80 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 ²
Mom. Inertia Bolt Grouping	1082.98 in ⁴
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	0 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	OK

ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation

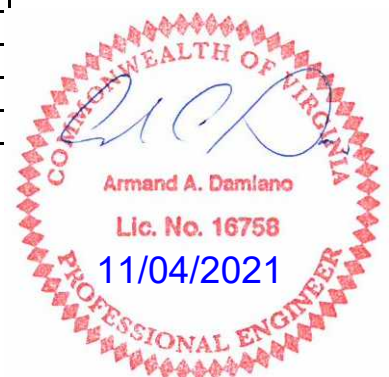
Anchor Bolt Length	60.0 in
Anchor Bolt Max. Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	127540 lbs
T = Anchorage Tensile Capacity	
A _b = Net Bearing Area	4.528 in ²
D _w = 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	35005 lbs
Computed Factor-of Safety	1.82 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	35005 lbs
Total Tensile Load	210030 lbs
Concrete Failure Surface Area	4002.39 in ²
Concrete Shear Strength	438440 psi
Computed Factor-of Safety	2.08 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	35005 lbs
Total Tensile Load	210030 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

16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' Arm

11/04/21

General

Wind Vel. - mph	80	No	Roadway - mph	55	Fatigue Importance Factors	
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		AASHTO Editon	6TH	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	0.3125	0.14	19.50	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	0.14	18.00	28.00	18.00	-	3.93	0	55	29000	180
	0.1880	0.14	14.87	49.93	-	2.93		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
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	14.25	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	Arm #1	Arm #2
GP I CSR	0.37	0.48	0.54	0.43					35.42	0.00
GP II CSR	0.81	0.91	0.91	0.81						
GP III CSR	0.65	0.76	0.80	0.69					57.85	

Arm #1 Flange Bolt (Max.) CSR	0.65
Arm #1 Flange Bolt Fatigue CSR	0.00
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	0.00
Handhole at Toe (Fatigue) CSR	0.00
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	0.67	
Anchor Bolt Max. Fatigue Stress Ratio	0.00	
Base Plate Max. CSR	0.68	
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)
	6353	6421	190433	193209



16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' 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			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										
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	#15										
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	#17										
	#18										
	#19										
	#20										



16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' 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	19.500	19.352	67.61	0.5287	0.53	1.714	16.65	0.80
2	I	1.06	1.06	19.352	19.204	67.08	0.5287	1.59	1.701	16.53	0.80
3	I	1.06	2.12	19.204	19.055	66.56	0.5287	2.65	1.688	16.41	0.80
4	I	1.06	3.18	19.055	18.907	66.03	0.5287	3.71	1.675	16.28	0.80
5	I	1.06	4.24	18.907	18.759	65.51	0.5287	4.76	1.662	16.16	0.80
6	I	1.06	5.29	18.759	18.611	64.99	0.5287	5.82	1.649	16.04	0.80
7	I	1.06	6.35	18.611	18.462	64.46	0.5287	6.88	1.636	15.91	0.80
8	I	1.06	7.41	18.462	18.314	63.94	0.5287	7.94	1.622	15.79	0.80
9	I	1.06	8.47	18.314	18.166	63.41	0.5287	9.00	1.609	15.67	0.80
10	I	1.06	9.53	18.166	18.018	62.89	0.5287	10.06	1.596	15.54	0.80
11	I	1.06	10.59	18.018	17.869	62.36	0.5287	11.12	1.583	15.42	0.80
12	I	1.06	11.65	17.869	17.721	61.84	0.5287	12.18	1.570	15.30	0.80
13	I	1.06	12.71	17.721	17.573	61.31	0.5287	13.23	1.557	15.17	1.00
14	I	1.06	13.76	17.573	17.425	60.79	0.5287	14.29	1.544	15.05	1.00
15	I	1.06	14.82	17.425	17.276	60.27	0.5287	15.35	1.531	14.93	1.00
16	I	1.06	15.88	17.276	17.128	59.74	0.5287	16.41	1.518	14.80	1.00
17	I	1.06	16.94	17.128	16.980	59.22	0.5286	17.47	1.505	14.68	1.00
18	J	0.50	18.00	16.980	16.910	27.78	0.2498	18.25	0.706	6.89	1.00
19	I	0.50	18.50	16.910	16.840	27.66	0.2498	18.75	0.703	6.86	1.00
20	I	0.50	19.00	16.840	16.770	27.55	0.2498	19.25	0.700	6.83	1.00
						1161					

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)	866.45	567.94	0.00	546.74
Section Modulus (in ³)	90.31	68.15	0.00	
Cross-Section Area (in ²)	18.83	16.35	0.00	
Width-Thickness Ratio	62.40	54.34	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)	20.514	20.514	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	1.248
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' 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	9.97	17.09	0.000	21.43	1.100	0.000	0.00
2	0.450	9.97	16.96	0.000	21.26	1.100	0.000	0.00
3	0.450	9.97	16.83	0.000	21.10	1.100	0.000	0.00
4	0.450	9.97	16.70	0.000	20.94	1.100	0.000	0.00
5	0.450	9.97	16.57	0.000	20.77	1.100	0.000	0.00
6	0.450	9.97	16.44	0.000	20.61	1.100	0.000	0.00
7	0.450	9.97	16.31	0.000	20.44	1.100	0.000	0.00
8	0.450	9.97	16.18	0.001	20.28	1.100	0.000	0.00
9	0.450	9.97	16.05	0.001	20.12	1.100	0.000	0.00
10	0.450	9.97	15.92	0.001	19.95	1.100	0.000	0.00
11	0.450	9.97	15.79	0.001	19.79	1.100	0.000	0.00
12	0.450	9.97	15.65	0.001	19.63	1.100	0.000	0.00
13	0.450	12.47	19.42	0.002	19.46	1.100	0.000	0.00
14	0.450	12.47	19.25	0.002	19.30	1.100	0.000	0.00
15	0.450	12.47	19.09	0.002	19.14	1.100	0.000	0.00
16	0.450	12.47	18.93	0.003	18.97	1.100	0.000	0.00
17	0.450	12.47	18.76	0.003	18.81	1.100	0.000	0.00
18	0.450	12.47	8.80	0.002	8.83	1.100	0.000	0.00
19	0.450	12.47	8.77	0.002	8.79	1.100	0.000	0.00
20	0.450	12.47	8.73	0.002	8.75	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.057	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' 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	4.18	0.00	18.000	17.415	194.9	2.0777	2.08	6.166	6.166	60.08
2	I	4.18	4.18	17.415	16.830	188.4	2.0773	6.26	5.962	5.962	58.16
3	I	4.18	8.36	16.830	16.245	181.9	2.0769	10.43	5.758	5.758	56.24
4	I	4.18	12.54	16.245	15.660	175.3	2.0764	14.61	5.555	5.555	54.32
5	I	4.18	16.71	15.660	15.075	168.8	2.0759	18.79	5.351	5.351	52.40
6	I	4.18	20.89	15.075	14.490	162.3	2.0754	22.97	5.147	5.147	50.48
7	J	2.93	25.07	14.870	14.460	195.2	1.4582	26.53	3.581	3.581	35.13
8	O	3.62	28.00	14.460	13.954	101.9	1.7970	29.80	4.280	4.280	42.04
9	O	3.62	31.62	13.954	13.447	98.2	1.7966	33.41	4.128	4.128	40.61
10	O	3.62	35.23	13.447	12.941	94.5	1.7961	37.03	3.975	3.975	39.17
11	O	3.62	38.85	12.941	12.435	90.8	1.7957	40.64	3.823	3.823	37.73
12	O	3.62	42.46	12.435	11.929	87.1	1.7952	44.26	3.670	3.670	36.29
13	O	3.62	46.08	11.929	11.423	83.5	1.7946	47.87	3.518	3.518	34.86
14	O	3.62	49.69	11.423	10.917	79.8	1.7940	51.49	3.365	3.365	33.42
15	O	3.62	53.31	10.917	10.411	76.1	1.7934	55.10	3.213	3.213	31.98
16	O	3.62	56.92	10.411	9.904	72.4	1.7927	58.72	3.060	3.060	30.55
17	O	3.62	60.54	9.904	9.398	68.8	1.7919	62.33	2.908	2.908	29.11
18	O	3.62	64.15	9.398	8.892	65.1	1.7910	65.94	2.755	2.755	27.67
19	O	3.62	67.77	8.892	8.386	61.4	1.7900	69.56	2.603	2.603	26.23
20	O	3.62	71.38	8.386	7.880	57.7	1.7889	73.17	2.450	2.450	24.80
		<u>75.00</u>				<u>2304</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)	61.831	31.813
Cross-Section Area (in^2)	13.934	8.667
Width-Thickness Ratio	72.00	79.10
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	35.588	34.319
Allow. Shear Stress (ksi)	18.150	16.903



16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' 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	12.47	76.89	77.07	1.100	0.000	0.00	0	0.467	0.00	0.00	
2	1.00	0.450	12.47	74.35	74.52	1.100	0.000	0.00	0	0.488	0.00	0.00	
3	1.00	0.450	12.47	71.81	71.98	1.100	0.000	0.00	0	0.511	0.00	0.00	
4	1.00	0.450	12.47	69.27	69.43	1.100	0.000	0.00	0	0.535	0.00	0.00	
5	1.00	0.450	12.47	66.73	66.89	1.100	0.000	0.00	0	0.562	0.00	0.00	
6	1.00	0.450	12.47	64.19	64.34	1.100	0.000	0.00	0	0.591	0.00	0.00	
7	1.00	0.450	12.47	44.65	44.76	1.100	0.000	0.00	0	0.597	0.00	0.00	
8	1.00	0.450	12.47	53.37	53.50	1.100	0.000	0.00	0	0.622	0.00	0.00	
9	1.00	0.450	12.47	51.47	51.60	1.100	0.000	0.00	0	0.652	0.00	0.00	
10	1.00	0.450	12.47	49.57	49.69	1.100	0.000	0.00	0	0.685	0.00	0.00	
11	1.00	0.450	12.47	47.67	47.78	1.100	0.000	0.00	0	0.720	0.00	0.00	
12	1.00	0.450	12.47	45.77	45.88	1.100	0.000	0.00	0	0.760	0.00	0.00	
13	1.00	0.450	12.47	43.87	43.97	1.100	0.000	0.00	0	0.803	0.00	0.00	
14	1.00	0.450	12.47	41.96	42.07	1.100	0.000	0.00	0	0.850	0.00	0.00	
15	1.00	0.450	12.47	40.06	40.16	1.100	0.000	0.00	0	0.903	0.00	0.00	
16	1.00	0.450	12.47	38.16	38.25	1.100	0.000	0.00	0	0.962	0.00	0.00	
17	1.00	0.450	12.47	36.26	36.35	1.100	0.000	0.00	1	1.028	0.00	0.00	
18	1.00	0.478	13.24	36.48	34.44	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.515	14.26	37.12	32.53	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.557	15.42	37.78	30.63	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	0.000	0.00	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #13	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #14	1.00	1.200	33.23	365.53	182.77	1.200	0.000	0.00	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



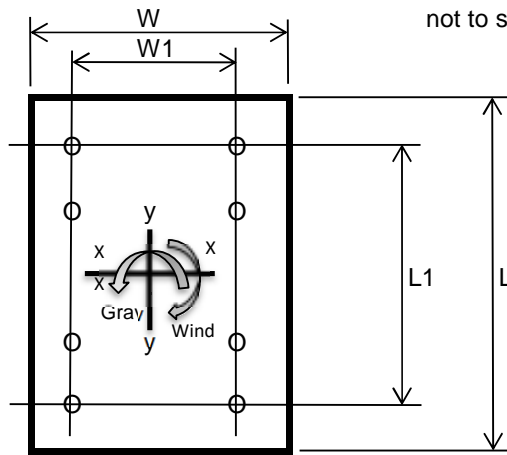
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2998	4578	-	lbs
Shear (Wind)	5394	3199	-	lbs
Torsion (Arm Rise)	21199	12573	-	ft-lbs
Moment (Gravity)	97327	155408	-	ft-lbs
Moment (Wind)	193209	112755	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	18.00	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	24.64	28.48	ksi
Bolt Shear Stress - fv	2.58	1.72	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.57	0.65	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	15.55	24.83	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	31.40	18.33	ksi
Combined applied stress for interaction (SRSS)	35.04	30.86	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' Arm

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

SHAFT TO BASEPLATE

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

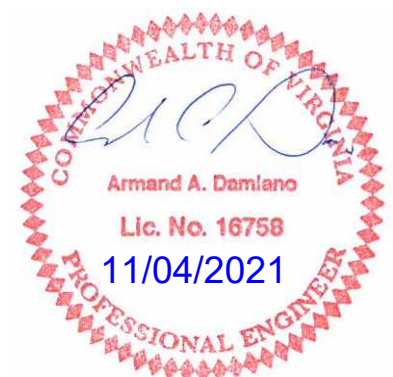
Tt - Thickness of shaft	0.3125	in
Dt - Shaft base diameter	19.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.333333	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.730769	
Kf - Fatigue stress concentration factor for finite life	2.31	
Ki - Fatigue stress concentration factor for infinite life	5.05	
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	18.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	1.77	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.333333	
Kf - Fatigue stress concentration factor for finite life	1.75	
Ki - Fatigue stress concentration factor for infinite life	3.28	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' 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)	19.07	in
Shaft Thickness	0.313	in
Total Area	23.571	in ²
Ix	911	in ⁴
Iy	1023	in ⁴
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' 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	2998		2998	97327		97327		431	18889		0.54
Gp II	2998	5394	6172	97327	193209	216338	21199	886	41987	2058	0.91
Gp III	4578	3199	5585	155408	112755	192004	12573	802	37264	1221	0.80
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	1688		1688	38664		38665		390	14585		0.43
Gp II	1688	2993	3436	38664	87565	95722	11762	793	36108	2219	0.81
Gp III	2666	1786	3210	64252	50106	81480	7019	741	30735	1324	0.69
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		-



16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' 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	4324		97327	0	97327		230		12932		0.37
Gp II	4324	6421	118291	132364	177519	193209	230	683	23587	12836	0.81
Gp III	6353	3936	70158	177038	190433	112755	337	419	25303	7491	0.65
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9971										

Shaft At Arm											
Gp I	3081		97327	0	97327		188		17138		0.48
Gp II	3081	5420	21199	97346	99628	193209	188	663	17543	17011	0.91
Gp III	4661	3226	12573	155427	155935	112755	285	395	27458	9927	0.76
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9971										



**Gusset Box Stress Check
For Flange Style F2
Used On Shaft Types B1 & E1
Wind Velocity of 80 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	19.50	in.	
Height To C.L. of Arm Attach.	18.00	ft.	
Shaft Dia. C.L. of Arm Attach.	16.98	in.	Width Between Gussets
Flange Plate Height	27.0	in.	
Flange Plate Width	27.0	in.	
Box Cross-Sectional Area	43.98	sq.in.	

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

Gravity Moment	97,327	ft-lbs
Wind Moment	193,209	ft-lbs
Torsion Moment	21199	ft-lbs
Direct Shear	6172	lbs

Computing Moments of Inertia

For Gravity			For Wind		
d	27	in	d	17.98	in
b	17.98	in	b	27	in
d'	26	in	d'	16.98	in
b'	16.98	in	b'	26	in
Inertia	4621.66	in ⁴	Inertia	2471.00	in ⁴

Computing Stress

Gravity = $Mc/I =$	3412	psi	
Wind = $Mc/I =$	8436	psi	
Torsion = $M/[2t(a-b)(b-t)] =$	549	psi	Roark's Table 10.1 #16
Shear = $2.25 * V / A =$	316	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 = 0.31 Which is ≤ 1 Therefore OK
To be conservative bending stresses were added not SRSS



16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' Arm
Weld Analysis

Page S4

INPUTS

	Gp II	GpIII		Arm Dimensions		
Applied Loads To Flange Connection						
Vert. Shr	2998	4578	lbs	Diameter (d)	18.0	in
Horz. Shr	5394	3199	lbs	Tube Wall Thk	0.25	in
Torsion Moment	21199	12573	ft-lbs	Plate Thk (D)	2.25	in
Gravity Moment	97327	155408	ft-lbs	Plate Yield (Fy)	50	ksi
Wind Moment	193209	112755	ft-lbs			
Applied Loads To Base Plate Connection						
Axial	0	0	lbs	Diameter (d)	19.5	in
Shear	0	0	lbs	Tube Wall Thk	0.3125	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.	18.0	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

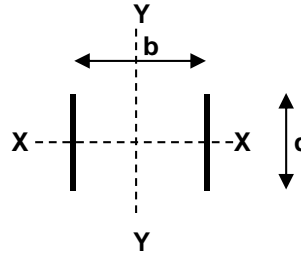


16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' Arm
Weld Analysis - Continued

ARM CONNECTING PLATES

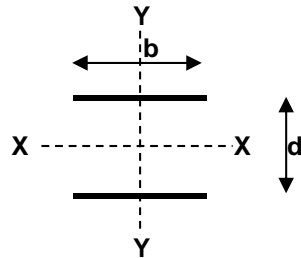
Side Plates

Vertical Length (d)	26.50	in
Horz. Dist Between Plates (b)	16.98	in
Thickness	0.5	in
Weld Size	0.313	in
Weld Throat (t ₁)	0.221	in
A ₁ = A _{w1} * t ₁ = 2 * d * t ₁	=	11.73 in ²
S _{x1} = S _{wx1} * t ₁ = (d ² / 3) * t ₁	=	51.80 in ³
S _{y1} = S _{wy1} * t ₁ = b * d * t ₁	=	99.57 in ³
J ₁ = J _{w1} * t ₁ = t ₁ * d(3b ² + d ²) / 6	=	1531.70 in ⁴



Top & Bottom Plates

Vert. Dist Between Plates (d)	26.50	in
Horz. Length (b)	26.67	in
Thickness	0.5	in
Weld Size	0.313	in
Weld Throat (t ₂)	0.221	in
A ₂ = A _{w2} * t ₂ = t ₂ * 2 * b	=	11.8 in ²
S _{x2} = S _{wx2} * t ₂ = t ₂ * b * d	=	156.4 in ³
S _{y2} = S _{wy2} * t ₂ = t ₂ * (b ² / 3)	=	52.5 in ³
J ₂ = J _{w2} * t ₂ = t ₂ * (b ³ + 3bd ²) / 6	=	2772.3 in ⁴



Combined Analysis

σ ₁ = Gravity Mom / (S _{x1} + S _{x2})	=	5610.0	Gp II	8957.0	psi
σ ₂ = Wind Mom / (S _{y1} + S _{y2})	=	15249.0	Gp II	8899.0	psi
σ ₂ = [Tor. Mom * C / (J ₁ + J ₂)] + [Res. Shr / (A ₁ + A ₂)]	=	1193.0	Gp II	790.0	psi
Res. Weld Stress = σ _r = Sqrt[(σ ₁ + σ ₂) ² + σ ₃ ²]	=	20894	Gp II	17874	psi
Allowable: E70 Electrodes * AASHTO Gp Factor	=	23341.5	Gp II	23341.5	psi
Actual Weld Stress vs. Allowable		Passes		Passes	



16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' Arm

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	6421 lbs
Bending Moment	190433 ft-lbs
Torsion Moment	193209 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	19.50 in

ANALYSIS - ANCHOR BOLTS

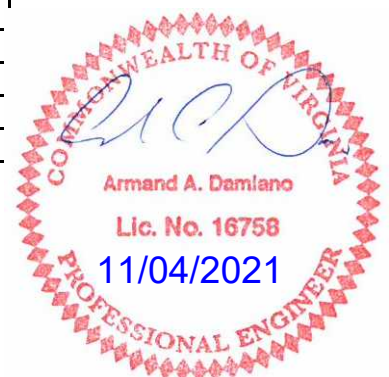
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	17.538 ksi
Bolt Direct Shear Stress	0.349 ksi
Bolt Torsion Shear Stress	9.693 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	17.538 ksi
$f_v =$	10.042 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.67 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	143 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	21.61 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	75 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	11.89 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-2 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 75' Arm

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	0 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	OK

ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation

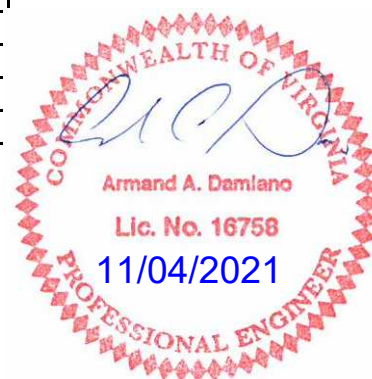
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A _b = Net Bearing Area	4.528 in ²
D _w = 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	43845 lbs
Computed Factor-of Safety	1.41 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	43845 lbs
Total Tensile Load	350760 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.34 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	43845 lbs
Total Tensile Load	350760 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

16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' Arm

11/04/21

General

Wind Vel. - mph	80	No	Roadway - mph	55	Fatigue Importance Factors	
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		AASHTO Editon	6TH	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	19.00	30.00	18.00	-	3.93	0	55	29000	180
	0.2190	0.14	15.66	48.02	-	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	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	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	0.38	0.49	0.51	0.42							33.67	0.00
GP II CSR	0.78	0.95	0.89	0.91								
GP III CSR	0.63	0.77	0.76	0.71							54.99	

Arm #1 Flange Bolt (Max.) CSR	0.79
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	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	0.88
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.73
Anchorage Capacity S.F.	1.11
Concrete Pull Out Capacity S.F.	1.06

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
7677	6475	241450	270460



16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' 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	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										
#13											
#14											
#15											
#16											
#17											
#18											
#19											
#20											



16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' 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	20.500	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	0.00	774.72
Section Modulus (in ³)	119.23	91.24	0.00	
Cross-Section Area (in ²)	23.70	20.73	0.00	
Width-Thickness Ratio	54.67	47.95	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)	21.411	21.411	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	1.213
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' 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	9.97	17.97	0.000	22.53	1.100	0.000	0.00
2	0.450	9.97	17.84	0.000	22.37	1.100	0.000	0.00
3	0.450	9.97	17.71	0.000	22.20	1.100	0.000	0.00
4	0.450	9.97	17.58	0.000	22.04	1.100	0.000	0.00
5	0.450	9.97	17.45	0.000	21.87	1.100	0.000	0.00
6	0.450	9.97	17.32	0.000	21.71	1.100	0.000	0.00
7	0.450	9.97	17.19	0.000	21.55	1.100	0.000	0.00
8	0.450	9.97	17.06	0.000	21.38	1.100	0.000	0.00
9	0.450	9.97	16.93	0.001	21.22	1.100	0.000	0.00
10	0.450	9.97	16.80	0.001	21.06	1.100	0.000	0.00
11	0.450	9.97	16.66	0.001	20.89	1.100	0.000	0.00
12	0.450	9.97	16.53	0.001	20.73	1.100	0.000	0.00
13	0.450	12.47	20.52	0.001	20.57	1.100	0.000	0.00
14	0.450	12.47	20.35	0.002	20.40	1.100	0.000	0.00
15	0.450	12.47	20.19	0.002	20.24	1.100	0.000	0.00
16	0.450	12.47	20.03	0.002	20.08	1.100	0.000	0.00
17	0.450	12.47	19.86	0.002	19.91	1.100	0.000	0.00
18	0.450	12.47	9.32	0.001	9.35	1.100	0.000	0.00
19	0.450	12.47	9.29	0.001	9.31	1.100	0.000	0.00
20	0.450	12.47	9.25	0.001	9.27	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.003	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.003	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.041	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' 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	3.85	0.00	19.000	18.460	237.1	1.9179	1.92	6.016	6.016	58.51
2	I	3.85	3.85	18.460	17.921	230.2	1.9176	5.77	5.843	5.843	56.88
3	I	3.85	7.71	17.921	17.381	223.2	1.9173	9.63	5.669	5.669	55.25
4	I	3.85	11.56	17.381	16.842	216.3	1.9170	13.48	5.496	5.496	53.61
5	I	3.85	15.42	16.842	16.302	209.4	1.9167	17.33	5.323	5.323	51.98
6	I	3.85	19.27	16.302	15.762	202.4	1.9163	21.19	5.149	5.149	50.35
7	I	3.85	23.13	15.762	15.223	195.5	1.9160	25.04	4.976	4.976	48.71
8	J	3.02	26.98	15.660	15.237	256.0	1.5031	28.48	3.888	3.888	38.07
9	O	3.75	30.00	15.237	14.712	129.5	1.8640	31.86	4.680	4.680	45.87
10	O	3.75	33.75	14.712	14.187	124.9	1.8636	35.61	4.516	4.516	44.32
11	O	3.75	37.50	14.187	13.662	120.3	1.8632	39.36	4.351	4.351	42.78
12	O	3.75	41.25	13.662	13.137	115.7	1.8628	43.11	4.187	4.187	41.23
13	O	3.75	45.00	13.137	12.612	111.1	1.8623	46.86	4.023	4.023	39.69
14	O	3.75	48.75	12.612	12.087	106.5	1.8617	50.61	3.859	3.859	38.14
15	O	3.75	52.50	12.087	11.562	101.9	1.8611	54.36	3.695	3.695	36.59
16	O	3.75	56.25	11.562	11.037	97.3	1.8605	58.11	3.531	3.531	35.05
17	O	3.75	60.00	11.037	10.512	92.7	1.8598	61.86	3.367	3.367	33.50
18	O	3.75	63.75	10.512	9.987	88.1	1.8590	65.61	3.203	3.203	31.95
19	O	3.75	67.50	9.987	9.462	83.5	1.8581	69.36	3.039	3.039	30.41
20	O	3.75	71.25	9.462	8.937	78.8	1.8572	73.11	2.875	2.875	28.86
		<u>75.00</u>				<u>3020</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)	85.669	40.989
Cross-Section Area (in^2)	18.337	10.618
Width-Thickness Ratio	60.80	71.51
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	35.685
Allow. Shear Stress (ksi)	18.150	18.150



16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' 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	12.47	75.02	75.20	1.100	0.000	0.00	0	0.450	0.00	0.00	
2	1.00	0.450	12.47	72.86	73.03	1.100	0.000	0.00	0	0.451	0.00	0.00	
3	1.00	0.450	12.47	70.70	70.87	1.100	0.000	0.00	0	0.469	0.00	0.00	
4	1.00	0.450	12.47	68.54	68.70	1.100	0.000	0.00	0	0.488	0.00	0.00	
5	1.00	0.450	12.47	66.37	66.53	1.100	0.000	0.00	0	0.509	0.00	0.00	
6	1.00	0.450	12.47	64.21	64.37	1.100	0.000	0.00	0	0.532	0.00	0.00	
7	1.00	0.450	12.47	62.05	62.20	1.100	0.000	0.00	0	0.556	0.00	0.00	
8	1.00	0.450	12.47	48.48	48.60	1.100	0.000	0.00	0	0.558	0.00	0.00	
9	1.00	0.450	12.47	58.35	58.49	1.100	0.000	0.00	0	0.581	0.00	0.00	
10	1.00	0.450	12.47	56.31	56.44	1.100	0.000	0.00	0	0.608	0.00	0.00	
11	1.00	0.450	12.47	54.26	54.39	1.100	0.000	0.00	0	0.638	0.00	0.00	
12	1.00	0.450	12.47	52.22	52.34	1.100	0.000	0.00	0	0.671	0.00	0.00	
13	1.00	0.450	12.47	50.17	50.29	1.100	0.000	0.00	0	0.707	0.00	0.00	
14	1.00	0.450	12.47	48.13	48.24	1.100	0.000	0.00	0	0.746	0.00	0.00	
15	1.00	0.450	12.47	46.08	46.19	1.100	0.000	0.00	0	0.790	0.00	0.00	
16	1.00	0.450	12.47	44.03	44.14	1.100	0.000	0.00	0	0.838	0.00	0.00	
17	1.00	0.450	12.47	41.99	42.09	1.100	0.000	0.00	1	0.891	0.00	0.00	
18	1.00	0.450	12.47	39.94	40.04	1.100	0.000	0.00	1	0.951	0.00	0.00	
19	1.00	0.450	12.47	37.90	37.99	1.100	0.000	0.00	1	1.018	0.00	0.00	
20	1.00	0.474	13.14	37.78	35.94	1.100	0.000	0.00	1	1.094	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #7	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #12	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #13	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #14	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #15	1.00	1.200	33.23	365.53	182.77	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #16	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #17	1.00	1.200	33.23	365.53	182.77	1.200	0.000	0.00	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



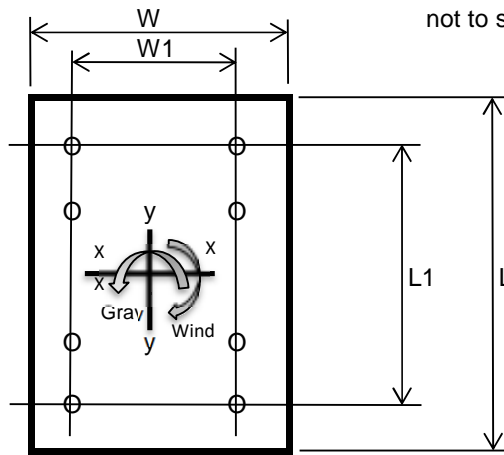
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	3820	5582	-	lbs
Shear (Wind)	5429	3263	-	lbs
Torsion (Arm Rise)	21335	12823	-	ft-lbs
Moment (Gravity)	131918	208497	-	ft-lbs
Moment (Wind)	270460	153339	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	19.00	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)	2.75
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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	979.65	979.65	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1763.77	1763.77	in ⁴
Bolt Tensile Stress - ft	30.62	34.49	ksi
Bolt Shear Stress - fv	2.45	1.7	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Fv =	44.22	44.22	ksi
Allowable Shear Stress = Ft =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.71	0.79	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	13.18	20.83	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	27.46	15.57	ksi
Combined applied stress for interaction (SRSS)	30.46	26.01	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' Arm

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

SHAFT TO BASEPLATE

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

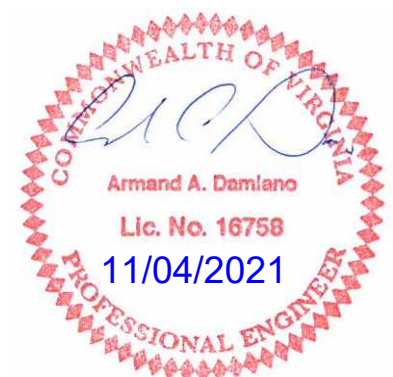
Tt - Thickness of shaft	0.375	in
Dt - Shaft base diameter	20.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.268293	
Dop - Baseplate center hole diameter	15.75	in
Cop - Center hole to shaft diameter ratio	0.768293	
Kf - Fatigue stress concentration 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	0.3125	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	1.70	
Ki - Fatigue stress concentration factor for infinite life	3.36	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' 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)	20.07	in
Shaft Thickness	0.375	in
Total Area	27.9058	in ²
Ix	1226	in ⁴
Iy	1349	in ⁴
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' 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	3820		3820	131918		131918		417	18479		0.51
Gp II	3820	5429	6638	131918	270460	300918	21335	724	42151	1495	0.89
Gp III	5582	3263	6466	208497	153339	258813	12823	706	36254	899	0.76
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		-

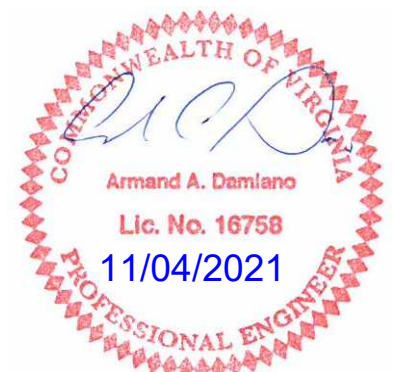
Arm#1 Joint											
Gp I	2219		2219	51010		51010		418	14934		0.42
Gp II	2219	4627	5132	51010	133486	142901	18183	967	41836	2662	0.91
Gp III	3518	2621	4387	86051	73427	113121	10300	827	33118	1508	0.71
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

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		-



16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' 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	5451		131918	0	131918		230		13277		0.38
Gp II	5451	6475	119051	167288	205325	270460	230	547	20666	13611	0.78
Gp III	7677	4022	71552	230604	241450	153339	324	340	24302	7717	0.63
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9973										

Shaft At Arm											
Gp I	3925		131918	0	131918		189		17351		0.49
Gp II	3925	5457	21335	131939	133653	270460	189	527	17579	17786	0.95
Gp III	5687	3291	12823	208518	208912	153339	274	318	27477	10084	0.77
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9973										



**Gusset Box Stress Check
For Flange Style F3
Used On Shaft Types B2 & E2
Wind Velocity of 80 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	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	29.5	in.	
Flange Plate Width	29.5	in.	
Box Cross-Sectional Area	47.48	sq.in.	

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

Gravity Moment	131,918	ft-lbs
Wind Moment	270,460	ft-lbs
Torsion Moment	21335	ft-lbs
Direct Shear	6638	lbs

Computing Moments of Inertia

For Gravity			For Wind		
d	29.5	in	d	18.98	in
b	18.98	in	b	29.5	in
d'	28.5	in	d'	17.98	in
b'	17.98	in	b'	28.5	in
Inertia	5920.03	in ⁴	Inertia	3003.64	in ⁴

Computing Stress

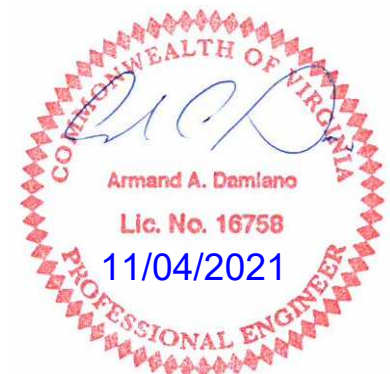
Gravity = $Mc/I =$	3945	psi	
Wind = $Mc/I =$	10255	psi	
Torsion = $M/[2t(a-b)(b-t)] =$	478	psi	Roark's Table 10.1 #16
Shear = $2.25 * V / A =$	315	psi	

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 = 0.37 Which is ≤ 1 Therefore OK
To be conservative bending stresses were added not SRSS



16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' Arm
Weld Analysis

Page S4

INPUTS

	Gp II	GpIII			
Applied Loads To Flange Connection			Arm Dimensions		
Vert. Shr	3820	5582	lbs	Diameter (d)	19.0 in
Horz. Shr	5429	3263	lbs	Tube Wall Thk	0.3125 in
Torsion Moment	21335	12823	ft-lbs	Plate Thk (D)	2.75 in
Gravity Moment	131918	208497	ft-lbs	Plate Yield (Fy)	50 ksi
Wind Moment	270460	153339	ft-lbs		
Applied Loads To Base Plate Connection			Shaft Dimensions		
Axial	0	0	lbs	Diameter (d)	20.5 in
Shear	0	0	lbs	Tube Wall Thk	0.375 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.	18.0 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

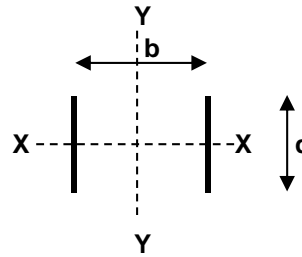


16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' Arm
Weld Analysis - Continued

ARM CONNECTING PLATES

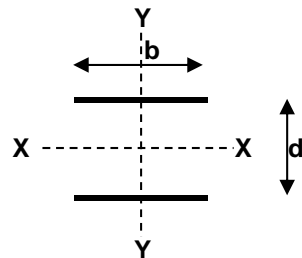
Side Plates

Vertical Length (d)	28.50	in
Horz. Dist Between Plates (b)	17.98	in
Thickness	0.5	in
Weld Size	0.375	in
Weld Throat (t ₁)	0.265	in
A ₁ = A _{w1} * t ₁ = 2 * d * t ₁	=	15.11 in ²
S _{x1} = S _{wx1} * t ₁ = (d ² / 3) * t ₁	=	71.78 in ³
S _{y1} = S _{wy1} * t ₁ = b * d * t ₁	=	135.86 in ³
J ₁ = J _{w1} * t ₁ = t ₁ * d(3b ² + d ²) / 6	=	2244.30 in ⁴



Top & Bottom Plates

Vert. Dist Between Plates (d)	28.50	in
Horz. Length (b)	28.24	in
Thickness	0.5	in
Weld Size	0.375	in
Weld Throat (t ₂)	0.265	in
A ₂ = A _{w2} * t ₂ = t ₂ * 2 * b	=	15.0 in ²
S _{x2} = S _{wx2} * t ₂ = t ₂ * b * d	=	213.4 in ³
S _{y2} = S _{wy2} * t ₂ = t ₂ * (b ² / 3)	=	70.5 in ³
J ₂ = J _{w2} * t ₂ = t ₂ * (b ³ + 3bd ²) / 6	=	4036.5 in ⁴



Combined Analysis

σ ₁ = Gravity Mom / (S _{x1} + S _{x2})	=	5551.0	Gp II	8773.0	psi
σ ₂ = Wind Mom / (S _{y1} + S _{y2})	=	15729.0	Gp III	8918.0	psi
σ ₂ = [Tor. Mom * C / (J ₁ + J ₂)] + [Res. Shr / (A ₁ + A ₂)]	=	908.0		628.0	psi
Res. Weld Stress = σ _r = Sqrt[(σ ₁ + σ ₂) ² + σ ₃ ²]	=	21300		17703	psi
Allowable: E70 Electrodes * AASHTO Gp Factor	=	23341.5		23341.5	psi
Actual Weld Stress vs. Allowable		Passes		Passes	



16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' Arm

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	6475 lbs
Bending Moment	241450 ft-lbs
Torsion Moment	270460 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

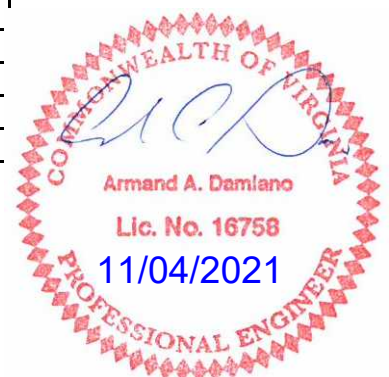
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	22.236 ksi
Bolt Direct Shear Stress	0.352 ksi
Bolt Torsion Shear Stress	13.569 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	22.236 ksi
$f_v =$	13.921 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.88 CSR
Therefore	OK

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	153 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	23.12 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

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 ³
Applied Plate Stress	10.62 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-3 - VA - 80 MPH - MP-3 Std. Loads - Type B2 - 75' Arm

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	0 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	OK

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	55590 lbs
Computed Factor-of Safety	1.11 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	55590 lbs
Total Tensile Load	444720 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.06 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	55590 lbs
Total Tensile Load	444720 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	10 Qty.



MAST ARM POLE ANALYSIS TO AASHTO

16362-2-4 - VA - 80 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

11/04/21

General

Wind Vel. - mph	80	No	Roadway - mph	55	Fatigue Importance Factors	
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		AASHTO Editon	6TH	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	19.00	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	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	14.25	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	0.35	0.46	0.49	0.41	0.43	0.34			28.19	19.26
GP II CSR	0.84	0.96	0.86	0.79	0.81	0.72				
GP III CSR	0.68	0.77	0.74	0.66	0.67	0.57			46.24	32.27

Arm #1 Flange Bolt (Max.) CSR	0.58
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.74
Arm #2 Flange Bolt (Max.) CSR	0.41
Arm #2 Flange Bolt Fatigue CSR	0.00
Arm #2 Flange Plate (Max.) CSR	0.58
Handhole at Root (Fatigue) CSR	0.00
Handhole at Toe (Fatigue) CSR	0.00
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	0.79
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.89
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)
9480	5918	230129	222645



16362-2-4 - VA - 80 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		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	3	22	1.20	
	#7	2.5'x3' Sign	44	8.7	4	2.5	3	1	7.5	22.5	1.13	
	#8		3 Section Head w/BP			47		1	26	65	1.20	
	#9	2.5'x3' Sign	55	8.7	4	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	11	5	3	3.5	1	10.5	26.7	1.13	
	#13		4 Section Head w/BP			69		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		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	3	22	1.20	
	#7	2.5'x3' Sign	45	8.7	4	2.5	3	1	7.5	22.5	1.13	
	#8		3 Section Head w/BP			48		1	26	65	1.20	
	#9	Camera	57	1	1			1	3	22	1.20	
	#10	3'x3.5' Sign	56	11	5	3	3.5	1	10.5	26.7	1.13	
	#11		4 Section Head w/BP			59		1	34	80	1.20	
	#12											
	#13											
	#14											
	#15											
	#16											
	#17											
	#18											
	#19											
	#20											



16362-2-4 - VA - 80 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	19.000	18.852	78.74	0.5287	0.53	1.670	16.24	0.80
2	I	1.06	1.06	18.852	18.704	78.11	0.5287	1.59	1.657	16.11	0.80
3	I	1.06	2.12	18.704	18.555	77.48	0.5287	2.65	1.644	15.99	0.80
4	I	1.06	3.18	18.555	18.407	76.85	0.5287	3.71	1.631	15.87	0.80
5	I	1.06	4.24	18.407	18.259	76.22	0.5287	4.76	1.618	15.74	0.80
6	I	1.06	5.29	18.259	18.111	75.59	0.5287	5.82	1.605	15.62	0.80
7	I	1.06	6.35	18.111	17.962	74.97	0.5287	6.88	1.591	15.50	0.80
8	I	1.06	7.41	17.962	17.814	74.34	0.5287	7.94	1.578	15.37	0.80
9	I	1.06	8.47	17.814	17.666	73.71	0.5287	9.00	1.565	15.25	0.80
10	I	1.06	9.53	17.666	17.518	73.08	0.5287	10.06	1.552	15.13	0.80
11	I	1.06	10.59	17.518	17.369	72.45	0.5287	11.12	1.539	15.00	0.80
12	I	1.06	11.65	17.369	17.221	71.82	0.5287	12.18	1.526	14.88	0.80
13	I	1.06	12.71	17.221	17.073	71.19	0.5286	13.23	1.513	14.76	1.00
14	I	1.06	13.76	17.073	16.925	70.56	0.5286	14.29	1.500	14.63	1.00
15	I	1.06	14.82	16.925	16.776	69.93	0.5286	15.35	1.487	14.51	1.00
16	I	1.06	15.88	16.776	16.628	69.30	0.5286	16.41	1.474	14.39	1.00
17	I	1.06	16.94	16.628	16.480	68.67	0.5286	17.47	1.461	14.27	1.00
18	J	0.50	18.00	16.480	16.410	32.21	0.2498	18.25	0.685	6.69	1.00
19	I	0.50	18.50	16.410	16.340	32.07	0.2498	18.75	0.682	6.67	1.00
20	I	0.50	19.00	16.340	16.270	31.93	0.2498	19.25	0.679	6.64	1.00
						1350					

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)	950.95	614.83	614.83	591.09
Section Modulus (in ³)	102.12	76.35	76.35	
Cross-Section Area (in ²)	21.93	18.96	18.96	
Width-Thickness Ratio	50.67	43.95	43.95	
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)	19.914	19.914	19.914	
Allow. Shear Stress (ksi)	18.150	18.150	18.150	

Shaft Deflection From Arm#1 GP I Load (in)	0.999
Shaft Deflection From Arm#2 GP I Load (in)	0.690



16362-2-4 - VA - 80 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	9.97	16.65	0.000	20.87	1.100	0.000	0.00
2	0.450	9.97	16.52	0.000	20.71	1.100	0.000	0.00
3	0.450	9.97	16.39	0.000	20.55	1.100	0.000	0.00
4	0.450	9.97	16.26	0.000	20.38	1.100	0.000	0.00
5	0.450	9.97	16.13	0.000	20.22	1.100	0.000	0.00
6	0.450	9.97	16.00	0.000	20.06	1.100	0.000	0.00
7	0.450	9.97	15.87	0.000	19.89	1.100	0.000	0.00
8	0.450	9.97	15.74	0.001	19.73	1.100	0.000	0.00
9	0.450	9.97	15.61	0.001	19.57	1.100	0.000	0.00
10	0.450	9.97	15.48	0.001	19.40	1.100	0.000	0.00
11	0.450	9.97	15.35	0.001	19.24	1.100	0.000	0.00
12	0.450	9.97	15.21	0.001	19.08	1.100	0.000	0.00
13	0.450	12.47	18.87	0.002	18.91	1.100	0.000	0.00
14	0.450	12.47	18.70	0.002	18.75	1.100	0.000	0.00
15	0.450	12.47	18.54	0.002	18.59	1.100	0.000	0.00
16	0.450	12.47	18.38	0.002	18.42	1.100	0.000	0.00
17	0.450	12.47	18.21	0.003	18.26	1.100	0.000	0.00
18	0.450	12.47	8.54	0.001	8.57	1.100	0.000	0.00
19	0.450	12.47	8.51	0.001	8.53	1.100	0.000	0.00
20	0.450	12.47	8.47	0.001	8.49	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.052	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-4 - VA - 80 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	167.1	1.8308	1.83	5.288	5.288	51.57
2	I	3.68	3.68	16.985	16.470	162.1	1.8306	5.51	5.130	5.130	50.08
3	I	3.68	7.36	16.470	15.954	157.0	1.8303	9.19	4.972	4.972	48.59
4	I	3.68	11.04	15.954	15.439	151.9	1.8299	12.87	4.814	4.814	47.10
5	I	3.68	14.72	15.439	14.924	146.8	1.8296	16.55	4.656	4.656	45.61
6	I	3.68	18.40	14.924	14.409	141.8	1.8292	20.23	4.498	4.498	44.12
7	J	2.92	22.08	14.790	14.381	193.4	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>2119</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)	58.397	31.467
Cross-Section Area (in^2)	13.541	8.620
Width-Thickness Ratio	70.00	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)	35.991	34.389
Allow. Shear Stress (ksi)	18.150	17.040



16362-2-4 - VA - 80 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)	
1	1.00	0.450	12.47	65.94	66.10	1.100	0.000	0.00	0	0.484	0.00	0.00	0.00
2	1.00	0.450	12.47	63.97	64.12	1.100	0.000	0.00	0	0.503	0.00	0.00	0.00
3	1.00	0.450	12.47	62.00	62.15	1.100	0.000	0.00	0	0.524	0.00	0.00	0.00
4	1.00	0.450	12.47	60.03	60.17	1.100	0.000	0.00	0	0.546	0.00	0.00	0.00
5	1.00	0.450	12.47	58.06	58.20	1.100	0.000	0.00	0	0.571	0.00	0.00	0.00
6	1.00	0.450	12.47	56.09	56.22	1.100	0.000	0.00	0	0.597	0.00	0.00	0.00
7	1.00	0.450	12.47	44.26	44.36	1.100	0.000	0.00	0	0.601	0.00	0.00	0.00
8	1.00	0.450	12.47	50.86	50.98	1.100	0.000	0.00	0	0.626	0.00	0.00	0.00
9	1.00	0.450	12.47	49.12	49.23	1.100	0.000	0.00	0	0.655	0.00	0.00	0.00
10	1.00	0.450	12.47	47.37	47.49	1.100	0.000	0.00	0	0.686	0.00	0.00	0.00
11	1.00	0.450	12.47	45.63	45.74	1.100	0.000	0.00	0	0.721	0.00	0.00	0.00
12	1.00	0.450	12.47	43.89	43.99	1.100	0.000	0.00	0	0.758	0.00	0.00	0.00
13	1.00	0.450	12.47	42.14	42.24	1.100	0.000	0.00	0	0.799	0.00	0.00	0.00
14	1.00	0.450	12.47	40.40	40.50	1.100	0.000	0.00	0	0.844	0.00	0.00	0.00
15	1.00	0.450	12.47	38.66	38.75	1.100	0.000	0.00	0	0.894	0.00	0.00	0.00
16	1.00	0.450	12.47	36.91	37.00	1.100	0.000	0.00	0	0.949	0.00	0.00	0.00
17	1.00	0.450	12.47	35.17	35.25	1.100	0.000	0.00	1	1.011	0.00	0.00	0.00
18	1.00	0.468	12.97	34.77	33.51	1.100	0.000	0.00	1	1.080	0.00	0.00	0.00
19	1.00	0.502	13.9	35.32	31.76	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
20	1.00	0.540	14.96	35.92	30.01	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	0.000	0.00	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	33.23	365.53	182.77	1.200	0.000	0.00	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



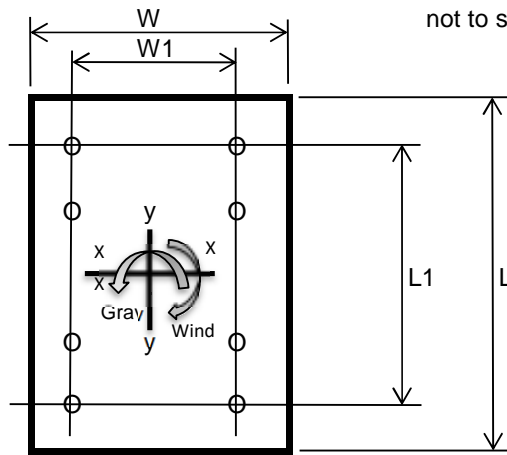
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2748	4188	-	lbs
Shear (Wind)	5024	2977	-	lbs
Torsion (Arm Rise)	18428	10918	-	ft-lbs
Moment (Gravity)	85096	136462	-	ft-lbs
Moment (Wind)	177343	102775	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	17.50	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	22.14	25.15	ksi
Bolt Shear Stress - fv	2.27	1.52	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	0.58	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	13.77	22.08	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	29.19	16.92	ksi
Combined applied stress for interaction (SRSS)	32.27	27.82	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-4 - VA - 80 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



16362-2-4 - VA - 80 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	12.47	47.92	48.03	1.100	0.000	0.00	0	0.562	0.00	0.00	
2	1.00	0.450	12.47	46.61	46.72	1.100	0.000	0.00	0	0.582	0.00	0.00	
3	1.00	0.450	12.47	45.30	45.41	1.100	0.000	0.00	0	0.604	0.00	0.00	
4	1.00	0.450	12.47	43.99	44.09	1.100	0.000	0.00	0	0.628	0.00	0.00	
5	1.00	0.450	12.47	42.68	42.78	1.100	0.000	0.00	0	0.653	0.00	0.00	
6	1.00	0.450	12.47	41.37	41.47	1.100	0.000	0.00	0	0.680	0.00	0.00	
7	1.00	0.450	12.47	40.06	40.16	1.100	0.000	0.00	0	0.709	0.00	0.00	
8	1.00	0.450	12.47	35.81	35.90	1.100	0.000	0.00	0	0.711	0.00	0.00	
9	1.00	0.450	12.47	39.03	39.12	1.100	0.000	0.00	0	0.741	0.00	0.00	
10	1.00	0.450	12.47	37.69	37.79	1.100	0.000	0.00	0	0.776	0.00	0.00	
11	1.00	0.450	12.47	36.36	36.45	1.100	0.000	0.00	0	0.813	0.00	0.00	
12	1.00	0.450	12.47	35.03	35.11	1.100	0.000	0.00	0	0.853	0.00	0.00	
13	1.00	0.450	12.47	33.70	33.78	1.100	0.000	0.00	0	0.897	0.00	0.00	
14	1.00	0.450	12.47	32.37	32.44	1.100	0.000	0.00	0	0.946	0.00	0.00	
15	1.00	0.450	12.47	31.03	31.11	1.100	0.000	0.00	0	0.999	0.00	0.00	
16	1.00	0.458	12.69	30.23	29.77	1.100	0.000	0.00	1	1.057	0.00	0.00	
17	1.00	0.486	13.47	30.65	28.44	1.100	0.000	0.00	1	1.100	0.00	0.00	
18	1.00	0.518	14.34	31.09	27.10	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.553	15.31	31.56	25.77	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.593	16.41	32.08	24.43	1.100	0.000	0.00	1	1.100	0.00	0.00	
Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	0.000	0.00	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	365.53	182.77	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



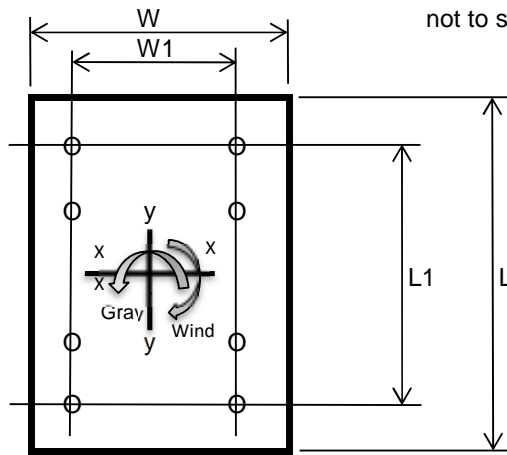
Flange Analysis - Arm #2

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2161	3337	-	lbs
Shear (Wind)	4297	2502	-	lbs
Torsion (Arm Rise)	13512	7868	-	ft-lbs
Moment (Gravity)	58769	96007	-	ft-lbs
Moment (Wind)	134647	76437	-	ft-lbs
Nat. Wind Moment	-	-	-	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	16.18	17.85	ksi
Bolt Shear Stress - fv	1.72	1.15	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.38	0.41	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W t^2 / 6)$	9.97	16.28	ksi
Stress from wind loads = $4P \cdot e / (L t^2 / 6)$	23.22	13.19	ksi
Combined applied stress for interaction (SRSS)	25.27	20.95	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	OK	OK	



16362-2-4 - VA - 80 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

Fatigue Allowable - Shaft to Baseplate Weld & 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	19.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.368421	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.75	
Kf - Fatigue stress concentration factor for finite life	2.58	
Ki - Fatigue stress concentration factor for infinite life	6.07	
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	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	1.76	
Ki - Fatigue stress concentration factor for infinite life	3.33	
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



16362-2-4 - VA - 80 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)	18.57	in
Shaft Thickness	0.375	in
Total Area	26.1281	in^2
Ix	988	in^4
Iy	1065	in^4
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-2-4 - VA - 80 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	2748		2748	85096		85097		406	17487		0.49
Gp II	2748	5024	5727	85096	177343	196703	18428	846	40421	1894	0.86
Gp III	4188	2977	5139	136462	102775	170836	10918	760	35106	1122	0.74
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	1710		1710	36287		36287		397	13839		0.41
Gp II	1710	3372	3782	36287	83811	91330	12370	878	34829	2359	0.79
Gp III	2742	1967	3375	60410	47848	77064	7214	784	29389	1376	0.66
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	2161		2161	58769		58770		360	15292		0.43
Gp II	2161	4297	4811	58769	134647	146914	13512	800	38226	1758	0.81
Gp III	3337	2502	4171	96007	76437	122720	7868	694	31931	1024	0.67
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	1273		1273	22969		22969		353	11914		0.34
Gp II	1273	2704	2989	22969	58957	63273	8501	829	32820	2205	0.72
Gp III	2084	1551	2598	39262	32847	51190	4876	720	26552	1265	0.57
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		-



16362-2-4 - VA - 80 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)						

Shaft Base											
Gp I	6423		85096	58769	103418		293		12153		0.35
Gp II	6423	5918	137077	159506	210315	222645	293	540	24715	13082	0.84
Gp III	9480	3627	140810	182022	230129	128075	432	331	27043	7525	0.68
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9957										

Shaft At Arm											
Gp I	5005		85096	58769	103418		264		16254		0.46
Gp II	5005	5050	72025	94502	118820	222645	264	533	18674	17496	0.96
Gp III	7621	3002	103861	141947	175886	128075	402	317	27643	10065	0.77
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9957										



**Gusset Box Stress Check
For Flange Style F2
Used On Shaft Type C & F
Wind Velocity of 80 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	19.00	in.	
Height To C.L. of Arm Attach.	18.00	ft.	
Shaft Dia. C.L. of Arm Attach.	16.48	in.	Width Between Gussets
Flange Plate Height	27.0	in.	
Flange Plate Width	27.0	in.	
Box Cross-Sectional Area	43.48	sq.in.	

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

Gravity Moment	85,096	ft-lbs
Wind Moment	177,343	ft-lbs
Torsion Moment	18428	ft-lbs
Direct Shear	5727	lbs

Computing Moments of Inertia

For Gravity			For Wind		
d	27	in	d	17.48	in
b	17.48	in	b	27	in
d'	26	in	d'	16.48	in
b'	16.48	in	b'	26	in
Inertia	4533.86	in ⁴	Inertia	2319.71	in ⁴

Computing Stress

Gravity = $Mc/I =$	3041	psi	
Wind = $Mc/I =$	8019	psi	
Torsion = $M/[2t(a-b)(b-t)] =$	491	psi	Roark's Table 10.1 #16
Shear = $2.25 * V / A =$	297	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 = 0.29 Which is ≤ 1 Therefore OK
To be conservative bending stresses were added not SRSS



16362-2-4 - VA - 80 MPH - MP-3 Std. Loads-Type C/F-70'/60' Arms
 Weld Analysis

INPUTS

	Gp II	GpIII			
Applied Loads To Flange Connection			Arm Dimensions		
Vert. Shr	2748	4188	lbs	Diameter (d)	17.5 in
Horz. Shr	5024	2977	lbs	Tube Wall Thk	0.25 in
Torsion Moment	18428	10918	ft-lbs	Plate Thk (D)	2.25 in
Gravity Moment	85096	136462	ft-lbs	Plate Yield (Fy)	50 ksi
Wind Moment	177343	102775	ft-lbs		
Applied Loads To Base Plate Connection			Shaft Dimensions		
Axial	0	0	lbs	Diameter (d)	19.0 in
Shear	0	0	lbs	Tube Wall Thk	0.375 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.	18.0 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

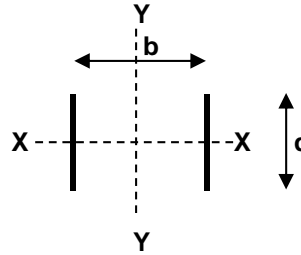


16362-2-4 - VA - 80 MPH - MP-3 Std. Loads-Type C/F-70'/60' Arms
Weld Analysis - Continued

ARM CONNECTING PLATES

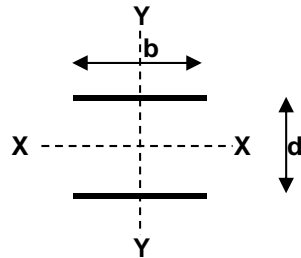
Side Plates

Vertical Length (d)	26.50	in
Horz. Dist Between Plates (b)	16.48	in
Thickness	0.5	in
Weld Size	0.375	in
Weld Throat (t ₁)	0.265	in
A ₁ = A _{w1} * t ₁ = 2 * d * t ₁	=	14.05 in ²
S _{x1} = S _{wx1} * t ₁ = (d ² / 3) * t ₁	=	62.06 in ³
S _{y1} = S _{wy1} * t ₁ = b * d * t ₁	=	115.79 in ³
J ₁ = J _{w1} * t ₁ = t ₁ * d(3b ² + d ²) / 6	=	1776.40 in ⁴



Top & Bottom Plates

Vert. Dist Between Plates (d)	26.50	in
Horz. Length (b)	25.89	in
Thickness	0.5	in
Weld Size	0.375	in
Weld Throat (t ₂)	0.265	in
A ₂ = A _{w2} * t ₂ = t ₂ * 2 * b	=	13.7 in ²
S _{x2} = S _{wx2} * t ₂ = t ₂ * b * d	=	181.9 in ³
S _{y2} = S _{wy2} * t ₂ = t ₂ * (b ² / 3)	=	59.2 in ³
J ₂ = J _{w2} * t ₂ = t ₂ * (b ³ + 3bd ²) / 6	=	3176.4 in ⁴



Combined Analysis

σ ₁ = Gravity Mom / (S _{x1} + S _{x2})	=	4187.0	Gp II	6713.0	psi
σ ₂ = Wind Mom / (S _{y1} + S _{y2})	=	12160.0	Gp II	7048.0	psi
σ ₂ = [Tor. Mom * C / (J ₁ + J ₂)] + [Res. Shr / (A ₁ + A ₂)]	=	903.0	Gp II	598.0	psi
Res. Weld Stress = σ _r = Sqrt[(σ ₁ + σ ₂) ² + σ ₃ ²]	=	16372	Gp II	13774	psi
Allowable: E70 Electrodes * AASHTO Gp Factor	=	23341.5	Gp II	23341.5	psi
Actual Weld Stress vs. Allowable		Passes		Passes	



16362-2-4 - VA - 80 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	5918 lbs
Bending Moment	230129 ft-lbs
Torsion Moment	222645 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	19.00 in

ANALYSIS - ANCHOR BOLTS

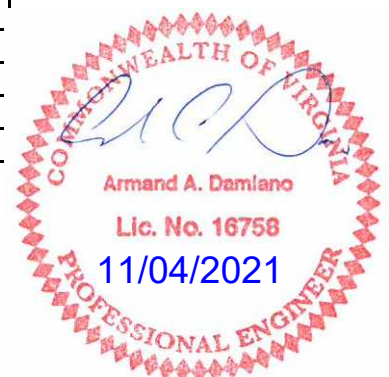
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	21.193 ksi
Bolt Direct Shear Stress	0.322 ksi
Bolt Torsion Shear Stress	11.17 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	21.193 ksi
$f_v =$	11.492 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.79 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.5 in
Design Moment	186 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	28.1 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.938 in
Design Moment	103 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	16.33 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-4 - VA - 80 MPH - MP-3 Std. Loads - Type C - 70'/60' Arms

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	0 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	OK

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	52983 lbs
Computed Factor-of Safety	1.17 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	52983 lbs
Total Tensile Load	423864 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.11 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	52983 lbs
Total Tensile Load	423864 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	9 Qty.



MAST ARM POLE ANALYSIS TO AASHTO

16362-2-5 - VA - 80 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

11/04/21

General

Wind Vel.- mph	80	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		AASHTO Editon	6TH	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	16.00	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.2093	0.14	13.00	49.00	18.00	-	2.57	0	55	29000	180
Traffic Arm #2					-	-		0	55	29000	90
Lum Arm #1	0.2760		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	11.50	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	0.26	0.36	0.45								17.83	0.00
GP II CSR	0.89	0.86	0.95				0.93					
GP III CSR	0.59	0.64	0.74				0.70				30.17	

Arm #1 Flange Bolt (Max.) CSR	0.30
Arm #1 Flange Bolt Fatigue CSR	0.00
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	0.00
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	0.55
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.59
Anchorage Capacity S.F.	1.62
Concrete Pull Out Capacity S.F.	1.86

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
4547	5252	117872	95415



16362-2-5 - VA - 80 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	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										



16362-2-5 - VA - 80 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	16.000	15.852	44.36	0.5286	0.53	1.405	13.74	0.80
2	I	1.06	1.06	15.852	15.704	43.94	0.5286	1.59	1.392	13.62	0.80
3	I	1.06	2.12	15.704	15.555	43.52	0.5286	2.65	1.379	13.50	0.80
4	I	1.06	3.18	15.555	15.407	43.10	0.5286	3.71	1.366	13.37	0.80
5	I	1.06	4.24	15.407	15.259	42.68	0.5286	4.76	1.353	13.25	0.80
6	I	1.06	5.29	15.259	15.111	42.26	0.5286	5.82	1.340	13.13	0.80
7	I	1.06	6.35	15.111	14.962	41.84	0.5285	6.88	1.327	13.00	0.80
8	I	1.06	7.41	14.962	14.814	41.42	0.5285	7.94	1.314	12.88	0.80
9	I	1.06	8.47	14.814	14.666	41.00	0.5285	9.00	1.301	12.76	0.80
10	I	1.06	9.53	14.666	14.518	40.58	0.5285	10.06	1.288	12.63	0.80
11	I	1.06	10.59	14.518	14.369	40.16	0.5285	11.12	1.274	12.51	0.80
12	I	1.06	11.65	14.369	14.221	39.74	0.5285	12.18	1.261	12.39	0.80
13	I	1.06	12.71	14.221	14.073	39.32	0.5285	13.23	1.248	12.26	1.00
14	I	1.06	13.76	14.073	13.925	38.91	0.5285	14.29	1.235	12.14	1.00
15	I	1.06	14.82	13.925	13.776	38.49	0.5285	15.35	1.222	12.02	1.00
16	I	1.06	15.88	13.776	13.628	38.07	0.5285	16.41	1.209	11.89	1.00
17	I	1.06	16.94	13.628	13.480	37.65	0.5284	17.47	1.196	11.77	1.00
18	J	3.00	18.00	13.480	13.060	104.39	1.4921	19.49	3.318	32.68	1.00
19	I	3.00	21.00	13.060	12.640	101.02	1.4918	22.49	3.213	31.69	1.00
20	J	1.00	24.00	12.640	12.500	32.93	0.4991	24.50	1.048	10.34	1.00
						936					

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)	383.37	227.23	0.00	180.38
Section Modulus (in ³)	48.68	34.35	0.00	
Cross-Section Area (in ²)	12.36	10.39	0.00	
Width-Thickness Ratio	64.00	53.92	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)	9.215	9.215	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	1.083
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-5 - VA - 80 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

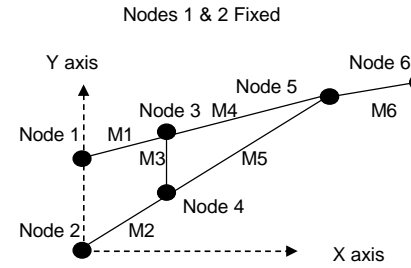
Shaft Analysis Continued

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	9.97	14.01	0.000	17.57	1.100	0.000	0.00
2	0.450	9.97	13.88	0.000	17.40	1.100	0.000	0.00
3	0.450	9.97	13.75	0.000	17.24	1.100	0.000	0.00
4	0.450	9.97	13.62	0.000	17.07	1.100	0.000	0.00
5	0.450	9.97	13.49	0.001	16.91	1.100	0.000	0.00
6	0.450	9.97	13.36	0.001	16.75	1.100	0.000	0.00
7	0.450	9.97	13.23	0.001	16.58	1.100	0.000	0.00
8	0.450	9.97	13.10	0.002	16.42	1.100	0.000	0.00
9	0.450	9.97	12.97	0.002	16.26	1.100	0.000	0.00
10	0.450	9.97	12.84	0.002	16.09	1.100	0.000	0.00
11	0.450	9.97	12.71	0.003	15.93	1.100	0.000	0.00
12	0.450	9.97	12.58	0.003	15.77	1.100	0.000	0.00
13	0.450	12.47	15.57	0.005	15.60	1.100	0.000	0.00
14	0.450	12.47	15.40	0.006	15.44	1.100	0.000	0.00
15	0.450	12.47	15.24	0.006	15.28	1.100	0.000	0.00
16	0.450	12.47	15.08	0.007	15.11	1.100	0.000	0.00
17	0.450	12.47	14.91	0.008	14.95	1.100	0.000	0.00
18	0.450	12.47	41.37	0.027	41.47	1.100	0.000	0.00
19	0.450	12.47	40.06	0.033	40.16	1.100	0.000	0.00
20	0.450	12.47	13.06	0.012	13.09	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.013	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.013	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.183	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-5 - VA - 80 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)
80									
Node #1	0	27	0	0	-33.67	-32.1	0	0	0
Node #2	0	0	0	0	-35.63	-33.9	0	0	0
Node #3	100	59.5	0	0	-66.63	-67	0	0	0
Node #4	100	48.8	0	0	-69.41	-69.7	0	0	0
Node #5	200	79	0	0	-94.35	-98.8	0	0	0
Node #6	288	87	0	0	-85.29	-90.6	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	0.276	105.15	2.10	2.258	-67.33	1.1	1	-64.05	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-71.25	1.1	1	-67.78	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.54	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-65.23	1.1	1.1	-68.27	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-66.89	1.1	1.1	-70.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-56.58	1.1	1.1	-59.21	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-60.92					

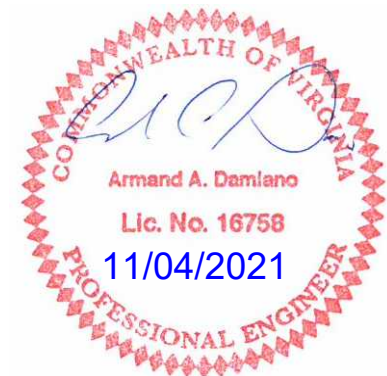
AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2180.2	lbs
P1y	-694.6	lbs
P1z	233.5	lbs
M1x	8700.6	in-lbs
M1y	-32862.2	in-lbs
M1z	-898.1	in-lbs
P2x	2180.2	lbs
P2y	1079.6	lbs
P2z	158.6	lbs
M2x	8937.3	in-lbs
M2y	-26660.6	in-lbs
M2z	-928.7	in-lbs

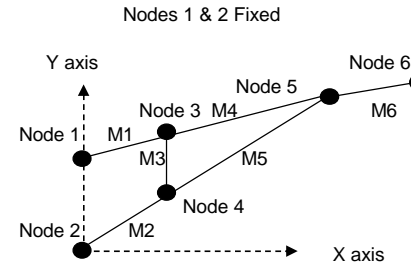
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1018	180	25256	-641	0.73
#2	1071	112	20749	-1246	0.93
#3	1489	513	10104	-511	0.39
#4	-1001	81	9678	-29	0.26
#5	1020	95	10774	-376	0.58
#6	4	110	8163	1	0.25

V09.19.15



16362-2-5 - VA - 80 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)
80									
Node #1	0	27	0	0	-40.85	-16.1	0	0	0
Node #2	0	0	0	0	-43.23	-17	0	0	0
Node #3	100	59.5	0	0	-81.04	-33.5	0	0	0
Node #4	100	48.8	0	0	-84.42	-34.9	0	0	0
Node #5	200	79	0	0	-114.49	-49.4	0	0	0
Node #6	288	87	0	0	-115.33	-45.3	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	0.276	105.15	2.10	2.258	-81.69	1.1	1	-32.03	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-86.45	1.1	1	-33.89	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.77	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-79.16	1.1	1.1	-34.13	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-81.16	1.1	1.1	-35.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-68.65	1.1	1.1	-29.60	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-30.46					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2797.7	lbs
P1y	-898.7	lbs
P1z	116.8	lbs
M1x	4351.1	in-lbs
M1y	-16433.7	in-lbs
M1z	-1426.8	in-lbs
P2x	2797.7	lbs
P2y	1378.1	lbs
P2z	79.4	lbs
M2x	4469.6	in-lbs
M2y	-13332.7	in-lbs
M2z	-1452.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1307	93	12670	-321	0.34
#2	1373	61	10427	-623	0.7
#3	1905	462	9337	-256	0.39
#4	-1287	51	4933	-15	0.11
#5	1311	56	5469	-188	0.49
#6	5	110	8115	1	0.25

V09.19.15



16362-2-5 - VA - 80 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	13.000	12.657	69.2	1.2195	1.22	2.619	2.619	25.84
2	I	2.45	2.45	12.657	12.314	67.3	1.2194	3.67	2.549	2.549	25.18
3	I	2.45	4.90	12.314	11.971	65.4	1.2192	6.12	2.479	2.479	24.52
4	I	2.45	7.35	11.971	11.628	63.5	1.2191	8.57	2.409	2.409	23.86
5	I	2.45	9.80	11.628	11.285	61.7	1.2189	11.02	2.339	2.339	23.20
6	I	2.45	12.25	11.285	10.942	59.8	1.2187	13.47	2.269	2.269	22.54
7	I	2.45	14.70	10.942	10.599	57.9	1.2185	15.92	2.199	2.199	21.88
8	I	2.45	17.15	10.599	10.256	56.0	1.2183	18.37	2.129	2.129	21.22
9	I	2.45	19.60	10.256	9.913	54.1	1.2181	20.82	2.059	2.059	20.56
10	I	2.45	22.05	9.913	9.570	52.3	1.2178	23.27	1.989	1.989	19.90
11	I	2.45	24.50	9.570	9.227	50.4	1.2175	25.72	1.919	1.919	19.24
12	I	2.45	26.95	9.227	8.884	48.5	1.2173	28.17	1.849	1.849	18.58
13	I	2.45	29.40	8.884	8.541	46.6	1.2170	30.62	1.779	1.779	17.92
14	I	2.45	31.85	8.541	8.198	44.7	1.2166	33.07	1.709	1.709	17.26
15	I	2.45	34.30	8.198	7.855	42.9	1.2163	35.52	1.639	1.639	16.60
16	I	2.45	36.75	7.855	7.512	41.0	1.2159	37.97	1.569	1.569	15.94
17	I	2.45	39.20	7.512	7.169	39.1	1.2155	40.42	1.499	1.499	15.28
18	I	2.45	41.65	7.169	6.826	37.2	1.2150	42.86	1.429	1.429	14.62
19	I	2.45	44.10	6.826	6.483	35.3	1.2145	45.31	1.359	1.359	13.96
20	I	2.45	46.55	6.483	6.140	33.5	1.2139	47.76	1.289	1.289	13.30
		<u>49.00</u>				<u>1026</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)	26.880	0.000
Cross-Section Area (in^2)	8.406	0.000
Width-Thickness Ratio	62.11	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



16362-2-5 - VA - 80 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	12.47	32.66	32.74	1.100	0.000	0.00	0	0.710	0.00	0.00	0.00
2	1.00	0.450	12.47	31.79	31.86	1.100	0.000	0.00	0	0.736	0.00	0.00	0.00
3	1.00	0.450	12.47	30.91	30.99	1.100	0.000	0.00	0	0.763	0.00	0.00	0.00
4	1.00	0.450	12.47	30.04	30.11	1.100	0.000	0.00	0	0.792	0.00	0.00	0.00
5	1.00	0.450	12.47	29.17	29.24	1.100	0.000	0.00	0	0.823	0.00	0.00	0.00
6	1.00	0.450	12.47	28.29	28.36	1.100	0.000	0.00	0	0.856	0.00	0.00	0.00
7	1.00	0.450	12.47	27.42	27.49	1.100	0.000	0.00	0	0.891	0.00	0.00	0.00
8	1.00	0.450	12.47	26.55	26.61	1.100	0.000	0.00	0	0.930	0.00	0.00	0.00
9	1.00	0.450	12.47	25.67	25.74	1.100	0.000	0.00	0	0.971	0.00	0.00	0.00
10	1.00	0.450	12.47	24.80	24.86	1.100	0.000	0.00	0	1.016	0.00	0.00	0.00
11	1.00	0.461	12.78	24.52	23.99	1.100	0.000	0.00	0	1.064	0.00	0.00	0.00
12	1.00	0.484	13.41	24.79	23.11	1.100	0.000	0.00	0	1.100	0.00	0.00	0.00
13	1.00	0.509	14.1	25.08	22.24	1.100	0.000	0.00	0	1.100	0.00	0.00	0.00
14	1.00	0.536	14.85	25.38	21.36	1.100	0.000	0.00	0	1.100	0.00	0.00	0.00
15	1.00	0.566	15.68	25.70	20.48	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
16	1.00	0.599	16.6	26.04	19.61	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
17	1.00	0.636	17.62	26.41	18.73	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
18	1.00	0.677	18.75	26.79	17.86	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
19	1.00	0.723	20.01	27.19	16.98	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
20	1.00	0.774	21.44	27.63	16.11	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	33.21	996.30	498.15	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	365.53	182.77	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



16362-2-5 - VA - 80 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

Flange Analysis - Arm #1

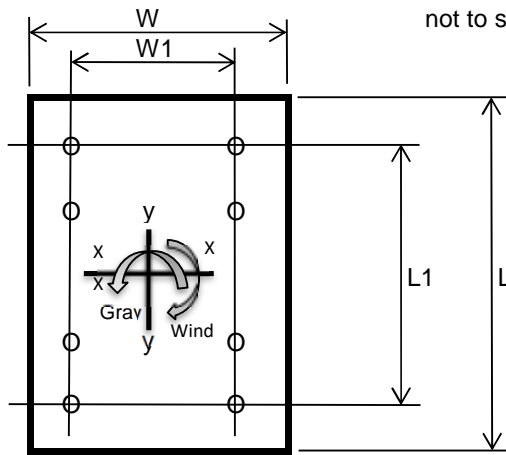
V06-21-16

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1545	2514	-	lbs
Shear (Wind)	3844	2137	-	lbs
Torsion (Arm Rise)	9869	5487	-	ft-lbs
Moment (Gravity)	36140	60455	-	ft-lbs
Moment (Wind)	93945	51038	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	13.00	in
Tube Wall Thick.	0.2093	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	596.99	596.99	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1073.57	1073.57	in ⁴
Bolt Tensile Stress - ft	12.45	13.09	ksi
Bolt Shear Stress - fv	1.45	0.92	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.29	0.30	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	8.85	14.80	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	23.40	12.72	ksi
Combined applied stress for interaction (SRSS)	25.02	19.52	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-5 - VA - 80 MPH - MP-3 Std. Loads - Type D - 49' 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	1545		1545	36140		36141		368	16135		0.45
Gp II	1545	3844	4143	36140	93945	100657	9869	986	44937	2203	0.95
Gp III	2514	2137	3300	60455	51038	79118	5487	786	35321	1225	0.74
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		-



16362-2-5 - VA - 80 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)						

Shaft Base											
Gp I	3030		36140	0	36140		245		8908		0.26
Gp II	3030	5252	51951	105806	117872	95415	245	850	29055	11760	0.89
Gp III	4547	3056	43950	84980	95672	51773	368	495	23583	6381	0.59
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9958										

Shaft At Arm											
Gp I	2168		36140	0	36140		209		12625		0.36
Gp II	2168	4330	9869	43780	44879	95415	209	834	15678	16666	0.86
Gp III	3232	2428	5487	64440	64673	51773	311	468	22593	9043	0.64
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9958										



16362-2-5 - VA - 80 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	5252 lbs
Bending Moment	117872 ft-lbs
Torsion Moment	95415 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	16.00 in

ANALYSIS - ANCHOR BOLTS

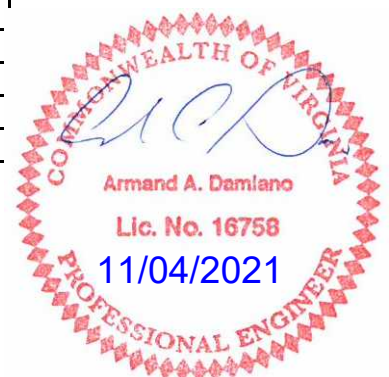
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1082.98 in ⁴
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	15.673 ksi
Bolt Direct Shear Stress	0.381 ksi
Bolt Torsion Shear Stress	6.915 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	15.673 ksi
$f_v =$	7.296 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.55 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	12.701 in
Dist. Shaft Face To Bolt Center	4 in
Design Moment	157 in-kip
Section Modulus of Failure Plane	8.46 in ³
Applied Plate Stress	18.56 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	12.052 in
Dist From Shaft To Nut Face	2.438 in
Design Moment	96 in-kip
Section Modulus of Failure Plane	8.03 in ³
Applied Plate Stress	11.96 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-5 - VA - 80 MPH - MP-3 Std. Loads - Type D - 49' Arm w/24' Lum.

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

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

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	39183 lbs
Computed Factor-of Safety	1.62 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	39183 lbs
Total Tensile Load	235098 lbs
Concrete Failure Surface Area	4002.39 in ²
Concrete Shear Strength	438440 psi
Computed Factor-of Safety	1.86 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	39183 lbs
Total Tensile Load	235098 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

16362-2-6 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

11/04/21

General

Wind Vel. - mph	80	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		AASHTO Editon	6TH	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	0.3125	0.14	19.50	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	0.14	18.00	28.00	18.00	-	3.93	0	55	29000	180
	0.1880	0.14	14.87	49.93	-	2.93		0	55	29000	
Traffic Arm #2								0	55	29000	90
								0	55	29000	
Lum Arm #1	0.2760		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	14.25	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	0.37	0.49	0.54	0.43							35.42	0.00
GP II CSR	0.86	0.95	0.91	0.81			0.93					
GP III CSR	0.67	0.78	0.80	0.69			0.70				57.85	

Arm #1 Flange Bolt (Max.) CSR	0.65
Arm #1 Flange Bolt Fatigue CSR	0.00
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	0.00
Handhole at Toe (Fatigue) CSR	0.00
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	0.00
Base Plate Max. CSR	0.71
Anchorage Capacity S.F.	1.35
Concrete Pull Out Capacity S.F.	1.28

Ground Line Reactions

	Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
	7201	6917	199086	194678



16362-2-6 - VA - 80 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										



16362-2-6 - VA - 80 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	19.500	19.352	67.61	0.5287	0.53	1.714	16.65	0.80
2	I	1.06	1.06	19.352	19.204	67.08	0.5287	1.59	1.701	16.53	0.80
3	I	1.06	2.12	19.204	19.055	66.56	0.5287	2.65	1.688	16.41	0.80
4	I	1.06	3.18	19.055	18.907	66.03	0.5287	3.71	1.675	16.28	0.80
5	I	1.06	4.24	18.907	18.759	65.51	0.5287	4.76	1.662	16.16	0.80
6	I	1.06	5.29	18.759	18.611	64.99	0.5287	5.82	1.649	16.04	0.80
7	I	1.06	6.35	18.611	18.462	64.46	0.5287	6.88	1.636	15.91	0.80
8	I	1.06	7.41	18.462	18.314	63.94	0.5287	7.94	1.622	15.79	0.80
9	I	1.06	8.47	18.314	18.166	63.41	0.5287	9.00	1.609	15.67	0.80
10	I	1.06	9.53	18.166	18.018	62.89	0.5287	10.06	1.596	15.54	0.80
11	I	1.06	10.59	18.018	17.869	62.36	0.5287	11.12	1.583	15.42	0.80
12	I	1.06	11.65	17.869	17.721	61.84	0.5287	12.18	1.570	15.30	0.80
13	I	1.06	12.71	17.721	17.573	61.31	0.5287	13.23	1.557	15.17	1.00
14	I	1.06	13.76	17.573	17.425	60.79	0.5287	14.29	1.544	15.05	1.00
15	I	1.06	14.82	17.425	17.276	60.27	0.5287	15.35	1.531	14.93	1.00
16	I	1.06	15.88	17.276	17.128	59.74	0.5287	16.41	1.518	14.80	1.00
17	I	1.06	16.94	17.128	16.980	59.22	0.5286	17.47	1.505	14.68	1.00
18	J	3.00	18.00	16.980	16.560	164.94	1.4937	19.49	4.193	40.93	1.00
19	I	3.00	21.00	16.560	16.140	160.73	1.4936	22.49	4.088	39.94	1.00
20	J	1.00	24.00	16.140	16.000	52.64	0.4993	24.50	1.339	13.09	1.00
						1457					

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)	866.45	567.94	0.00	473.53
Section Modulus (in ³)	90.31	68.15	0.00	
Cross-Section Area (in ²)	18.83	16.35	0.00	
Width-Thickness Ratio	62.40	54.34	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)	14.296	14.296	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	1.248
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-6 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

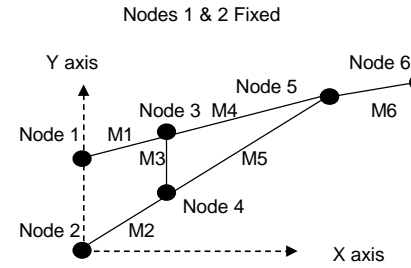
Shaft Analysis Continued

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	9.97	17.09	0.000	21.43	1.100	0.000	0.00
2	0.450	9.97	16.96	0.000	21.26	1.100	0.000	0.00
3	0.450	9.97	16.83	0.000	21.10	1.100	0.000	0.00
4	0.450	9.97	16.70	0.000	20.94	1.100	0.000	0.00
5	0.450	9.97	16.57	0.000	20.77	1.100	0.000	0.00
6	0.450	9.97	16.44	0.000	20.61	1.100	0.000	0.00
7	0.450	9.97	16.31	0.001	20.44	1.100	0.000	0.00
8	0.450	9.97	16.18	0.001	20.28	1.100	0.000	0.00
9	0.450	9.97	16.05	0.001	20.12	1.100	0.000	0.00
10	0.450	9.97	15.92	0.001	19.95	1.100	0.000	0.00
11	0.450	9.97	15.79	0.002	19.79	1.100	0.000	0.00
12	0.450	9.97	15.65	0.002	19.63	1.100	0.000	0.00
13	0.450	12.47	19.42	0.003	19.46	1.100	0.000	0.00
14	0.450	12.47	19.25	0.003	19.30	1.100	0.000	0.00
15	0.450	12.47	19.09	0.003	19.14	1.100	0.000	0.00
16	0.450	12.47	18.93	0.004	18.97	1.100	0.000	0.00
17	0.450	12.47	18.76	0.004	18.81	1.100	0.000	0.00
18	0.450	12.47	52.28	0.014	52.41	1.100	0.000	0.00
19	0.450	12.47	50.97	0.018	51.09	1.100	0.000	0.00
20	0.450	12.47	16.70	0.007	16.74	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.006	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.006	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.079	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-6 - VA - 80 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)
80									
Node #1	0	27	0	0	-33.67	-32.1	0	0	0
Node #2	0	0	0	0	-35.63	-33.9	0	0	0
Node #3	100	59.5	0	0	-66.63	-67	0	0	0
Node #4	100	48.8	0	0	-69.41	-69.7	0	0	0
Node #5	200	79	0	0	-94.35	-98.8	0	0	0
Node #6	288	87	0	0	-85.29	-90.6	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	0.276	105.15	2.10	2.258	-67.33	1.1	1	-64.05	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-71.25	1.1	1	-67.78	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.54	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-65.23	1.1	1.1	-68.27	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-66.89	1.1	1.1	-70.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-56.58	1.1	1.1	-59.21	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-60.92					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2180.2	lbs
P1y	-694.6	lbs
P1z	233.5	lbs
M1x	8700.6	in-lbs
M1y	-32862.2	in-lbs
M1z	-898.1	in-lbs
P2x	2180.2	lbs
P2y	1079.6	lbs
P2z	158.6	lbs
M2x	8937.3	in-lbs
M2y	-26660.6	in-lbs
M2z	-928.7	in-lbs

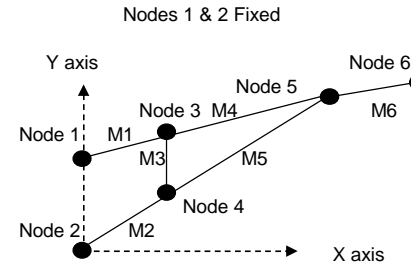
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1018	180	25256	-641	0.73
#2	1071	112	20749	-1246	0.93
#3	1489	513	10104	-511	0.39
#4	-1001	81	9678	-29	0.26
#5	1020	95	10774	-376	0.58
#6	4	110	8163	1	0.25

V09.19.15



16362-2-6 - VA - 80 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)
80									
Node #1	0	27	0	0	-40.85	-16.1	0	0	0
Node #2	0	0	0	0	-43.23	-17	0	0	0
Node #3	100	59.5	0	0	-81.04	-33.5	0	0	0
Node #4	100	48.8	0	0	-84.42	-34.9	0	0	0
Node #5	200	79	0	0	-114.49	-49.4	0	0	0
Node #6	288	87	0	0	-115.33	-45.3	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	0.276	105.15	2.10	2.258	-81.69	1.1	1	-32.03	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-86.45	1.1	1	-33.89	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.77	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-79.16	1.1	1.1	-34.13	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-81.16	1.1	1.1	-35.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-68.65	1.1	1.1	-29.60	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-30.46					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2797.7	lbs
P1y	-898.7	lbs
P1z	116.8	lbs
M1x	4351.1	in-lbs
M1y	-16433.7	in-lbs
M1z	-1426.8	in-lbs
P2x	2797.7	lbs
P2y	1378.1	lbs
P2z	79.4	lbs
M2x	4469.6	in-lbs
M2y	-13332.7	in-lbs
M2z	-1452.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1307	93	12670	-321	0.34
#2	1373	61	10427	-623	0.7
#3	1905	462	9337	-256	0.39
#4	-1287	51	4933	-15	0.11
#5	1311	56	5469	-188	0.49
#6	5	110	8115	1	0.25

V09.19.15



16362-2-6 - VA - 80 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	18.000	17.415	194.9	2.0777	2.08	6.166	6.166	60.08
2	I	4.18	4.18	17.415	16.830	188.4	2.0773	6.26	5.962	5.962	58.16
3	I	4.18	8.36	16.830	16.245	181.9	2.0769	10.43	5.758	5.758	56.24
4	I	4.18	12.54	16.245	15.660	175.3	2.0764	14.61	5.555	5.555	54.32
5	I	4.18	16.71	15.660	15.075	168.8	2.0759	18.79	5.351	5.351	52.40
6	I	4.18	20.89	15.075	14.490	162.3	2.0754	22.97	5.147	5.147	50.48
7	J	2.93	25.07	14.870	14.460	195.2	1.4582	26.53	3.581	3.581	35.13
8	O	3.62	28.00	14.460	13.954	101.9	1.7970	29.80	4.280	4.280	42.04
9	O	3.62	31.62	13.954	13.447	98.2	1.7966	33.41	4.128	4.128	40.61
10	O	3.62	35.23	13.447	12.941	94.5	1.7961	37.03	3.975	3.975	39.17
11	O	3.62	38.85	12.941	12.435	90.8	1.7957	40.64	3.823	3.823	37.73
12	O	3.62	42.46	12.435	11.929	87.1	1.7952	44.26	3.670	3.670	36.29
13	O	3.62	46.08	11.929	11.423	83.5	1.7946	47.87	3.518	3.518	34.86
14	O	3.62	49.69	11.423	10.917	79.8	1.7940	51.49	3.365	3.365	33.42
15	O	3.62	53.31	10.917	10.411	76.1	1.7934	55.10	3.213	3.213	31.98
16	O	3.62	56.92	10.411	9.904	72.4	1.7927	58.72	3.060	3.060	30.55
17	O	3.62	60.54	9.904	9.398	68.8	1.7919	62.33	2.908	2.908	29.11
18	O	3.62	64.15	9.398	8.892	65.1	1.7910	65.94	2.755	2.755	27.67
19	O	3.62	67.77	8.892	8.386	61.4	1.7900	69.56	2.603	2.603	26.23
20	O	3.62	71.38	8.386	7.880	57.7	1.7889	73.17	2.450	2.450	24.80
		<u>75.00</u>				<u>2304</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)	61.831	31.813
Cross-Section Area (in^2)	13.934	8.667
Width-Thickness Ratio	72.00	79.10
Compact Limit	68.55	68.55
Non-Compact Limit	137.09	137.09
Maximum Limit	237.27	237.27
Allow. Bending Stress (ksi)	35.588	34.319
Allow. Shear Stress (ksi)	18.150	16.903



16362-2-6 - VA - 80 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)	Load (lbs)	
1	1.00	0.450	12.47	76.89	77.07	1.100	0.000	0.00	0	0.467	0.00	0.00	
2	1.00	0.450	12.47	74.35	74.52	1.100	0.000	0.00	0	0.488	0.00	0.00	
3	1.00	0.450	12.47	71.81	71.98	1.100	0.000	0.00	0	0.511	0.00	0.00	
4	1.00	0.450	12.47	69.27	69.43	1.100	0.000	0.00	0	0.535	0.00	0.00	
5	1.00	0.450	12.47	66.73	66.89	1.100	0.000	0.00	0	0.562	0.00	0.00	
6	1.00	0.450	12.47	64.19	64.34	1.100	0.000	0.00	0	0.591	0.00	0.00	
7	1.00	0.450	12.47	44.65	44.76	1.100	0.000	0.00	0	0.597	0.00	0.00	
8	1.00	0.450	12.47	53.37	53.50	1.100	0.000	0.00	0	0.622	0.00	0.00	
9	1.00	0.450	12.47	51.47	51.60	1.100	0.000	0.00	0	0.652	0.00	0.00	
10	1.00	0.450	12.47	49.57	49.69	1.100	0.000	0.00	0	0.685	0.00	0.00	
11	1.00	0.450	12.47	47.67	47.78	1.100	0.000	0.00	0	0.720	0.00	0.00	
12	1.00	0.450	12.47	45.77	45.88	1.100	0.000	0.00	0	0.760	0.00	0.00	
13	1.00	0.450	12.47	43.87	43.97	1.100	0.000	0.00	0	0.803	0.00	0.00	
14	1.00	0.450	12.47	41.96	42.07	1.100	0.000	0.00	0	0.850	0.00	0.00	
15	1.00	0.450	12.47	40.06	40.16	1.100	0.000	0.00	0	0.903	0.00	0.00	
16	1.00	0.450	12.47	38.16	38.25	1.100	0.000	0.00	0	0.962	0.00	0.00	
17	1.00	0.450	12.47	36.26	36.35	1.100	0.000	0.00	1	1.028	0.00	0.00	
18	1.00	0.478	13.24	36.48	34.44	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.515	14.26	37.12	32.53	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.557	15.42	37.78	30.63	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	0.000	0.00	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #13	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #14	1.00	1.200	33.23	365.53	182.77	1.200	0.000	0.00	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



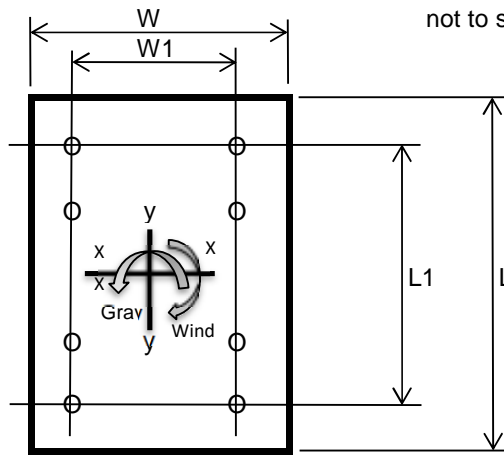
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2998	4578	-	lbs
Shear (Wind)	5394	3199	-	lbs
Torsion (Arm Rise)	21199	12573	-	ft-lbs
Moment (Gravity)	97327	155408	-	ft-lbs
Moment (Wind)	193209	112755	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	18.00	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	24.64	28.48	ksi
Bolt Shear Stress - fv	2.58	1.72	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.57	0.65	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	15.55	24.83	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	31.40	18.33	ksi
Combined applied stress for interaction (SRSS)	35.04	30.86	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-6 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

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

SHAFT TO BASEPLATE

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

Tt - Thickness of shaft	0.3125	in
Dt - Shaft base diameter	19.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.333333	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.730769	
Kf - Fatigue stress concentration factor for finite life	2.31	
Ki - Fatigue stress concentration factor for infinite life	5.05	
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	18.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	1.77	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.333333	
Kf - Fatigue stress concentration factor for finite life	1.75	
Ki - Fatigue stress concentration factor for infinite life	3.28	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-2-6 - VA - 80 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)	19.07	in
Shaft Thickness	0.313	in
Total Area	23.571	in^2
Ix	911	in^4
Iy	1023	in^4
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-2-6 - VA - 80 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	0.31	in
Shaft Diameter (At hand hole location)	16.98	in
Shaft Thickness	0.313	in
Total Area	18.6471	in ²
Ix	583	in ⁴
Iy	645	in ⁴
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-2-6 - VA - 80 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)					

Arm#1 Base											
Gp I	2998		2998	97327		97327		431	18889		0.54
Gp II	2998	5394	6172	97327	193209	216338	21199	886	41987	2058	0.91
Gp III	4578	3199	5585	155408	112755	192004	12573	802	37264	1221	0.80
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	1688		1688	38664		38665		390	14585		0.43
Gp II	1688	2993	3436	38664	87565	95722	11762	793	36108	2219	0.81
Gp III	2666	1786	3210	64252	50106	81480	7019	741	30735	1324	0.69
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		-



16362-2-6 - VA - 80 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)						

Shaft Base											
Gp I	5004		97327	0	97327		266		12932		0.37
Gp II	5004	6917	118291	148816	190103	194678	266	735	25259	12933	0.86
Gp III	7201	4232	70158	186314	199086	113490	382	450	26452	7540	0.67
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9968										

Shaft At Arm											
Gp I	3761		97327	0	97327		230		17138		0.49
Gp II	3761	5906	21199	105055	107173	194678	230	723	18871	17140	0.95
Gp III	5435	3516	12573	159482	159977	113490	332	430	28169	9992	0.78
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9968										



16362-2-6 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	6917 lbs
Bending Moment	199086 ft-lbs
Torsion Moment	194678 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	19.50 in

ANALYSIS - ANCHOR BOLTS

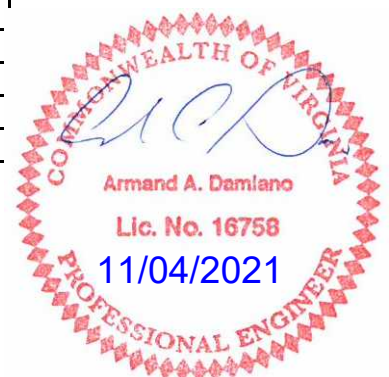
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	18.334 ksi
Bolt Direct Shear Stress	0.376 ksi
Bolt Torsion Shear Stress	9.767 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	18.334 ksi
$f_v =$	10.143 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.69 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	149 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	22.51 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	78 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	12.37 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-6 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 75' Arm w/24' Lum.

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	0 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	OK

ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation

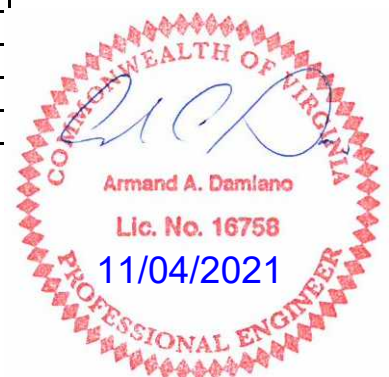
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A _b = Net Bearing Area	4.528 in ²
D _w = 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	45835 lbs
Computed Factor-of Safety	1.35 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	45835 lbs
Total Tensile Load	366680 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.28 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	45835 lbs
Total Tensile Load	366680 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

16362-2-7 - VA - 80 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

11/04/21

General

Wind Vel. - mph	80	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		AASHTO Editon	6TH	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	20.50	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.3125	0.14	19.00	30.00	18.00	-	3.93	0	55	29000	180
	0.2190	0.14	15.66	48.02	-	3.02		0	55	29000	
Traffic Arm #2								0	55	29000	90
								0	55	29000	
Lum Arm #1	0.2760		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	15.75	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	0.38	0.49	0.51	0.42							33.67	0.00
GP II CSR	0.82	0.98	0.89	0.91			0.93					
GP III CSR	0.65	0.78	0.76	0.71			0.70				54.99	

Arm #1 Flange Bolt (Max.) CSR	0.79
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	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	0.90
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.76
Anchorage Capacity S.F.	1.07
Concrete Pull Out Capacity S.F.	1.02

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
8609	6976	250447	271930



16362-2-7 - VA - 80 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										



16362-2-7 - VA - 80 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	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	3.00	18.00	17.980	17.560	209.20	1.4941	19.49	4.443	43.28	1.00
19	I	3.00	21.00	17.560	17.140	204.15	1.4939	22.49	4.338	42.29	1.00
20	J	1.00	24.00	17.140	17.000	66.93	0.4993	24.50	1.423	13.88	1.00
						1842					

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	0.00	676.33
Section Modulus (in ³)	119.23	91.24	0.00	
Cross-Section Area (in ²)	23.70	20.73	0.00	
Width-Thickness Ratio	54.67	47.95	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)	15.735	15.735	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	1.213
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-7 - VA - 80 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

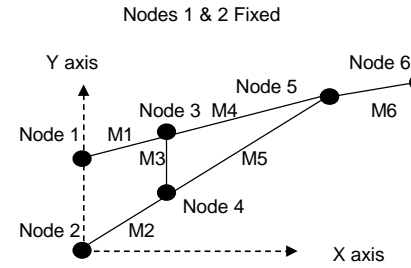
Shaft Analysis Continued

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	9.97	17.97	0.000	22.53	1.100	0.000	0.00
2	0.450	9.97	17.84	0.000	22.37	1.100	0.000	0.00
3	0.450	9.97	17.71	0.000	22.20	1.100	0.000	0.00
4	0.450	9.97	17.58	0.000	22.04	1.100	0.000	0.00
5	0.450	9.97	17.45	0.000	21.87	1.100	0.000	0.00
6	0.450	9.97	17.32	0.000	21.71	1.100	0.000	0.00
7	0.450	9.97	17.19	0.000	21.55	1.100	0.000	0.00
8	0.450	9.97	17.06	0.001	21.38	1.100	0.000	0.00
9	0.450	9.97	16.93	0.001	21.22	1.100	0.000	0.00
10	0.450	9.97	16.80	0.001	21.06	1.100	0.000	0.00
11	0.450	9.97	16.66	0.001	20.89	1.100	0.000	0.00
12	0.450	9.97	16.53	0.001	20.73	1.100	0.000	0.00
13	0.450	12.47	20.52	0.002	20.57	1.100	0.000	0.00
14	0.450	12.47	20.35	0.002	20.40	1.100	0.000	0.00
15	0.450	12.47	20.19	0.003	20.24	1.100	0.000	0.00
16	0.450	12.47	20.03	0.003	20.08	1.100	0.000	0.00
17	0.450	12.47	19.86	0.003	19.91	1.100	0.000	0.00
18	0.450	12.47	55.40	0.011	55.53	1.100	0.000	0.00
19	0.450	12.47	54.09	0.014	54.22	1.100	0.000	0.00
20	0.450	12.47	17.74	0.005	17.78	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.057	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-7 - VA - 80 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)
80									
Node #1	0	27	0	0	-33.67	-32.1	0	0	0
Node #2	0	0	0	0	-35.63	-33.9	0	0	0
Node #3	100	59.5	0	0	-66.63	-67	0	0	0
Node #4	100	48.8	0	0	-69.41	-69.7	0	0	0
Node #5	200	79	0	0	-94.35	-98.8	0	0	0
Node #6	288	87	0	0	-85.29	-90.6	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	0.276	105.15	2.10	2.258	-67.33	1.1	1	-64.05	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-71.25	1.1	1	-67.78	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.54	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-65.23	1.1	1.1	-68.27	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-66.89	1.1	1.1	-70.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-56.58	1.1	1.1	-59.21	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-60.92					

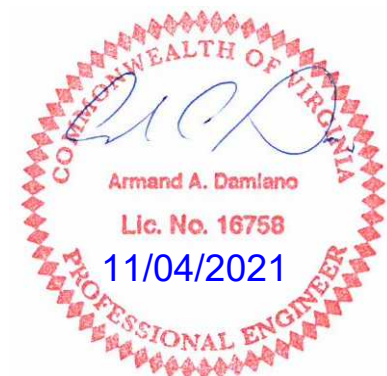
AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2180.2	lbs
P1y	-694.6	lbs
P1z	233.5	lbs
M1x	8700.6	in-lbs
M1y	-32862.2	in-lbs
M1z	-898.1	in-lbs
P2x	2180.2	lbs
P2y	1079.6	lbs
P2z	158.6	lbs
M2x	8937.3	in-lbs
M2y	-26660.6	in-lbs
M2z	-928.7	in-lbs

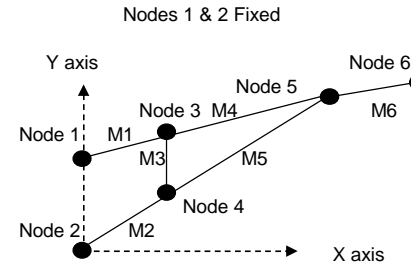
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1018	180	25256	-641	0.73
#2	1071	112	20749	-1246	0.93
#3	1489	513	10104	-511	0.39
#4	-1001	81	9678	-29	0.26
#5	1020	95	10774	-376	0.58
#6	4	110	8163	1	0.25

V09.19.15



16362-2-7 - VA - 80 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)
80									
Node #1	0	27	0	0	-40.85	-16.1	0	0	0
Node #2	0	0	0	0	-43.23	-17	0	0	0
Node #3	100	59.5	0	0	-81.04	-33.5	0	0	0
Node #4	100	48.8	0	0	-84.42	-34.9	0	0	0
Node #5	200	79	0	0	-114.49	-49.4	0	0	0
Node #6	288	87	0	0	-115.33	-45.3	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	0.276	105.15	2.10	2.258	-81.69	1.1	1	-32.03	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-86.45	1.1	1	-33.89	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.77	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-79.16	1.1	1.1	-34.13	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-81.16	1.1	1.1	-35.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-68.65	1.1	1.1	-29.60	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-30.46					

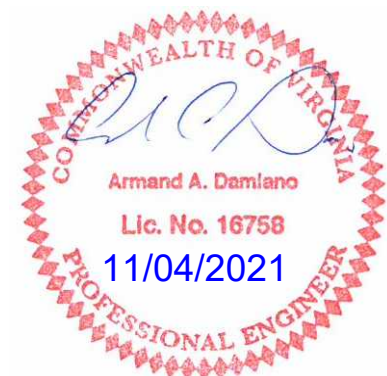
AASHTO Gp	3
Mntg Hght =	29.00
Datum =	1

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2797.7	lbs
P1y	-898.7	lbs
P1z	116.8	lbs
M1x	4351.1	in-lbs
M1y	-16433.7	in-lbs
M1z	-1426.8	in-lbs
P2x	2797.7	lbs
P2y	1378.1	lbs
P2z	79.4	lbs
M2x	4469.6	in-lbs
M2y	-13332.7	in-lbs
M2z	-1452.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1307	93	12670	-321	0.34
#2	1373	61	10427	-623	0.7
#3	1905	462	9337	-256	0.39
#4	-1287	51	4933	-15	0.11
#5	1311	56	5469	-188	0.49
#6	5	110	8115	1	0.25

V09.19.15



16362-2-7 - VA - 80 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	3.85	0.00	19.000	18.460	237.1	1.9179	1.92	6.016	6.016	58.51
2	I	3.85	3.85	18.460	17.921	230.2	1.9176	5.77	5.843	5.843	56.88
3	I	3.85	7.71	17.921	17.381	223.2	1.9173	9.63	5.669	5.669	55.25
4	I	3.85	11.56	17.381	16.842	216.3	1.9170	13.48	5.496	5.496	53.61
5	I	3.85	15.42	16.842	16.302	209.4	1.9167	17.33	5.323	5.323	51.98
6	I	3.85	19.27	16.302	15.762	202.4	1.9163	21.19	5.149	5.149	50.35
7	I	3.85	23.13	15.762	15.223	195.5	1.9160	25.04	4.976	4.976	48.71
8	J	3.02	26.98	15.660	15.237	256.0	1.5031	28.48	3.888	3.888	38.07
9	O	3.75	30.00	15.237	14.712	129.5	1.8640	31.86	4.680	4.680	45.87
10	O	3.75	33.75	14.712	14.187	124.9	1.8636	35.61	4.516	4.516	44.32
11	O	3.75	37.50	14.187	13.662	120.3	1.8632	39.36	4.351	4.351	42.78
12	O	3.75	41.25	13.662	13.137	115.7	1.8628	43.11	4.187	4.187	41.23
13	O	3.75	45.00	13.137	12.612	111.1	1.8623	46.86	4.023	4.023	39.69
14	O	3.75	48.75	12.612	12.087	106.5	1.8617	50.61	3.859	3.859	38.14
15	O	3.75	52.50	12.087	11.562	101.9	1.8611	54.36	3.695	3.695	36.59
16	O	3.75	56.25	11.562	11.037	97.3	1.8605	58.11	3.531	3.531	35.05
17	O	3.75	60.00	11.037	10.512	92.7	1.8598	61.86	3.367	3.367	33.50
18	O	3.75	63.75	10.512	9.987	88.1	1.8590	65.61	3.203	3.203	31.95
19	O	3.75	67.50	9.987	9.462	83.5	1.8581	69.36	3.039	3.039	30.41
20	O	3.75	71.25	9.462	8.937	78.8	1.8572	73.11	2.875	2.875	28.86
		<u>75.00</u>				<u>3020</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)	85.669	40.989
Cross-Section Area (in^2)	18.337	10.618
Width-Thickness Ratio	60.80	71.51
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	35.685
Allow. Shear Stress (ksi)	18.150	18.150



16362-2-7 - VA - 80 MPH - MP-3 Std. Loads - Type E2 - 75' 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	12.47	75.02	75.20	1.100	0.000	0.00	0	0.450	0.00	0.00	
2	1.00	0.450	12.47	72.86	73.03	1.100	0.000	0.00	0	0.451	0.00	0.00	
3	1.00	0.450	12.47	70.70	70.87	1.100	0.000	0.00	0	0.469	0.00	0.00	
4	1.00	0.450	12.47	68.54	68.70	1.100	0.000	0.00	0	0.488	0.00	0.00	
5	1.00	0.450	12.47	66.37	66.53	1.100	0.000	0.00	0	0.509	0.00	0.00	
6	1.00	0.450	12.47	64.21	64.37	1.100	0.000	0.00	0	0.532	0.00	0.00	
7	1.00	0.450	12.47	62.05	62.20	1.100	0.000	0.00	0	0.556	0.00	0.00	
8	1.00	0.450	12.47	48.48	48.60	1.100	0.000	0.00	0	0.558	0.00	0.00	
9	1.00	0.450	12.47	58.35	58.49	1.100	0.000	0.00	0	0.581	0.00	0.00	
10	1.00	0.450	12.47	56.31	56.44	1.100	0.000	0.00	0	0.608	0.00	0.00	
11	1.00	0.450	12.47	54.26	54.39	1.100	0.000	0.00	0	0.638	0.00	0.00	
12	1.00	0.450	12.47	52.22	52.34	1.100	0.000	0.00	0	0.671	0.00	0.00	
13	1.00	0.450	12.47	50.17	50.29	1.100	0.000	0.00	0	0.707	0.00	0.00	
14	1.00	0.450	12.47	48.13	48.24	1.100	0.000	0.00	0	0.746	0.00	0.00	
15	1.00	0.450	12.47	46.08	46.19	1.100	0.000	0.00	0	0.790	0.00	0.00	
16	1.00	0.450	12.47	44.03	44.14	1.100	0.000	0.00	0	0.838	0.00	0.00	
17	1.00	0.450	12.47	41.99	42.09	1.100	0.000	0.00	1	0.891	0.00	0.00	
18	1.00	0.450	12.47	39.94	40.04	1.100	0.000	0.00	1	0.951	0.00	0.00	
19	1.00	0.450	12.47	37.90	37.99	1.100	0.000	0.00	1	1.018	0.00	0.00	
20	1.00	0.474	13.14	37.78	35.94	1.100	0.000	0.00	1	1.094	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #7	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #12	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #13	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #14	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #15	1.00	1.200	33.23	365.53	182.77	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #16	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #17	1.00	1.200	33.23	365.53	182.77	1.200	0.000	0.00	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



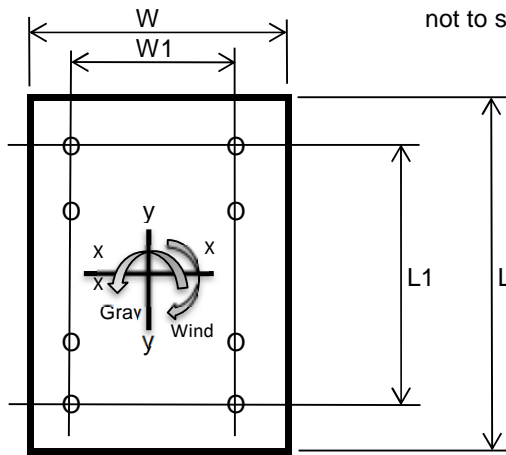
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	3820	5582	-	lbs
Shear (Wind)	5429	3263	-	lbs
Torsion (Arm Rise)	21335	12823	-	ft-lbs
Moment (Gravity)	131918	208497	-	ft-lbs
Moment (Wind)	270460	153339	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	19.00	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)	2.75
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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	979.65	979.65	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1763.77	1763.77	in ⁴
Bolt Tensile Stress - ft	30.62	34.49	ksi
Bolt Shear Stress - fv	2.45	1.7	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Fv =	44.22	44.22	ksi
Allowable Shear Stress = Ft =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.71	0.79	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	13.18	20.83	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	27.46	15.57	ksi
Combined applied stress for interaction (SRSS)	30.46	26.01	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-7 - VA - 80 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

Fatigue Allowable - Shaft to Baseplate Weld & 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	0.3125	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	1.70	
Ki - Fatigue stress concentration factor for infinite life	3.36	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-2-7 - VA - 80 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)	20.07	in
Shaft Thickness	0.375	in
Total Area	27.9058	in ²
Ix	1226	in ⁴
Iy	1349	in ⁴
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-2-7 - VA - 80 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

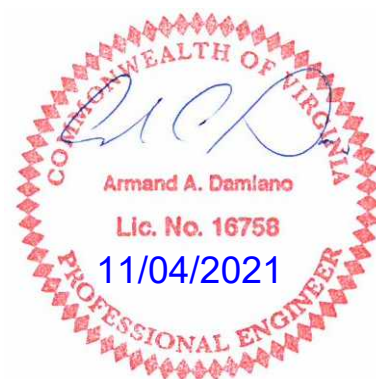
Upper Hand Hole Stresses

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)	17.98	in
Shaft Thickness	0.375	in
Total Area	22.7877	in ²
Ix	818	in ⁴
Iy	884	in ⁴
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-2-7 - VA - 80 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	3820		3820	131918		131918		417	18479		0.51
Gp II	3820	5429	6638	131918	270460	300918	21335	724	42151	1495	0.89
Gp III	5582	3263	6466	208497	153339	258813	12823	706	36254	899	0.76
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	2219		2219	51010		51010		418	14934		0.42
Gp II	2219	4627	5132	51010	133486	142901	18183	967	41836	2662	0.91
Gp III	3518	2621	4387	86051	73427	113121	10300	827	33118	1508	0.71
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		-



16362-2-7 - VA - 80 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)						

Shaft Base											
Gp I	6211		131918	0	131918		262		13277		0.38
Gp II	6211	6976	119051	183867	219044	271930	262	589	22046	13685	0.82
Gp III	8609	4323	71552	240008	250447	154074	363	365	25207	7754	0.65
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9971										

Shaft At Arm											
Gp I	4685		131918	0	131918		226		17351		0.49
Gp II	4685	5948	21335	139672	141292	271930	226	574	18583	17883	0.98
Gp III	6541	3586	12823	212597	212983	154074	316	347	28013	10132	0.78
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9971										



16362-2-7 - VA - 80 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	6976 lbs
Bending Moment	250447 ft-lbs
Torsion Moment	271930 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

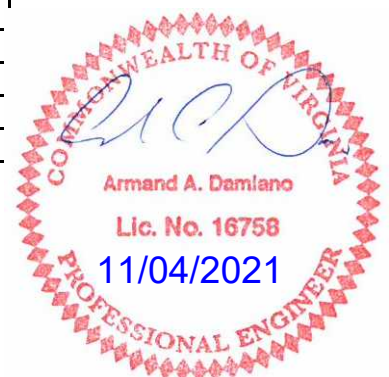
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	23.064 ksi
Bolt Direct Shear Stress	0.38 ksi
Bolt Torsion Shear Stress	13.642 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	23.064 ksi
$f_v =$	14.022 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.9 CSR
Therefore	OK

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	159 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	24.02 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

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	69 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	10.94 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-7 - VA - 80 MPH - MP-3 Std. Loads - Type E2 - 75' Arm w/24' Lum.

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	0 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	OK

ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation

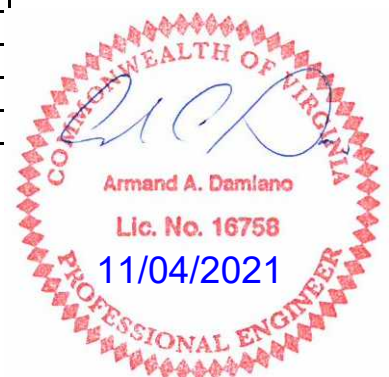
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A _b = Net Bearing Area	4.528 in ²
D _w = 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	57660 lbs
Computed Factor-of Safety	1.07 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	57660 lbs
Total Tensile Load	461280 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.02 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	57660 lbs
Total Tensile Load	461280 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	10 Qty.



MAST ARM POLE ANALYSIS TO AASHTO

16362-2-8 - VA - 80 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

11/04/21

General

Wind Vel. - mph	80	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		AASHTO Editon	6TH	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	19.00	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	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	0.2760		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	14.25	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	0.35	0.46	0.49	0.41	0.43	0.34					28.19	19.26
GP II CSR	0.88	0.99	0.86	0.79	0.81	0.72	0.93					
GP III CSR	0.70	0.79	0.74	0.66	0.67	0.57	0.70				46.24	32.27

Arm #1 Flange Bolt (Max.) CSR	0.58
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.74
Arm #2 Flange Bolt (Max.) CSR	0.41
Arm #2 Flange Bolt Fatigue CSR	0.00
Arm #2 Flange Plate (Max.) CSR	0.58
Handhole at Root (Fatigue) CSR	0.00
Handhole at Toe (Fatigue) CSR	0.00
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	0.80	
Anchor Bolt Max. Fatigue Stress Ratio	0.00	
Base Plate Max. CSR	0.92	
Anchorage Capacity S.F.	1.13	
Concrete Pull Out Capacity S.F.	1.07	

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
10373	6401	237529	224115



16362-2-8 - VA - 80 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										



16362-2-8 - VA - 80 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	19.000	18.852	78.74	0.5287	0.53	1.670	16.24	0.80
2	I	1.06	1.06	18.852	18.704	78.11	0.5287	1.59	1.657	16.11	0.80
3	I	1.06	2.12	18.704	18.555	77.48	0.5287	2.65	1.644	15.99	0.80
4	I	1.06	3.18	18.555	18.407	76.85	0.5287	3.71	1.631	15.87	0.80
5	I	1.06	4.24	18.407	18.259	76.22	0.5287	4.76	1.618	15.74	0.80
6	I	1.06	5.29	18.259	18.111	75.59	0.5287	5.82	1.605	15.62	0.80
7	I	1.06	6.35	18.111	17.962	74.97	0.5287	6.88	1.591	15.50	0.80
8	I	1.06	7.41	17.962	17.814	74.34	0.5287	7.94	1.578	15.37	0.80
9	I	1.06	8.47	17.814	17.666	73.71	0.5287	9.00	1.565	15.25	0.80
10	I	1.06	9.53	17.666	17.518	73.08	0.5287	10.06	1.552	15.13	0.80
11	I	1.06	10.59	17.518	17.369	72.45	0.5287	11.12	1.539	15.00	0.80
12	I	1.06	11.65	17.369	17.221	71.82	0.5287	12.18	1.526	14.88	0.80
13	I	1.06	12.71	17.221	17.073	71.19	0.5286	13.23	1.513	14.76	1.00
14	I	1.06	13.76	17.073	16.925	70.56	0.5286	14.29	1.500	14.63	1.00
15	I	1.06	14.82	16.925	16.776	69.93	0.5286	15.35	1.487	14.51	1.00
16	I	1.06	15.88	16.776	16.628	69.30	0.5286	16.41	1.474	14.39	1.00
17	I	1.06	16.94	16.628	16.480	68.67	0.5286	17.47	1.461	14.27	1.00
18	J	3.00	18.00	16.480	16.060	191.16	1.4935	19.49	4.068	39.75	1.00
19	I	3.00	21.00	16.060	15.640	186.11	1.4934	22.49	3.963	38.76	1.00
20	J	1.00	24.00	15.640	15.500	60.91	0.4993	24.50	1.298	12.70	1.00
						1692					

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)	950.95	614.83	614.83	509.28
Section Modulus (in ³)	102.12	76.35	76.35	
Cross-Section Area (in ²)	21.93	18.96	18.96	
Width-Thickness Ratio	50.67	43.95	43.95	
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)	13.388	13.388	13.388	
Allow. Shear Stress (ksi)	18.150	18.150	18.150	

Shaft Deflection From Arm#1 GP I Load (in)	0.999
Shaft Deflection From Arm#2 GP I Load (in)	0.690



16362-2-8 - VA - 80 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

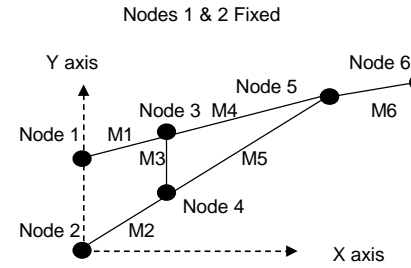
Shaft Analysis Continued

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	9.97	16.65	0.000	20.87	1.100	0.000	0.00
2	0.450	9.97	16.52	0.000	20.71	1.100	0.000	0.00
3	0.450	9.97	16.39	0.000	20.55	1.100	0.000	0.00
4	0.450	9.97	16.26	0.000	20.38	1.100	0.000	0.00
5	0.450	9.97	16.13	0.000	20.22	1.100	0.000	0.00
6	0.450	9.97	16.00	0.000	20.06	1.100	0.000	0.00
7	0.450	9.97	15.87	0.001	19.89	1.100	0.000	0.00
8	0.450	9.97	15.74	0.001	19.73	1.100	0.000	0.00
9	0.450	9.97	15.61	0.001	19.57	1.100	0.000	0.00
10	0.450	9.97	15.48	0.001	19.40	1.100	0.000	0.00
11	0.450	9.97	15.35	0.001	19.24	1.100	0.000	0.00
12	0.450	9.97	15.21	0.002	19.08	1.100	0.000	0.00
13	0.450	12.47	18.87	0.002	18.91	1.100	0.000	0.00
14	0.450	12.47	18.70	0.003	18.75	1.100	0.000	0.00
15	0.450	12.47	18.54	0.003	18.59	1.100	0.000	0.00
16	0.450	12.47	18.38	0.003	18.42	1.100	0.000	0.00
17	0.450	12.47	18.21	0.004	18.26	1.100	0.000	0.00
18	0.450	12.47	50.72	0.013	50.84	1.100	0.000	0.00
19	0.450	12.47	49.41	0.016	49.53	1.100	0.000	0.00
20	0.450	12.47	16.18	0.006	16.22	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.005	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.005	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.072	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-8 - VA - 80 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)
80									
Node #1	0	27	0	0	-33.67	-32.1	0	0	0
Node #2	0	0	0	0	-35.63	-33.9	0	0	0
Node #3	100	59.5	0	0	-66.63	-67	0	0	0
Node #4	100	48.8	0	0	-69.41	-69.7	0	0	0
Node #5	200	79	0	0	-94.35	-98.8	0	0	0
Node #6	288	87	0	0	-85.29	-90.6	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	0.276	105.15	2.10	2.258	-67.33	1.1	1	-64.05	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-71.25	1.1	1	-67.78	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.54	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-65.23	1.1	1.1	-68.27	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-66.89	1.1	1.1	-70.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-56.58	1.1	1.1	-59.21	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-60.92					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2180.2	lbs
P1y	-694.6	lbs
P1z	233.5	lbs
M1x	8700.6	in-lbs
M1y	-32862.2	in-lbs
M1z	-898.1	in-lbs
P2x	2180.2	lbs
P2y	1079.6	lbs
P2z	158.6	lbs
M2x	8937.3	in-lbs
M2y	-26660.6	in-lbs
M2z	-928.7	in-lbs

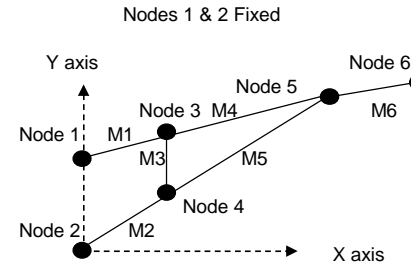
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1018	180	25256	-641	0.73
#2	1071	112	20749	-1246	0.93
#3	1489	513	10104	-511	0.39
#4	-1001	81	9678	-29	0.26
#5	1020	95	10774	-376	0.58
#6	4	110	8163	1	0.25

V09.19.15



16362-2-8 - VA - 80 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)
80									
Node #1	0	27	0	0	-40.85	-16.1	0	0	0
Node #2	0	0	0	0	-43.23	-17	0	0	0
Node #3	100	59.5	0	0	-81.04	-33.5	0	0	0
Node #4	100	48.8	0	0	-84.42	-34.9	0	0	0
Node #5	200	79	0	0	-114.49	-49.4	0	0	0
Node #6	288	87	0	0	-115.33	-45.3	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	0.276	105.15	2.10	2.258	-81.69	1.1	1	-32.03	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-86.45	1.1	1	-33.89	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.77	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-79.16	1.1	1.1	-34.13	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-81.16	1.1	1.1	-35.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-68.65	1.1	1.1	-29.60	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-30.46					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2797.7	lbs
P1y	-898.7	lbs
P1z	116.8	lbs
M1x	4351.1	in-lbs
M1y	-16433.7	in-lbs
M1z	-1426.8	in-lbs
P2x	2797.7	lbs
P2y	1378.1	lbs
P2z	79.4	lbs
M2x	4469.6	in-lbs
M2y	-13332.7	in-lbs
M2z	-1452.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1307	93	12670	-321	0.34
#2	1373	61	10427	-623	0.7
#3	1905	462	9337	-256	0.39
#4	-1287	51	4933	-15	0.11
#5	1311	56	5469	-188	0.49
#6	5	110	8115	1	0.25

V09.19.15



16362-2-8 - VA - 80 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	167.1	1.8308	1.83	5.288	5.288	51.57
2	I	3.68	3.68	16.985	16.470	162.1	1.8306	5.51	5.130	5.130	50.08
3	I	3.68	7.36	16.470	15.954	157.0	1.8303	9.19	4.972	4.972	48.59
4	I	3.68	11.04	15.954	15.439	151.9	1.8299	12.87	4.814	4.814	47.10
5	I	3.68	14.72	15.439	14.924	146.8	1.8296	16.55	4.656	4.656	45.61
6	I	3.68	18.40	14.924	14.409	141.8	1.8292	20.23	4.498	4.498	44.12
7	J	2.92	22.08	14.790	14.381	193.4	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>2119</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)	58.397	31.467
Cross-Section Area (in^2)	13.541	8.620
Width-Thickness Ratio	70.00	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)	35.991	34.389
Allow. Shear Stress (ksi)	18.150	17.040



16362-2-8 - VA - 80 MPH - MP-3 Std. Loads - Type F - 70'/60' 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	12.47	65.94	66.10	1.100	0.000	0.00	0	0.484	0.00	0.00	
2	1.00	0.450	12.47	63.97	64.12	1.100	0.000	0.00	0	0.503	0.00	0.00	
3	1.00	0.450	12.47	62.00	62.15	1.100	0.000	0.00	0	0.524	0.00	0.00	
4	1.00	0.450	12.47	60.03	60.17	1.100	0.000	0.00	0	0.546	0.00	0.00	
5	1.00	0.450	12.47	58.06	58.20	1.100	0.000	0.00	0	0.571	0.00	0.00	
6	1.00	0.450	12.47	56.09	56.22	1.100	0.000	0.00	0	0.597	0.00	0.00	
7	1.00	0.450	12.47	44.26	44.36	1.100	0.000	0.00	0	0.601	0.00	0.00	
8	1.00	0.450	12.47	50.86	50.98	1.100	0.000	0.00	0	0.626	0.00	0.00	
9	1.00	0.450	12.47	49.12	49.23	1.100	0.000	0.00	0	0.655	0.00	0.00	
10	1.00	0.450	12.47	47.37	47.49	1.100	0.000	0.00	0	0.686	0.00	0.00	
11	1.00	0.450	12.47	45.63	45.74	1.100	0.000	0.00	0	0.721	0.00	0.00	
12	1.00	0.450	12.47	43.89	43.99	1.100	0.000	0.00	0	0.758	0.00	0.00	
13	1.00	0.450	12.47	42.14	42.24	1.100	0.000	0.00	0	0.799	0.00	0.00	
14	1.00	0.450	12.47	40.40	40.50	1.100	0.000	0.00	0	0.844	0.00	0.00	
15	1.00	0.450	12.47	38.66	38.75	1.100	0.000	0.00	0	0.894	0.00	0.00	
16	1.00	0.450	12.47	36.91	37.00	1.100	0.000	0.00	0	0.949	0.00	0.00	
17	1.00	0.450	12.47	35.17	35.25	1.100	0.000	0.00	1	1.011	0.00	0.00	
18	1.00	0.468	12.97	34.77	33.51	1.100	0.000	0.00	1	1.080	0.00	0.00	
19	1.00	0.502	13.9	35.32	31.76	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.540	14.96	35.92	30.01	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	0.000	0.00	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	33.23	365.53	182.77	1.200	0.000	0.00	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

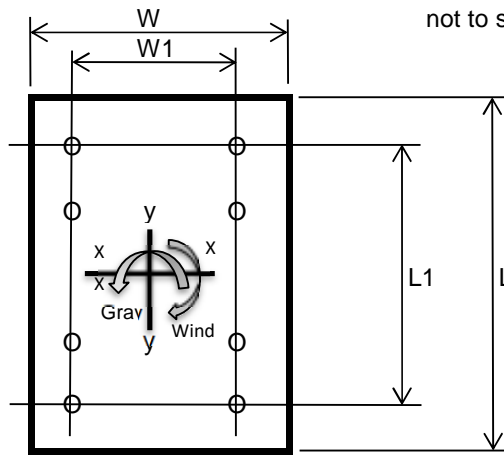
Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2748	4188	-	lbs
Shear (Wind)	5024	2977	-	lbs
Torsion (Arm Rise)	18428	10918	-	ft-lbs
Moment (Gravity)	85096	136462	-	ft-lbs
Moment (Wind)	177343	102775	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs

Diameter of tube	17.50	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 GpII	Results GpIII	
Bolt Tensile Stress Area	1.41	1.41	in ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	22.14	25.15	ksi
Bolt Shear Stress - fv	2.27	1.52	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	0.58	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis

Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	13.77	22.08	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	29.19	16.92	ksi
Combined applied stress for interaction (SRSS)	32.27	27.82	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-8 - VA - 80 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



16362-2-8 - VA - 80 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	12.47	47.92	48.03	1.100	0.000	0.00	0	0.562	0.00	0.00	
2	1.00	0.450	12.47	46.61	46.72	1.100	0.000	0.00	0	0.582	0.00	0.00	
3	1.00	0.450	12.47	45.30	45.41	1.100	0.000	0.00	0	0.604	0.00	0.00	
4	1.00	0.450	12.47	43.99	44.09	1.100	0.000	0.00	0	0.628	0.00	0.00	
5	1.00	0.450	12.47	42.68	42.78	1.100	0.000	0.00	0	0.653	0.00	0.00	
6	1.00	0.450	12.47	41.37	41.47	1.100	0.000	0.00	0	0.680	0.00	0.00	
7	1.00	0.450	12.47	40.06	40.16	1.100	0.000	0.00	0	0.709	0.00	0.00	
8	1.00	0.450	12.47	35.81	35.90	1.100	0.000	0.00	0	0.711	0.00	0.00	
9	1.00	0.450	12.47	39.03	39.12	1.100	0.000	0.00	0	0.741	0.00	0.00	
10	1.00	0.450	12.47	37.69	37.79	1.100	0.000	0.00	0	0.776	0.00	0.00	
11	1.00	0.450	12.47	36.36	36.45	1.100	0.000	0.00	0	0.813	0.00	0.00	
12	1.00	0.450	12.47	35.03	35.11	1.100	0.000	0.00	0	0.853	0.00	0.00	
13	1.00	0.450	12.47	33.70	33.78	1.100	0.000	0.00	0	0.897	0.00	0.00	
14	1.00	0.450	12.47	32.37	32.44	1.100	0.000	0.00	0	0.946	0.00	0.00	
15	1.00	0.450	12.47	31.03	31.11	1.100	0.000	0.00	0	0.999	0.00	0.00	
16	1.00	0.458	12.69	30.23	29.77	1.100	0.000	0.00	1	1.057	0.00	0.00	
17	1.00	0.486	13.47	30.65	28.44	1.100	0.000	0.00	1	1.100	0.00	0.00	
18	1.00	0.518	14.34	31.09	27.10	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.553	15.31	31.56	25.77	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.593	16.41	32.08	24.43	1.100	0.000	0.00	1	1.100	0.00	0.00	
Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	0.000	0.00	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	365.53	182.77	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



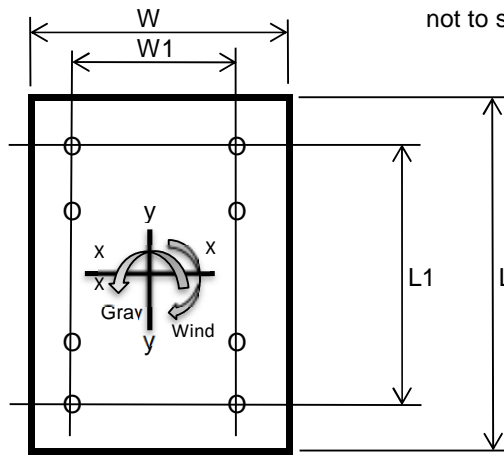
Flange Analysis - Arm #2

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2161	3337	-	lbs
Shear (Wind)	4297	2502	-	lbs
Torsion (Arm Rise)	13512	7868	-	ft-lbs
Moment (Gravity)	58769	96007	-	ft-lbs
Moment (Wind)	134647	76437	-	ft-lbs
Nat. Wind Moment	-	-	-	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	16.18	17.85	ksi
Bolt Shear Stress - fv	1.72	1.15	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.38	0.41	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	9.97	16.28	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	23.22	13.19	ksi
Combined applied stress for interaction (SRSS)	25.27	20.95	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-8 - VA - 80 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

Fatigue Allowable - Shaft to Baseplate Weld & 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	19.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.368421	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.75	
Kf - Fatigue stress concentration factor for finite life	2.58	
Ki - Fatigue stress concentration factor for infinite life	6.07	
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	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	1.76	
Ki - Fatigue stress concentration factor for infinite life	3.33	
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



16362-2-8 - VA - 80 MPH - MP-3 Std. Loads - Type F - 70/60' Arms w/24' Lum.

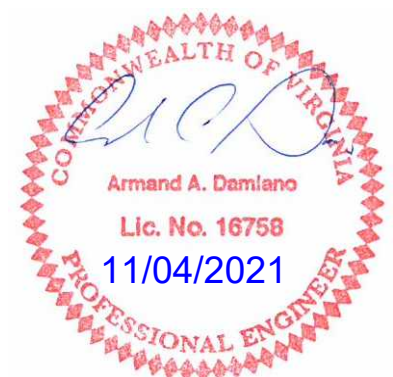
Lower Hand Hole Stresses

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)	18.57	in
Shaft Thickness	0.375	in
Total Area	26.1281	in ²
Ix	988	in ⁴
Iy	1065	in ⁴
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-2-8 - VA - 80 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)	16.48	in
Shaft Thickness	0.375	in
Total Area	21.0186	in ²
Ix	630	in ⁴
Iy	677	in ⁴
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-2-8 - VA - 80 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)					

Arm#1 Base											
Gp I	2748		2748	85096		85097		406	17487		0.49
Gp II	2748	5024	5727	85096	177343	196703	18428	846	40421	1894	0.86
Gp III	4188	2977	5139	136462	102775	170836	10918	760	35106	1122	0.74
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	1710		1710	36287		36287		397	13839		0.41
Gp II	1710	3372	3782	36287	83811	91330	12370	878	34829	2359	0.79
Gp III	2742	1967	3375	60410	47848	77064	7214	784	29389	1376	0.66
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	2161		2161	58769		58770		360	15292		0.43
Gp II	2161	4297	4811	58769	134647	146914	13512	800	38226	1758	0.81
Gp III	3337	2502	4171	96007	76437	122720	7868	694	31931	1024	0.67
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	1273		1273	22969		22969		353	11914		0.34
Gp II	1273	2704	2989	22969	58957	63273	8501	829	32820	2205	0.72
Gp III	2084	1551	2598	39262	32847	51190	4876	720	26552	1265	0.57
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		-



16362-2-8 - VA - 80 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	7150		85096	58769	103418		326		12153		0.35
Gp II	7150	6401	128743	182381	223243	224115	326	584	26234	13168	0.88
Gp III	10373	3914	139163	192493	237529	128810	473	357	27913	7568	0.70
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9955										

Shaft At Arm											
Gp I	5732		85096	58769	103418		302		16254		0.46
Gp II	5732	5532	71571	102532	125041	224115	302	584	19652	17612	0.99
Gp III	8442	3289	103592	146184	179168	128810	445	347	28159	10122	0.79
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9955										



16362-2-8 - VA - 80 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	6401 lbs
Bending Moment	237529 ft-lbs
Torsion Moment	224115 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	19.00 in

ANALYSIS - ANCHOR BOLTS

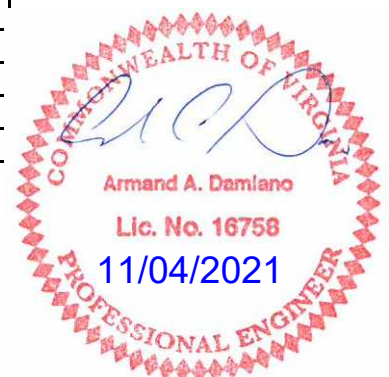
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	21.875 ksi
Bolt Direct Shear Stress	0.348 ksi
Bolt Torsion Shear Stress	11.244 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	21.875 ksi
$f_v =$	11.592 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.8 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.5 in
Design Moment	192 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	29.01 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.938 in
Design Moment	106 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	16.8 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-8 - VA - 80 MPH - MP-3 Std. Loads - Type F - 70'/60' Arms w/24' Lum.

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	0 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	OK

ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation

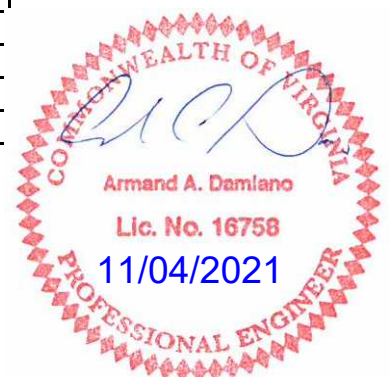
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A _b = Net Bearing Area	4.528 in ²
D _w = 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	54688 lbs
Computed Factor-of Safety	1.13 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	54688 lbs
Total Tensile Load	437504 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.07 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	54688 lbs
Total Tensile Load	437504 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	10 Qty.



MAST ARM POLE ANALYSIS TO AASHTO

16362-2-9 - VA - 80 MPH - MP-3 Std. Loads - Type A - 30' Arm

11/04/21

General

Wind Vel. - mph	80	No	Roadway - mph	55	Fatigue Importance Factors	
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		AASHTO Editon	6TH	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	0.2500	0.14	16.00	19.50	-	-	-	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	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	11.50	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	0.11	0.15	0.25								3.76	0.00
GP II CSR	0.43	0.23	0.60									
GP III CSR	0.28	0.23	0.45								6.69	

Arm #1 Flange Bolt (Max.) CSR	0.14
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.27
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	3

Fatigue Allowable - Shaft to Baseplate	
Fatigue Allowable - Arm#1 to Flange	
Fatigue Allowable - Arm#2 to Flange	
Anchor Bolt Max. CSR	0.31
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.35
Anchorage Capacity S.F.	2.72
Concrete Pull Out Capacity S.F.	3.12

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
2882	3720	70408	44208



16362-2-9 - VA - 80 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										
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	#17										
	#18										
	#19										
	#20										



16362-2-9 - VA - 80 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	16.000	15.852	44.36	0.5286	0.53	1.405	13.74	0.80
2	I	1.06	1.06	15.852	15.704	43.94	0.5286	1.59	1.392	13.62	0.80
3	I	1.06	2.12	15.704	15.555	43.52	0.5286	2.65	1.379	13.50	0.80
4	I	1.06	3.18	15.555	15.407	43.10	0.5286	3.71	1.366	13.37	0.80
5	I	1.06	4.24	15.407	15.259	42.68	0.5286	4.76	1.353	13.25	0.80
6	I	1.06	5.29	15.259	15.111	42.26	0.5286	5.82	1.340	13.13	0.80
7	I	1.06	6.35	15.111	14.962	41.84	0.5285	6.88	1.327	13.00	0.80
8	I	1.06	7.41	14.962	14.814	41.42	0.5285	7.94	1.314	12.88	0.80
9	I	1.06	8.47	14.814	14.666	41.00	0.5285	9.00	1.301	12.76	0.80
10	I	1.06	9.53	14.666	14.518	40.58	0.5285	10.06	1.288	12.63	0.80
11	I	1.06	10.59	14.518	14.369	40.16	0.5285	11.12	1.274	12.51	0.80
12	I	1.06	11.65	14.369	14.221	39.74	0.5285	12.18	1.261	12.39	0.80
13	I	1.06	12.71	14.221	14.073	39.32	0.5285	13.23	1.248	12.26	1.00
14	I	1.06	13.76	14.073	13.925	38.91	0.5285	14.29	1.235	12.14	1.00
15	I	1.06	14.82	13.925	13.776	38.49	0.5285	15.35	1.222	12.02	1.00
16	I	1.06	15.88	13.776	13.628	38.07	0.5285	16.41	1.209	11.89	1.00
17	I	1.06	16.94	13.628	13.480	37.65	0.5284	17.47	1.196	11.77	1.00
18	J	0.50	18.00	13.480	13.410	17.63	0.2498	18.25	0.560	5.52	1.00
19	I	0.50	18.50	13.410	13.340	17.54	0.2498	18.75	0.557	5.49	1.00
20	I	0.50	19.00	13.340	13.270	17.44	0.2498	19.25	0.554	5.46	1.00
						750					

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)	383.37	227.23	0.00	216.58
Section Modulus (in^3)	48.68	34.35	0.00	
Cross-Section Area (in^2)	12.36	10.39	0.00	
Width-Thickness Ratio	64.00	53.92	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)	15.830	15.830	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.430
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-9 - VA - 80 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	9.97	14.01	0.000	17.57	1.100	0.000	0.00
2	0.450	9.97	13.88	0.000	17.40	1.100	0.000	0.00
3	0.450	9.97	13.75	0.000	17.24	1.100	0.000	0.00
4	0.450	9.97	13.62	0.000	17.07	1.100	0.000	0.00
5	0.450	9.97	13.49	0.000	16.91	1.100	0.000	0.00
6	0.450	9.97	13.36	0.001	16.75	1.100	0.000	0.00
7	0.450	9.97	13.23	0.001	16.58	1.100	0.000	0.00
8	0.450	9.97	13.10	0.001	16.42	1.100	0.000	0.00
9	0.450	9.97	12.97	0.001	16.26	1.100	0.000	0.00
10	0.450	9.97	12.84	0.002	16.09	1.100	0.000	0.00
11	0.450	9.97	12.71	0.002	15.93	1.100	0.000	0.00
12	0.450	9.97	12.58	0.002	15.77	1.100	0.000	0.00
13	0.450	12.47	15.57	0.004	15.60	1.100	0.000	0.00
14	0.450	12.47	15.40	0.004	15.44	1.100	0.000	0.00
15	0.450	12.47	15.24	0.005	15.28	1.100	0.000	0.00
16	0.450	12.47	15.08	0.005	15.11	1.100	0.000	0.00
17	0.450	12.47	14.91	0.006	14.95	1.100	0.000	0.00
18	0.450	12.47	6.99	0.003	7.00	1.100	0.000	0.00
19	0.450	12.47	6.95	0.003	6.97	1.100	0.000	0.00
20	0.450	12.47	6.91	0.003	6.93	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.010	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.010	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.131	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-9 - VA - 80 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



16362-2-9 - VA - 80 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)	Load (lbs)	
1	1.00	0.450	12.47	18.54	18.59	1.100	0.000	0.00	0	0.784	0.00	0.00	
2	1.00	0.450	12.47	18.21	18.26	1.100	0.000	0.00	0	0.802	0.00	0.00	
3	1.00	0.450	12.47	17.89	17.93	1.100	0.000	0.00	0	0.821	0.00	0.00	
4	1.00	0.450	12.47	17.56	17.60	1.100	0.000	0.00	0	0.841	0.00	0.00	
5	1.00	0.450	12.47	17.23	17.27	1.100	0.000	0.00	0	0.862	0.00	0.00	
6	1.00	0.450	12.47	16.90	16.95	1.100	0.000	0.00	0	0.884	0.00	0.00	
7	1.00	0.450	12.47	16.58	16.62	1.100	0.000	0.00	0	0.906	0.00	0.00	
8	1.00	0.450	12.47	16.25	16.29	1.100	0.000	0.00	0	0.930	0.00	0.00	
9	1.00	0.450	12.47	15.92	15.96	1.100	0.000	0.00	0	0.955	0.00	0.00	
10	1.00	0.450	12.47	15.60	15.63	1.100	0.000	0.00	0	0.981	0.00	0.00	
11	1.00	0.450	12.47	15.27	15.30	1.100	0.000	0.00	1	1.009	0.00	0.00	
12	1.00	0.450	12.45	14.92	14.98	1.100	0.000	0.00	1	1.037	0.00	0.00	
13	1.00	0.463	12.82	15.02	14.65	1.100	0.000	0.00	1	1.068	0.00	0.00	
14	1.00	0.477	13.2	15.12	14.32	1.100	0.000	0.00	1	1.100	0.00	0.00	
15	1.00	0.491	13.61	15.23	13.99	1.100	0.000	0.00	1	1.100	0.00	0.00	
16	1.00	0.507	14.03	15.34	13.66	1.100	0.000	0.00	1	1.100	0.00	0.00	
17	1.00	0.523	14.48	15.45	13.34	1.100	0.000	0.00	1	1.100	0.00	0.00	
18	1.00	0.540	14.96	15.57	13.01	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.558	15.46	15.68	12.68	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.578	16	15.81	12.35	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	33.21	996.30	498.15	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	365.53	182.77	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



16362-2-9 - VA - 80 MPH - MP-3 Std. Loads - Type A - 30' Arm

Flange Analysis - Arm #1

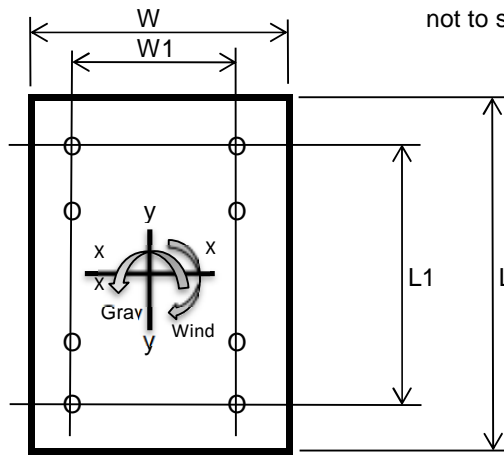
V06-21-16

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	925	1572	-	lbs
Shear (Wind)	2807	1551	-	lbs
Torsion (Arm Rise)	4413	2438	-	ft-lbs
Moment (Gravity)	14359	25276	-	ft-lbs
Moment (Wind)	44208	24066	-	ft-lbs
Nat. Wind Moment	-	-	-	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	596.99	596.99	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1073.57	1073.57	in ⁴
Bolt Tensile Stress - ft	5.58	5.61	ksi
Bolt Shear Stress - fv	0.75	0.48	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.14	0.13	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	3.63	6.38	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	11.35	6.18	ksi
Combined applied stress for interaction (SRSS)	11.92	8.88	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-9 - VA - 80 MPH - MP-3 Std. Loads - Type A - 30' 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	925		925	14359		14360		278	8762		0.25
Gp II	925	2807	2956	14359	44208	46482	4413	889	28362	1347	0.60
Gp III	1572	1551	2208	25276	24066	34901	2438	664	21296	744	0.45
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		-



16362-2-9 - VA - 80 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	1840		14359	0	14359		149		3539		0.11
Gp II	1840	3720	25347	65687	70408	44208	149	602	17355	5449	0.43
Gp III	2882	2183	30354	38252	48832	24066	233	354	12037	2966	0.28
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9976										

Shaft At Arm											
Gp I	978		14359	0	14359		94		5016		0.15
Gp II	978	2828	4413	14375	15037	44208	94	545	5253	7722	0.23
Gp III	1624	1572	2438	25292	25409	24066	156	303	8877	4204	0.23
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9976										



16362-2-9 - VA - 80 MPH - MP-3 Std. Loads - Type A - 30' Arm

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	3720 lbs
Bending Moment	70408 ft-lbs
Torsion Moment	44208 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	16.00 in

ANALYSIS - ANCHOR BOLTS

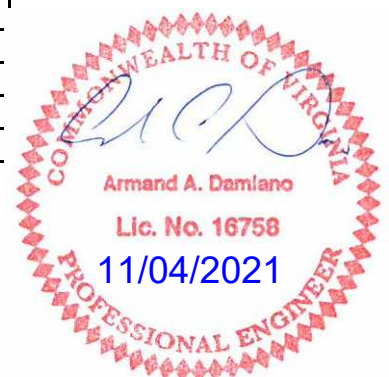
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1082.98 in ⁴
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	9.362 ksi
Bolt Direct Shear Stress	0.27 ksi
Bolt Torsion Shear Stress	3.204 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	9.362 ksi
$f_v =$	3.474 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.31 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	12.701 in
Dist. Shaft Face To Bolt Center	4 in
Design Moment	94 in-kip
Section Modulus of Failure Plane	8.46 in ³
Applied Plate Stress	11.12 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	12.052 in
Dist From Shaft To Nut Face	2.438 in
Design Moment	58 in-kip
Section Modulus of Failure Plane	8.03 in ³
Applied Plate Stress	7.23 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-9 - VA - 80 MPH - MP-3 Std. Loads - Type A - 30' Arm

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

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

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	23405 lbs
Computed Factor-of Safety	2.72 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	23405 lbs
Total Tensile Load	140430 lbs
Concrete Failure Surface Area	4002.39 in ²
Concrete Shear Strength	438440 psi
Computed Factor-of Safety	3.12 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	23405 lbs
Total Tensile Load	140430 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	3 Qty.



MAST ARM POLE ANALYSIS TO AASHTO

16362-2-10 - VA - 80 MPH - MP-3 Std. Loads - Type A - 40' Arm

11/04/21

General

Wind Vel. - mph	80	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		AASHTO Editon	6TH	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	16.00	19.50	-	-	-	0	55	29000	29000	-
Traffic Arm #1	0.1793	0.14	12.00	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	11.50	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	0.16	0.22	0.38								9.89	0.00
GP II CSR	0.57	0.43	0.90									
GP III CSR	0.38	0.37	0.68								17.51	

Arm #1 Flange Bolt (Max.) CSR	0.20
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.41
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	0.39
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.42
Anchorage Capacity S.F.	2.31
Concrete Pull Out Capacity S.F.	2.64

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
3218	4126	83012	66134



16362-2-10 - VA - 80 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	4 Section Head w/BP	36			3	3.5	1	10.5	26.7	1.13
	#9			39	11	5			1	34	80
	#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										



16362-2-10 - VA - 80 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	16.000	15.852	44.36	0.5286	0.53	1.405	13.74	0.80
2	I	1.06	1.06	15.852	15.704	43.94	0.5286	1.59	1.392	13.62	0.80
3	I	1.06	2.12	15.704	15.555	43.52	0.5286	2.65	1.379	13.50	0.80
4	I	1.06	3.18	15.555	15.407	43.10	0.5286	3.71	1.366	13.37	0.80
5	I	1.06	4.24	15.407	15.259	42.68	0.5286	4.76	1.353	13.25	0.80
6	I	1.06	5.29	15.259	15.111	42.26	0.5286	5.82	1.340	13.13	0.80
7	I	1.06	6.35	15.111	14.962	41.84	0.5285	6.88	1.327	13.00	0.80
8	I	1.06	7.41	14.962	14.814	41.42	0.5285	7.94	1.314	12.88	0.80
9	I	1.06	8.47	14.814	14.666	41.00	0.5285	9.00	1.301	12.76	0.80
10	I	1.06	9.53	14.666	14.518	40.58	0.5285	10.06	1.288	12.63	0.80
11	I	1.06	10.59	14.518	14.369	40.16	0.5285	11.12	1.274	12.51	0.80
12	I	1.06	11.65	14.369	14.221	39.74	0.5285	12.18	1.261	12.39	0.80
13	I	1.06	12.71	14.221	14.073	39.32	0.5285	13.23	1.248	12.26	1.00
14	I	1.06	13.76	14.073	13.925	38.91	0.5285	14.29	1.235	12.14	1.00
15	I	1.06	14.82	13.925	13.776	38.49	0.5285	15.35	1.222	12.02	1.00
16	I	1.06	15.88	13.776	13.628	38.07	0.5285	16.41	1.209	11.89	1.00
17	I	1.06	16.94	13.628	13.480	37.65	0.5284	17.47	1.196	11.77	1.00
18	J	0.50	18.00	13.480	13.410	17.63	0.2498	18.25	0.560	5.52	1.00
19	I	0.50	18.50	13.410	13.340	17.54	0.2498	18.75	0.557	5.49	1.00
20	I	0.50	19.00	13.340	13.270	17.44	0.2498	19.25	0.554	5.46	1.00
						750					

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)	383.37	227.23	0.00	216.58
Section Modulus (in^3)	48.68	34.35	0.00	
Cross-Section Area (in^2)	12.36	10.39	0.00	
Width-Thickness Ratio	64.00	53.92	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)	15.830	15.830	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.670
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-10 - VA - 80 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	9.97	14.01	0.000	17.57	1.100	0.000	0.00
2	0.450	9.97	13.88	0.000	17.40	1.100	0.000	0.00
3	0.450	9.97	13.75	0.000	17.24	1.100	0.000	0.00
4	0.450	9.97	13.62	0.000	17.07	1.100	0.000	0.00
5	0.450	9.97	13.49	0.000	16.91	1.100	0.000	0.00
6	0.450	9.97	13.36	0.001	16.75	1.100	0.000	0.00
7	0.450	9.97	13.23	0.001	16.58	1.100	0.000	0.00
8	0.450	9.97	13.10	0.001	16.42	1.100	0.000	0.00
9	0.450	9.97	12.97	0.001	16.26	1.100	0.000	0.00
10	0.450	9.97	12.84	0.002	16.09	1.100	0.000	0.00
11	0.450	9.97	12.71	0.002	15.93	1.100	0.000	0.00
12	0.450	9.97	12.58	0.002	15.77	1.100	0.000	0.00
13	0.450	12.47	15.57	0.004	15.60	1.100	0.000	0.00
14	0.450	12.47	15.40	0.004	15.44	1.100	0.000	0.00
15	0.450	12.47	15.24	0.005	15.28	1.100	0.000	0.00
16	0.450	12.47	15.08	0.005	15.11	1.100	0.000	0.00
17	0.450	12.47	14.91	0.006	14.95	1.100	0.000	0.00
18	0.450	12.47	6.99	0.003	7.00	1.100	0.000	0.00
19	0.450	12.47	6.95	0.003	6.97	1.100	0.000	0.00
20	0.450	12.47	6.91	0.003	6.93	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.010	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.010	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.131	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-10 - VA - 80 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	12.000	11.720	44.8	0.9961	1.00	1.977	1.977	19.57
2	I	2.00	2.00	11.720	11.440	43.7	0.9960	3.00	1.930	1.930	19.13
3	I	2.00	4.00	11.440	11.160	42.6	0.9959	5.00	1.883	1.883	18.69
4	I	2.00	6.00	11.160	10.880	41.6	0.9958	7.00	1.837	1.837	18.25
5	I	2.00	8.00	10.880	10.600	40.5	0.9957	9.00	1.790	1.790	17.81
6	I	2.00	10.00	10.600	10.320	39.4	0.9955	11.00	1.743	1.743	17.37
7	I	2.00	12.00	10.320	10.040	38.3	0.9954	13.00	1.697	1.697	16.93
8	I	2.00	14.00	10.040	9.760	37.3	0.9953	15.00	1.650	1.650	16.49
9	I	2.00	16.00	9.760	9.480	36.2	0.9951	17.00	1.603	1.603	16.05
10	I	2.00	18.00	9.480	9.200	35.1	0.9950	19.00	1.557	1.557	15.61
11	I	2.00	20.00	9.200	8.920	34.0	0.9948	20.99	1.510	1.510	15.17
12	I	2.00	22.00	8.920	8.640	33.0	0.9947	22.99	1.463	1.463	14.73
13	I	2.00	24.00	8.640	8.360	31.9	0.9945	24.99	1.417	1.417	14.29
14	I	2.00	26.00	8.360	8.080	30.8	0.9943	26.99	1.370	1.370	13.85
15	I	2.00	28.00	8.080	7.800	29.8	0.9941	28.99	1.323	1.323	13.41
16	I	2.00	30.00	7.800	7.520	28.7	0.9939	30.99	1.277	1.277	12.97
17	I	2.00	32.00	7.520	7.240	27.6	0.9937	32.99	1.230	1.230	12.53
18	I	2.00	34.00	7.240	6.960	26.5	0.9934	34.99	1.183	1.183	12.10
19	I	2.00	36.00	6.960	6.680	25.5	0.9932	36.99	1.137	1.137	11.66
20	I	2.00	38.00	6.680	6.400	24.4	0.9929	38.99	1.090	1.090	11.22
		<u>40.00</u>				<u>692</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)	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



16362-2-10 - VA - 80 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	12.47	24.65	24.71	1.100	0.000	0.00	0	0.787	0.00	0.00	0.00
2	1.00	0.450	12.47	24.07	24.13	1.100	0.000	0.00	0	0.811	0.00	0.00	0.00
3	1.00	0.450	12.47	23.49	23.54	1.100	0.000	0.00	0	0.838	0.00	0.00	0.00
4	1.00	0.450	12.47	22.90	22.96	1.100	0.000	0.00	0	0.865	0.00	0.00	0.00
5	1.00	0.450	12.47	22.32	22.38	1.100	0.000	0.00	0	0.895	0.00	0.00	0.00
6	1.00	0.450	12.47	21.74	21.79	1.100	0.000	0.00	0	0.926	0.00	0.00	0.00
7	1.00	0.450	12.47	21.16	21.21	1.100	0.000	0.00	0	0.959	0.00	0.00	0.00
8	1.00	0.450	12.47	20.58	20.63	1.100	0.000	0.00	0	0.995	0.00	0.00	0.00
9	1.00	0.450	12.47	19.99	20.04	1.100	0.000	0.00	0	1.033	0.00	0.00	0.00
10	1.00	0.465	12.88	20.05	19.46	1.100	0.000	0.00	0	1.073	0.00	0.00	0.00
11	1.00	0.484	13.4	20.23	18.88	1.100	0.000	0.00	0	1.100	0.00	0.00	0.00
12	1.00	0.504	13.96	20.43	18.29	1.100	0.000	0.00	0	1.100	0.00	0.00	0.00
13	1.00	0.526	14.56	20.63	17.71	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
14	1.00	0.549	15.21	20.84	17.13	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
15	1.00	0.574	15.91	21.05	16.54	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
16	1.00	0.602	16.67	21.28	15.96	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
17	1.00	0.632	17.49	21.51	15.38	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
18	1.00	0.664	18.4	21.77	14.79	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
19	1.00	0.700	19.38	22.03	14.21	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00
20	1.00	0.739	20.47	22.31	13.63	1.100	0.000	0.00	1	1.100	0.00	0.00	0.00

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	33.21	996.30	498.15	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #5	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	365.53	182.77	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



16362-2-10 - VA - 80 MPH - MP-3 Std. Loads - Type A - 40' Arm
Flange Analysis - Arm #1

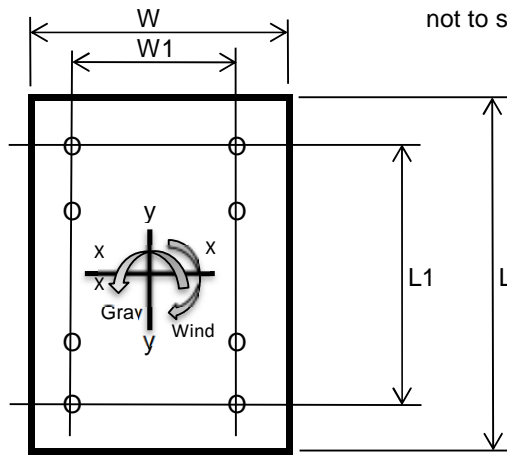
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Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1123	1908	-	lbs
Shear (Wind)	3205	1769	-	lbs
Torsion (Arm Rise)	6718	3709	-	ft-lbs
Moment (Gravity)	22366	39143	-	ft-lbs
Moment (Wind)	66134	35697	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	596.99	596.99	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1073.57	1073.57	in ⁴
Bolt Tensile Stress - ft	8.44	8.61	ksi
Bolt Shear Stress - fv	1.04	0.66	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.2	0.20	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	5.65	9.88	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	16.98	9.17	ksi
Combined applied stress for interaction (SRSS)	17.90	13.48	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-10 - VA - 80 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	1123		1123	22366		22366		338	13647		0.38
Gp II	1123	3205	3397	22366	66134	69814	6718	1021	42598	2050	0.90
Gp III	1908	1769	2602	39143	35697	52977	3709	782	32325	1132	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		-

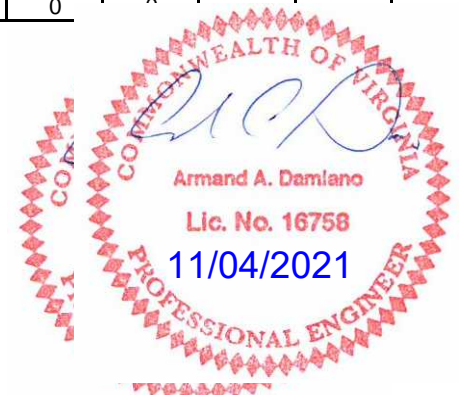
Arm#1 Joint											
Gp I	0		0	0		0		0	0		0.00
Gp II	0	0	0	0	0	0	0	0	0	0	0.00
Gp III	0	0	0	0	0	0	0	0	0	0	0.00
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

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		-



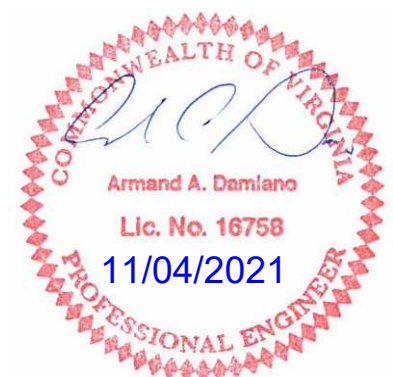
16362-2-10 - VA - 80 MPH - MP-3 Std. Loads - Type A - 40' Arm

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)						

Shaft Base											
Gp I	2037		22366	0	22366		165		5513		0.16
Gp II	2037	4126	35248	75157	83012	66134	165	668	20462	8151	0.57
Gp III	3218	2406	35558	53160	63956	35697	260	390	15765	4400	0.38
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9972										

Shaft At Arm											
Gp I	1175		22366	0	22366		113		7813		0.22
Gp II	1175	3226	6718	22381	23368	66134	113	622	8163	11552	0.43
Gp III	1960	1790	3709	39159	39334	35697	189	345	13741	6235	0.37
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9972										



16362-2-10 - VA - 80 MPH - MP-3 Std. Loads - Type A - 40' Arm

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	4126 lbs
Bending Moment	83012 ft-lbs
Torsion Moment	66134 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	16.00 in

ANALYSIS - ANCHOR BOLTS

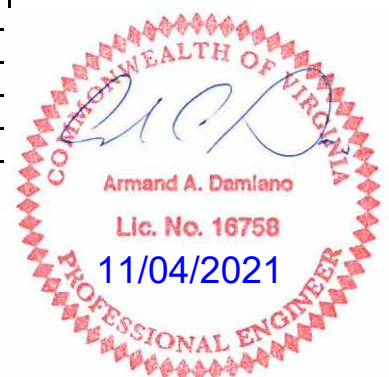
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1082.98 in ⁴
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	11.038 ksi
Bolt Direct Shear Stress	0.3 ksi
Bolt Torsion Shear Stress	4.793 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	11.038 ksi
$f_v =$	5.093 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.39 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	12.701 in
Dist. Shaft Face To Bolt Center	4 in
Design Moment	111 in-kip
Section Modulus of Failure Plane	8.46 in ³
Applied Plate Stress	13.13 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	12.052 in
Dist From Shaft To Nut Face	2.438 in
Design Moment	68 in-kip
Section Modulus of Failure Plane	8.03 in ³
Applied Plate Stress	8.47 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-10 - VA - 80 MPH - MP-3 Std. Loads - Type A - 40' Arm

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

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

ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation

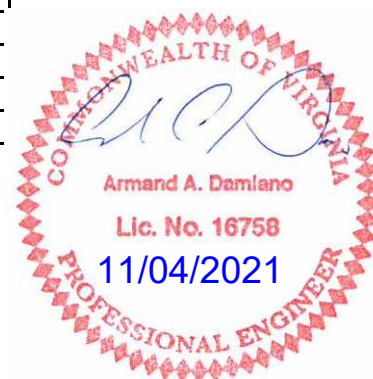
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	127540 lbs
T = Anchorage Tensile Capacity	
A _b = Net Bearing Area	4.528 in ²
D _w = 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	27595 lbs
Computed Factor-of Safety	2.31 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	27595 lbs
Total Tensile Load	165570 lbs
Concrete Failure Surface Area	4002.39 in ²
Concrete Shear Strength	438440 psi
Computed Factor-of Safety	2.64 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	27595 lbs
Total Tensile Load	165570 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

16362-2-11 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

11/04/21

General

Wind Vel. - mph	80	No	Roadway - mph	55	Fatigue Importance Factors	
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		AASHTO Editon	6TH	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	0.3125	0.14	19.50	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	14.25	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	0.23	0.29	0.43	0.34							19.71	0.00
GP II CSR	0.52	0.49	0.81	0.72								
GP III CSR	0.41	0.45	0.67	0.57							33.00	

Arm #1 Flange Bolt (Max.) CSR	0.41
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.58
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	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.46
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.46
Anchorage Capacity S.F.	2.1
Concrete Pull Out Capacity S.F.	2.00

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
5112	5303	127962	134647



16362-2-11 - VA - 80 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										



16362-2-11 - VA - 80 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	19.500	19.352	67.61	0.5287	0.53	1.714	16.65	0.80
2	I	1.06	1.06	19.352	19.204	67.08	0.5287	1.59	1.701	16.53	0.80
3	I	1.06	2.12	19.204	19.055	66.56	0.5287	2.65	1.688	16.41	0.80
4	I	1.06	3.18	19.055	18.907	66.03	0.5287	3.71	1.675	16.28	0.80
5	I	1.06	4.24	18.907	18.759	65.51	0.5287	4.76	1.662	16.16	0.80
6	I	1.06	5.29	18.759	18.611	64.99	0.5287	5.82	1.649	16.04	0.80
7	I	1.06	6.35	18.611	18.462	64.46	0.5287	6.88	1.636	15.91	0.80
8	I	1.06	7.41	18.462	18.314	63.94	0.5287	7.94	1.622	15.79	0.80
9	I	1.06	8.47	18.314	18.166	63.41	0.5287	9.00	1.609	15.67	0.80
10	I	1.06	9.53	18.166	18.018	62.89	0.5287	10.06	1.596	15.54	0.80
11	I	1.06	10.59	18.018	17.869	62.36	0.5287	11.12	1.583	15.42	0.80
12	I	1.06	11.65	17.869	17.721	61.84	0.5287	12.18	1.570	15.30	0.80
13	I	1.06	12.71	17.721	17.573	61.31	0.5287	13.23	1.557	15.17	1.00
14	I	1.06	13.76	17.573	17.425	60.79	0.5287	14.29	1.544	15.05	1.00
15	I	1.06	14.82	17.425	17.276	60.27	0.5287	15.35	1.531	14.93	1.00
16	I	1.06	15.88	17.276	17.128	59.74	0.5287	16.41	1.518	14.80	1.00
17	I	1.06	16.94	17.128	16.980	59.22	0.5286	17.47	1.505	14.68	1.00
18	J	0.50	18.00	16.980	16.910	27.78	0.2498	18.25	0.706	6.89	1.00
19	I	0.50	18.50	16.910	16.840	27.66	0.2498	18.75	0.703	6.86	1.00
20	I	0.50	19.00	16.840	16.770	27.55	0.2498	19.25	0.700	6.83	1.00
						1161					

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)	866.45	567.94	0.00	546.74
Section Modulus (in^3)	90.31	68.15	0.00	
Cross-Section Area (in^2)	18.83	16.35	0.00	
Width-Thickness Ratio	62.40	54.34	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)	20.514	20.514	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.754
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-11 - VA - 80 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	9.97	17.09	0.000	21.43	1.100	0.000	0.00
2	0.450	9.97	16.96	0.000	21.26	1.100	0.000	0.00
3	0.450	9.97	16.83	0.000	21.10	1.100	0.000	0.00
4	0.450	9.97	16.70	0.000	20.94	1.100	0.000	0.00
5	0.450	9.97	16.57	0.000	20.77	1.100	0.000	0.00
6	0.450	9.97	16.44	0.000	20.61	1.100	0.000	0.00
7	0.450	9.97	16.31	0.000	20.44	1.100	0.000	0.00
8	0.450	9.97	16.18	0.001	20.28	1.100	0.000	0.00
9	0.450	9.97	16.05	0.001	20.12	1.100	0.000	0.00
10	0.450	9.97	15.92	0.001	19.95	1.100	0.000	0.00
11	0.450	9.97	15.79	0.001	19.79	1.100	0.000	0.00
12	0.450	9.97	15.65	0.001	19.63	1.100	0.000	0.00
13	0.450	12.47	19.42	0.002	19.46	1.100	0.000	0.00
14	0.450	12.47	19.25	0.002	19.30	1.100	0.000	0.00
15	0.450	12.47	19.09	0.002	19.14	1.100	0.000	0.00
16	0.450	12.47	18.93	0.003	18.97	1.100	0.000	0.00
17	0.450	12.47	18.76	0.003	18.81	1.100	0.000	0.00
18	0.450	12.47	8.80	0.002	8.83	1.100	0.000	0.00
19	0.450	12.47	8.77	0.002	8.79	1.100	0.000	0.00
20	0.450	12.47	8.73	0.002	8.75	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.057	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-11 - VA - 80 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



16362-2-11 - VA - 80 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)	
1	1.00	0.450	12.47	47.92	48.03	1.100	0.000	0.00	0	0.562	0.00	0.00	
2	1.00	0.450	12.47	46.61	46.72	1.100	0.000	0.00	0	0.582	0.00	0.00	
3	1.00	0.450	12.47	45.30	45.41	1.100	0.000	0.00	0	0.604	0.00	0.00	
4	1.00	0.450	12.47	43.99	44.09	1.100	0.000	0.00	0	0.628	0.00	0.00	
5	1.00	0.450	12.47	42.68	42.78	1.100	0.000	0.00	0	0.653	0.00	0.00	
6	1.00	0.450	12.47	41.37	41.47	1.100	0.000	0.00	0	0.680	0.00	0.00	
7	1.00	0.450	12.47	40.06	40.16	1.100	0.000	0.00	0	0.709	0.00	0.00	
8	1.00	0.450	12.47	35.81	35.90	1.100	0.000	0.00	0	0.711	0.00	0.00	
9	1.00	0.450	12.47	39.03	39.12	1.100	0.000	0.00	0	0.741	0.00	0.00	
10	1.00	0.450	12.47	37.69	37.79	1.100	0.000	0.00	0	0.776	0.00	0.00	
11	1.00	0.450	12.47	36.36	36.45	1.100	0.000	0.00	0	0.813	0.00	0.00	
12	1.00	0.450	12.47	35.03	35.11	1.100	0.000	0.00	0	0.853	0.00	0.00	
13	1.00	0.450	12.47	33.70	33.78	1.100	0.000	0.00	0	0.897	0.00	0.00	
14	1.00	0.450	12.47	32.37	32.44	1.100	0.000	0.00	0	0.946	0.00	0.00	
15	1.00	0.450	12.47	31.03	31.11	1.100	0.000	0.00	0	0.999	0.00	0.00	
16	1.00	0.458	12.69	30.23	29.77	1.100	0.000	0.00	1	1.057	0.00	0.00	
17	1.00	0.486	13.47	30.65	28.44	1.100	0.000	0.00	1	1.100	0.00	0.00	
18	1.00	0.518	14.34	31.09	27.10	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.553	15.31	31.56	25.77	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.593	16.41	32.08	24.43	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	0.000	0.00	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	365.53	182.77	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



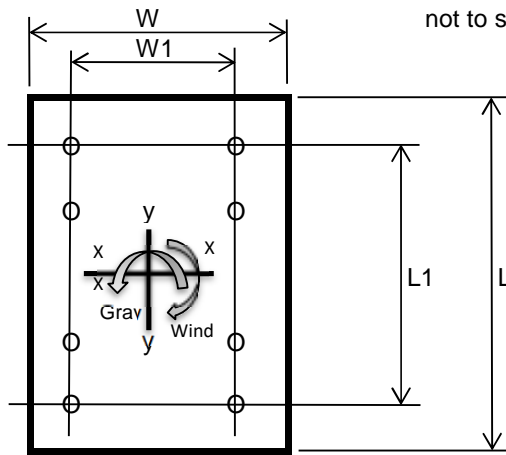
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2161	3337	-	lbs
Shear (Wind)	4297	2502	-	lbs
Torsion (Arm Rise)	13512	7868	-	ft-lbs
Moment (Gravity)	58769	96007	-	ft-lbs
Moment (Wind)	134647	76437	-	ft-lbs
Nat. Wind Moment	-	-	-	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	16.18	17.85	ksi
Bolt Shear Stress - fv	1.72	1.15	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Fv =	44.22	44.22	ksi
Allowable Shear Stress = Ft =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.38	0.41	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	9.97	16.28	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	23.22	13.19	ksi
Combined applied stress for interaction (SRSS)	25.27	20.95	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-11 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

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

SHAFT TO BASEPLATE

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

Tt - Thickness of shaft	0.3125	in
Dt - Shaft base diameter	19.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.333333	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.730769	
Kf - Fatigue stress concentration factor for finite life	2.31	
Ki - Fatigue stress concentration factor for infinite life	5.05	
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



16362-2-11 - VA - 80 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)	19.07	in
Shaft Thickness	0.313	in
Total Area	23.571	in ²
Ix	911	in ⁴
Iy	1023	in ⁴
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-2-11 - VA - 80 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	4297	4811	58769	134647	146914	13512	800	38226	1758	0.81
Gp III	3337	2502	4171	96007	76437	122720	7868	694	31931	1024	0.67
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	1273		1273	22969		22969		353	11914		0.34
Gp II	1273	2704	2989	22969	58957	63273	8501	829	32820	2205	0.72
Gp III	2084	1551	2598	39262	32847	51190	4876	720	26552	1265	0.57
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		-



16362-2-11 - VA - 80 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)						

Shaft Base											
Gp I	3487		58769	0	58769		185		7809		0.23
Gp II	3487	5303	76943	102245	127962	134647	185	564	17002	8945	0.52
Gp III	5112	3226	52910	114188	125851	76437	271	343	16722	5078	0.41
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9978										

Shaft At Arm											
Gp I	2244		58769	0	58769		137		10348		0.29
Gp II	2244	4324	13512	58789	60322	134647	137	529	10622	11855	0.49
Gp III	3420	2529	7868	96027	96349	76437	209	310	16966	6730	0.45
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9978										



16362-2-11 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	5303 lbs
Bending Moment	127962 ft-lbs
Torsion Moment	134647 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	19.50 in

ANALYSIS - ANCHOR BOLTS

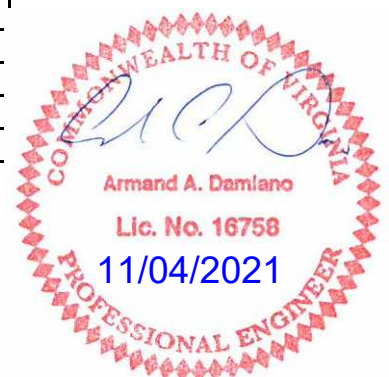
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	11.785 ksi
Bolt Direct Shear Stress	0.289 ksi
Bolt Torsion Shear Stress	6.755 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	11.785 ksi
$f_v =$	7.044 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.46 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	96 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	14.51 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	50 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	7.93 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-11 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 60' Arm

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	0 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	OK

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	29463 lbs
Computed Factor-of Safety	2.1 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	29463 lbs
Total Tensile Load	235704 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	2 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	29463 lbs
Total Tensile Load	235704 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

16362-2-12 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

11/04/21

General

Wind Vel. - mph	80	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		AASHTO Editon	6TH	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	0.3125	0.14	19.50	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	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	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	14.25	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	Arm #1	Arm #2
GP I CSR	0.27	0.35	0.47	0.33					24.24	0.00
GP II CSR	0.62	0.62	0.86	0.70						
GP III CSR	0.48	0.54	0.72	0.56					40.33	

Arm #1 Flange Bolt (Max.) CSR	0.49
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.66
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	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.53
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.53
Anchorage Capacity S.F.	1.82
Concrete Pull Out Capacity S.F.	1.73

Ground Line Reactions

	Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
	5574	5923	147857	155040



16362-2-12 - VA - 80 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
	#5	3 Section Head w/BP	31	8.7	4			1	26	65	1.20
	#6		Camera	35	1	1			1	3	22
	#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
	#10	3 Section Head w/BP	53	8.7	4			1	26	65	1.20
	#11		Camera	57	1	1			1	3	22
	#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											



16362-2-12 - VA - 80 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	19.500	19.352	67.61	0.5287	0.53	1.714	16.65	0.80
2	I	1.06	1.06	19.352	19.204	67.08	0.5287	1.59	1.701	16.53	0.80
3	I	1.06	2.12	19.204	19.055	66.56	0.5287	2.65	1.688	16.41	0.80
4	I	1.06	3.18	19.055	18.907	66.03	0.5287	3.71	1.675	16.28	0.80
5	I	1.06	4.24	18.907	18.759	65.51	0.5287	4.76	1.662	16.16	0.80
6	I	1.06	5.29	18.759	18.611	64.99	0.5287	5.82	1.649	16.04	0.80
7	I	1.06	6.35	18.611	18.462	64.46	0.5287	6.88	1.636	15.91	0.80
8	I	1.06	7.41	18.462	18.314	63.94	0.5287	7.94	1.622	15.79	0.80
9	I	1.06	8.47	18.314	18.166	63.41	0.5287	9.00	1.609	15.67	0.80
10	I	1.06	9.53	18.166	18.018	62.89	0.5287	10.06	1.596	15.54	0.80
11	I	1.06	10.59	18.018	17.869	62.36	0.5287	11.12	1.583	15.42	0.80
12	I	1.06	11.65	17.869	17.721	61.84	0.5287	12.18	1.570	15.30	0.80
13	I	1.06	12.71	17.721	17.573	61.31	0.5287	13.23	1.557	15.17	1.00
14	I	1.06	13.76	17.573	17.425	60.79	0.5287	14.29	1.544	15.05	1.00
15	I	1.06	14.82	17.425	17.276	60.27	0.5287	15.35	1.531	14.93	1.00
16	I	1.06	15.88	17.276	17.128	59.74	0.5287	16.41	1.518	14.80	1.00
17	I	1.06	16.94	17.128	16.980	59.22	0.5286	17.47	1.505	14.68	1.00
18	J	0.50	18.00	16.980	16.910	27.78	0.2498	18.25	0.706	6.89	1.00
19	I	0.50	18.50	16.910	16.840	27.66	0.2498	18.75	0.703	6.86	1.00
20	I	0.50	19.00	16.840	16.770	27.55	0.2498	19.25	0.700	6.83	1.00
						1161					

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)	866.45	567.94	0.00	546.74
Section Modulus (in^3)	90.31	68.15	0.00	
Cross-Section Area (in^2)	18.83	16.35	0.00	
Width-Thickness Ratio	62.40	54.34	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)	20.514	20.514	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.901
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-12 - VA - 80 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	9.97	17.09	0.000	21.43	1.100	0.000	0.00
2	0.450	9.97	16.96	0.000	21.26	1.100	0.000	0.00
3	0.450	9.97	16.83	0.000	21.10	1.100	0.000	0.00
4	0.450	9.97	16.70	0.000	20.94	1.100	0.000	0.00
5	0.450	9.97	16.57	0.000	20.77	1.100	0.000	0.00
6	0.450	9.97	16.44	0.000	20.61	1.100	0.000	0.00
7	0.450	9.97	16.31	0.000	20.44	1.100	0.000	0.00
8	0.450	9.97	16.18	0.001	20.28	1.100	0.000	0.00
9	0.450	9.97	16.05	0.001	20.12	1.100	0.000	0.00
10	0.450	9.97	15.92	0.001	19.95	1.100	0.000	0.00
11	0.450	9.97	15.79	0.001	19.79	1.100	0.000	0.00
12	0.450	9.97	15.65	0.001	19.63	1.100	0.000	0.00
13	0.450	12.47	19.42	0.002	19.46	1.100	0.000	0.00
14	0.450	12.47	19.25	0.002	19.30	1.100	0.000	0.00
15	0.450	12.47	19.09	0.002	19.14	1.100	0.000	0.00
16	0.450	12.47	18.93	0.003	18.97	1.100	0.000	0.00
17	0.450	12.47	18.76	0.003	18.81	1.100	0.000	0.00
18	0.450	12.47	8.80	0.002	8.83	1.100	0.000	0.00
19	0.450	12.47	8.77	0.002	8.79	1.100	0.000	0.00
20	0.450	12.47	8.73	0.002	8.75	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.057	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-12 - VA - 80 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	137.3	1.6173	1.62	4.348	4.348	42.51
2	I	3.25	3.25	15.825	15.370	133.3	1.6171	4.87	4.224	4.224	41.34
3	I	3.25	6.50	15.370	14.915	129.4	1.6169	8.12	4.101	4.101	40.18
4	I	3.25	9.75	14.915	14.460	125.4	1.6166	11.37	3.978	3.978	39.02
5	I	3.25	13.00	14.460	14.005	121.4	1.6163	14.62	3.855	3.855	37.86
6	I	3.25	16.25	14.005	13.550	117.5	1.6161	17.87	3.731	3.731	36.70
7	I	3.25	19.50	13.550	13.095	113.5	1.6158	21.12	3.608	3.608	35.54
8	I	3.25	22.75	13.095	12.640	109.6	1.6154	24.37	3.485	3.485	34.38
9	J	2.69	26.00	13.000	12.623	152.9	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>1829</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)	50.429	23.135
Cross-Section Area (in^2)	12.584	7.218
Width-Thickness Ratio	65.12	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



16362-2-12 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 65' 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	12.47	54.21	54.34	1.100	0.000	0.00	0	0.531	0.00	0.00	
2	1.00	0.450	12.47	52.68	52.80	1.100	0.000	0.00	0	0.551	0.00	0.00	
3	1.00	0.450	12.47	51.14	51.26	1.100	0.000	0.00	0	0.572	0.00	0.00	
4	1.00	0.450	12.47	49.60	49.72	1.100	0.000	0.00	0	0.596	0.00	0.00	
5	1.00	0.450	12.47	48.07	48.18	1.100	0.000	0.00	0	0.621	0.00	0.00	
6	1.00	0.450	12.47	46.53	46.64	1.100	0.000	0.00	0	0.647	0.00	0.00	
7	1.00	0.450	12.47	44.99	45.10	1.100	0.000	0.00	0	0.676	0.00	0.00	
8	1.00	0.450	12.47	43.46	43.56	1.100	0.000	0.00	0	0.707	0.00	0.00	
9	1.00	0.450	12.47	35.81	35.90	1.100	0.000	0.00	0	0.711	0.00	0.00	
10	1.00	0.450	12.47	42.51	42.61	1.100	0.000	0.00	0	0.743	0.00	0.00	
11	1.00	0.450	12.47	40.92	41.02	1.100	0.000	0.00	0	0.781	0.00	0.00	
12	1.00	0.450	12.47	39.34	39.43	1.100	0.000	0.00	0	0.822	0.00	0.00	
13	1.00	0.450	12.47	37.75	37.84	1.100	0.000	0.00	0	0.867	0.00	0.00	
14	1.00	0.450	12.47	36.17	36.25	1.100	0.000	0.00	0	0.916	0.00	0.00	
15	1.00	0.450	12.47	34.58	34.67	1.100	0.000	0.00	0	0.971	0.00	0.00	
16	1.00	0.450	12.47	33.00	33.08	1.100	0.000	0.00	0	1.033	0.00	0.00	
17	1.00	0.477	13.22	33.30	31.49	1.100	0.000	0.00	1	1.101	0.00	0.00	
18	1.00	0.510	14.14	33.82	29.90	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.548	15.18	34.38	28.31	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.591	16.36	34.97	26.72	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	0.000	0.00	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	33.23	365.53	182.77	1.200	0.000	0.00	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



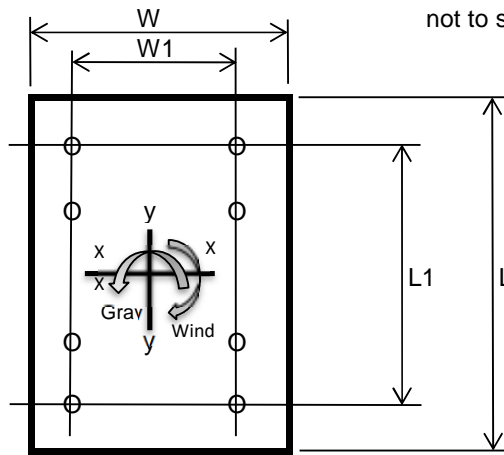
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2458	3799	-	lbs
Shear (Wind)	4905	2848	-	lbs
Torsion (Arm Rise)	16706	9699	-	ft-lbs
Moment (Gravity)	70215	113930	-	ft-lbs
Moment (Wind)	155040	88506	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	16.28	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	18.90	21.09	ksi
Bolt Shear Stress - fv	2.09	1.37	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	0.49	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	11.71	19.00	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	26.30	15.01	ksi
Combined applied stress for interaction (SRSS)	28.79	24.21	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-12 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

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

SHAFT TO BASEPLATE

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

Tt - Thickness of shaft	0.3125	in
Dt - Shaft base diameter	19.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.333333	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.730769	
Kf - Fatigue stress concentration factor for finite life	2.31	
Ki - Fatigue stress concentration factor for infinite life	5.05	
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	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	1.80	
Ki - Fatigue stress concentration factor for infinite life	3.44	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-2-12 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

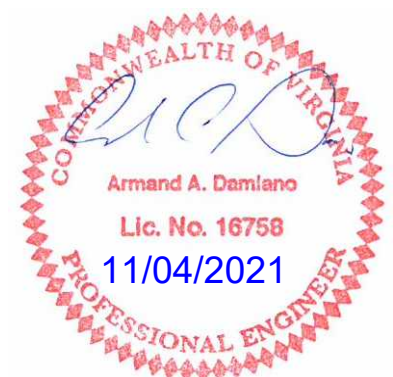
Hand Hole Stresses

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)	19.07	in
Shaft Thickness	0.313	in
Total Area	23.571	in ²
Ix	911	in ⁴
Iy	1023	in ⁴
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-2-12 - VA - 80 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	2458		2458	70215		70215		391	16709		0.47
Gp II	2458	4905	5487	70215	155040	170199	16706	873	40501	1988	0.86
Gp III	3799	2848	4748	113930	88506	144269	9699	755	34331	1154	0.72
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	1233		1233	22307		22307		342	11571		0.33
Gp II	1233	2536	2820	22307	57418	61600	8638	782	31951	2241	0.70
Gp III	1996	1467	2478	38171	32078	49861	4997	687	25862	1296	0.56
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		-



16362-2-12 - VA - 80 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)						

Shaft Base											
Gp I	3784		70215	0	70215		201		9329		0.27
Gp II	3784	5923	91213	116370	147857	155040	201	630	19646	10300	0.62
Gp III	5574	3578	60956	133719	146957	88506	296	381	19526	5880	0.48
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9975										

Shaft At Arm											
Gp I	2541		70215	0	70215		155		12364		0.35
Gp II	2541	4931	16706	70235	72194	155040	155	604	12712	13650	0.62
Gp III	3882	2874	9699	113950	114362	88506	237	352	20137	7792	0.54
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9975										



16362-2-12 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	5923 lbs
Bending Moment	147857 ft-lbs
Torsion Moment	155040 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	19.50 in

ANALYSIS - ANCHOR BOLTS

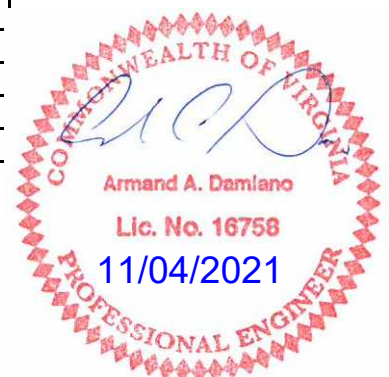
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	13.617 ksi
Bolt Direct Shear Stress	0.322 ksi
Bolt Torsion Shear Stress	7.778 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	13.617 ksi
$f_v =$	8.1 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.53 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	111 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	16.77 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	58 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	9.2 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-12 - VA - 80 MPH - MP-3 Std. Loads - Type B1 - 65' Arm

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	0 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	OK

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	34043 lbs
Computed Factor-of Safety	1.82 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	34043 lbs
Total Tensile Load	272344 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.73 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	34043 lbs
Total Tensile Load	272344 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

16362-2-13 - VA - 80 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

11/04/21

General

Wind Vel. - mph	80	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		AASHTO Editon	6TH	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	16.00	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	0.2760		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	11.50	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

	<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	0.11	0.15	0.25								3.76	0.00
GP II CSR	0.52	0.30	0.60				0.93					
GP III CSR	0.32	0.26	0.45				0.70				6.69	

Arm #1 Flange Bolt (Max.) CSR	0.14
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.27
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	0.36
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.43
Anchorage Capacity S.F.	2.24
Concrete Pull Out Capacity S.F.	2.56

Ground Line Reactions

	Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
	3605	4195	85536	45678



16362-2-13 - VA - 80 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										
	#10										
	#11										
	#12										
	#13										
	#14										
	#15										
	#16										
	#17										
	#18										
	#19										
	#20										



16362-2-13 - VA - 80 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	16.000	15.852	44.36	0.5286	0.53	1.405	13.74	0.80
2	I	1.06	1.06	15.852	15.704	43.94	0.5286	1.59	1.392	13.62	0.80
3	I	1.06	2.12	15.704	15.555	43.52	0.5286	2.65	1.379	13.50	0.80
4	I	1.06	3.18	15.555	15.407	43.10	0.5286	3.71	1.366	13.37	0.80
5	I	1.06	4.24	15.407	15.259	42.68	0.5286	4.76	1.353	13.25	0.80
6	I	1.06	5.29	15.259	15.111	42.26	0.5286	5.82	1.340	13.13	0.80
7	I	1.06	6.35	15.111	14.962	41.84	0.5285	6.88	1.327	13.00	0.80
8	I	1.06	7.41	14.962	14.814	41.42	0.5285	7.94	1.314	12.88	0.80
9	I	1.06	8.47	14.814	14.666	41.00	0.5285	9.00	1.301	12.76	0.80
10	I	1.06	9.53	14.666	14.518	40.58	0.5285	10.06	1.288	12.63	0.80
11	I	1.06	10.59	14.518	14.369	40.16	0.5285	11.12	1.274	12.51	0.80
12	I	1.06	11.65	14.369	14.221	39.74	0.5285	12.18	1.261	12.39	0.80
13	I	1.06	12.71	14.221	14.073	39.32	0.5285	13.23	1.248	12.26	1.00
14	I	1.06	13.76	14.073	13.925	38.91	0.5285	14.29	1.235	12.14	1.00
15	I	1.06	14.82	13.925	13.776	38.49	0.5285	15.35	1.222	12.02	1.00
16	I	1.06	15.88	13.776	13.628	38.07	0.5285	16.41	1.209	11.89	1.00
17	I	1.06	16.94	13.628	13.480	37.65	0.5284	17.47	1.196	11.77	1.00
18	J	3.00	18.00	13.480	13.060	104.39	1.4921	19.49	3.318	32.68	1.00
19	I	3.00	21.00	13.060	12.640	101.02	1.4918	22.49	3.213	31.69	1.00
20	J	1.00	24.00	12.640	12.500	32.93	0.4991	24.50	1.048	10.34	1.00
						936					

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)	383.37	227.23	0.00	180.38
Section Modulus (in ³)	48.68	34.35	0.00	
Cross-Section Area (in ²)	12.36	10.39	0.00	
Width-Thickness Ratio	64.00	53.92	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)	9.215	9.215	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.430
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-13 - VA - 80 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

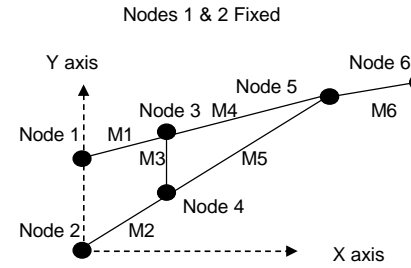
Shaft Analysis Continued

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	9.97	14.01	0.000	17.57	1.100	0.000	0.00
2	0.450	9.97	13.88	0.000	17.40	1.100	0.000	0.00
3	0.450	9.97	13.75	0.000	17.24	1.100	0.000	0.00
4	0.450	9.97	13.62	0.000	17.07	1.100	0.000	0.00
5	0.450	9.97	13.49	0.001	16.91	1.100	0.000	0.00
6	0.450	9.97	13.36	0.001	16.75	1.100	0.000	0.00
7	0.450	9.97	13.23	0.001	16.58	1.100	0.000	0.00
8	0.450	9.97	13.10	0.002	16.42	1.100	0.000	0.00
9	0.450	9.97	12.97	0.002	16.26	1.100	0.000	0.00
10	0.450	9.97	12.84	0.002	16.09	1.100	0.000	0.00
11	0.450	9.97	12.71	0.003	15.93	1.100	0.000	0.00
12	0.450	9.97	12.58	0.003	15.77	1.100	0.000	0.00
13	0.450	12.47	15.57	0.005	15.60	1.100	0.000	0.00
14	0.450	12.47	15.40	0.006	15.44	1.100	0.000	0.00
15	0.450	12.47	15.24	0.006	15.28	1.100	0.000	0.00
16	0.450	12.47	15.08	0.007	15.11	1.100	0.000	0.00
17	0.450	12.47	14.91	0.008	14.95	1.100	0.000	0.00
18	0.450	12.47	41.37	0.027	41.47	1.100	0.000	0.00
19	0.450	12.47	40.06	0.033	40.16	1.100	0.000	0.00
20	0.450	12.47	13.06	0.012	13.09	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.013	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.013	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.183	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-13 - VA - 80 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)
80									
Node #1	0	27	0	0	-33.67	-32.1	0	0	0
Node #2	0	0	0	0	-35.63	-33.9	0	0	0
Node #3	100	59.5	0	0	-66.63	-67	0	0	0
Node #4	100	48.8	0	0	-69.41	-69.7	0	0	0
Node #5	200	79	0	0	-94.35	-98.8	0	0	0
Node #6	288	87	0	0	-85.29	-90.6	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	0.276	105.15	2.10	2.258	-67.33	1.1	1	-64.05	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-71.25	1.1	1	-67.78	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.54	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-65.23	1.1	1.1	-68.27	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-66.89	1.1	1.1	-70.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-56.58	1.1	1.1	-59.21	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-60.92					

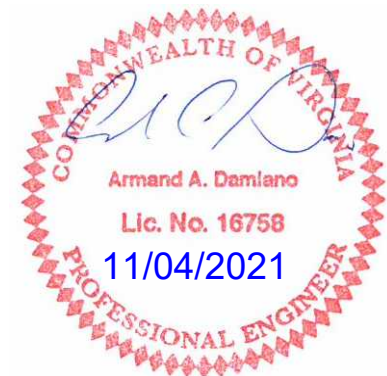
AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2180.2	lbs
P1y	-694.6	lbs
P1z	233.5	lbs
M1x	8700.6	in-lbs
M1y	-32862.2	in-lbs
M1z	-898.1	in-lbs
P2x	2180.2	lbs
P2y	1079.6	lbs
P2z	158.6	lbs
M2x	8937.3	in-lbs
M2y	-26660.6	in-lbs
M2z	-928.7	in-lbs

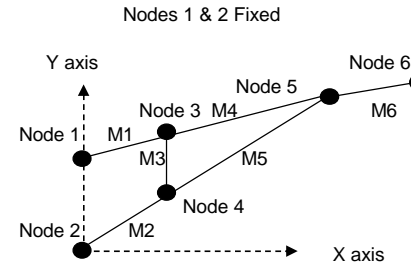
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1018	180	25256	-641	0.73
#2	1071	112	20749	-1246	0.93
#3	1489	513	10104	-511	0.39
#4	-1001	81	9678	-29	0.26
#5	1020	95	10774	-376	0.58
#6	4	110	8163	1	0.25

V09.19.15



16362-2-13 - VA - 80 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)
80									
Node #1	0	27	0	0	-40.85	-16.1	0	0	0
Node #2	0	0	0	0	-43.23	-17	0	0	0
Node #3	100	59.5	0	0	-81.04	-33.5	0	0	0
Node #4	100	48.8	0	0	-84.42	-34.9	0	0	0
Node #5	200	79	0	0	-114.49	-49.4	0	0	0
Node #6	288	87	0	0	-115.33	-45.3	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	0.276	105.15	2.10	2.258	-81.69	1.1	1	-32.03	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-86.45	1.1	1	-33.89	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.77	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-79.16	1.1	1.1	-34.13	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-81.16	1.1	1.1	-35.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-68.65	1.1	1.1	-29.60	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-30.46					

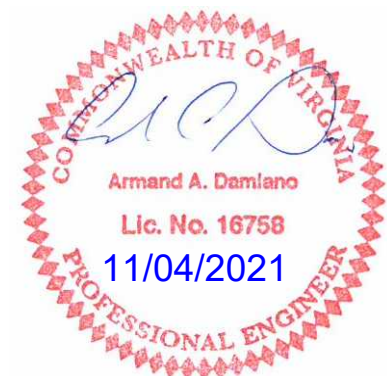
AASHTO Gp	3
Mntg Hght =	29.00
Datum =	1

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2797.7	lbs
P1y	-898.7	lbs
P1z	116.8	lbs
M1x	4351.1	in-lbs
M1y	-16433.7	in-lbs
M1z	-1426.8	in-lbs
P2x	2797.7	lbs
P2y	1378.1	lbs
P2z	79.4	lbs
M2x	4469.6	in-lbs
M2y	-13332.7	in-lbs
M2z	-1452.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1307	93	12670	-321	0.34
#2	1373	61	10427	-623	0.7
#3	1905	462	9337	-256	0.39
#4	-1287	51	4933	-15	0.11
#5	1311	56	5469	-188	0.49
#6	5	110	8115	1	0.25

V09.19.15



16362-2-13 - VA - 80 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



16362-2-13 - VA - 80 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	12.47	18.54	18.59	1.100	0.000	0.00	0	0.784	0.00	0.00	
2	1.00	0.450	12.47	18.21	18.26	1.100	0.000	0.00	0	0.802	0.00	0.00	
3	1.00	0.450	12.47	17.89	17.93	1.100	0.000	0.00	0	0.821	0.00	0.00	
4	1.00	0.450	12.47	17.56	17.60	1.100	0.000	0.00	0	0.841	0.00	0.00	
5	1.00	0.450	12.47	17.23	17.27	1.100	0.000	0.00	0	0.862	0.00	0.00	
6	1.00	0.450	12.47	16.90	16.95	1.100	0.000	0.00	0	0.884	0.00	0.00	
7	1.00	0.450	12.47	16.58	16.62	1.100	0.000	0.00	0	0.906	0.00	0.00	
8	1.00	0.450	12.47	16.25	16.29	1.100	0.000	0.00	0	0.930	0.00	0.00	
9	1.00	0.450	12.47	15.92	15.96	1.100	0.000	0.00	0	0.955	0.00	0.00	
10	1.00	0.450	12.47	15.60	15.63	1.100	0.000	0.00	0	0.981	0.00	0.00	
11	1.00	0.450	12.47	15.27	15.30	1.100	0.000	0.00	1	1.009	0.00	0.00	
12	1.00	0.450	12.45	14.92	14.98	1.100	0.000	0.00	1	1.037	0.00	0.00	
13	1.00	0.463	12.82	15.02	14.65	1.100	0.000	0.00	1	1.068	0.00	0.00	
14	1.00	0.477	13.2	15.12	14.32	1.100	0.000	0.00	1	1.100	0.00	0.00	
15	1.00	0.491	13.61	15.23	13.99	1.100	0.000	0.00	1	1.100	0.00	0.00	
16	1.00	0.507	14.03	15.34	13.66	1.100	0.000	0.00	1	1.100	0.00	0.00	
17	1.00	0.523	14.48	15.45	13.34	1.100	0.000	0.00	1	1.100	0.00	0.00	
18	1.00	0.540	14.96	15.57	13.01	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.558	15.46	15.68	12.68	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.578	16	15.81	12.35	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	33.21	996.30	498.15	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	365.53	182.77	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



16362-2-13 - VA - 80 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

Flange Analysis - Arm #1

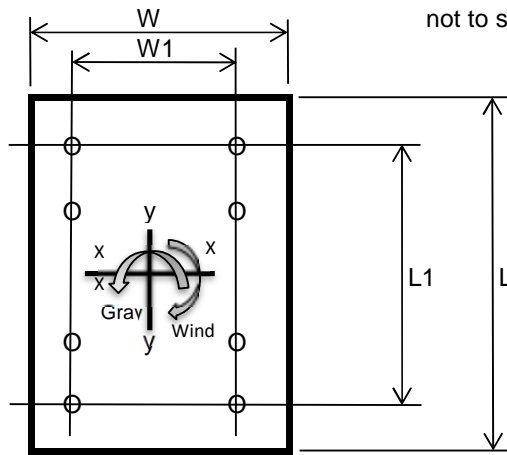
V06-21-16

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	925	1572	-	lbs
Shear (Wind)	2807	1551	-	lbs
Torsion (Arm Rise)	4413	2438	-	ft-lbs
Moment (Gravity)	14359	25276	-	ft-lbs
Moment (Wind)	44208	24066	-	ft-lbs
Nat. Wind Moment	-	-	-	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	596.99	596.99	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1073.57	1073.57	in ⁴
Bolt Tensile Stress - ft	5.58	5.61	ksi
Bolt Shear Stress - fv	0.75	0.48	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.14	0.13	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	3.63	6.38	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	11.35	6.18	ksi
Combined applied stress for interaction (SRSS)	11.92	8.88	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-13 - VA - 80 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	2807	2956	14359	44208	46482	4413	889	28362	1347	0.60
Gp III	1572	1551	2208	25276	24066	34901	2438	664	21296	744	0.45
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		-



16362-2-13 - VA - 80 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)						

Shaft Base											
Gp I	2411		14359	0	14359		195		3539		0.11
Gp II	2411	4195	25347	81694	85536	45678	195	679	21084	5630	0.52
Gp III	3605	2458	30354	47082	56019	24801	292	398	13808	3057	0.32
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9970										

Shaft At Arm											
Gp I	1548		14359	0	14359		149		5016		0.15
Gp II	1548	3294	4413	21999	22437	45678	149	635	7838	7979	0.30
Gp III	2289	1842	2438	29261	29362	24801	220	355	10258	4332	0.26
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9970										



16362-2-13 - VA - 80 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	4195 lbs
Bending Moment	85536 ft-lbs
Torsion Moment	45678 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	16.00 in

ANALYSIS - ANCHOR BOLTS

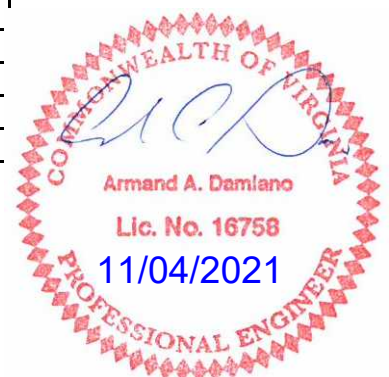
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1082.98 in ⁴
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	11.374 ksi
Bolt Direct Shear Stress	0.305 ksi
Bolt Torsion Shear Stress	3.311 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	11.374 ksi
$f_v =$	3.616 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.36 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	12.701 in
Dist. Shaft Face To Bolt Center	4 in
Design Moment	114 in-kip
Section Modulus of Failure Plane	8.46 in ³
Applied Plate Stress	13.48 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	12.052 in
Dist From Shaft To Nut Face	2.438 in
Design Moment	70 in-kip
Section Modulus of Failure Plane	8.03 in ³
Applied Plate Stress	8.72 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-13 - VA - 80 MPH - MP-3 Std. Loads - Type D - 30' Arm W/24' Lum.

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

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

ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation

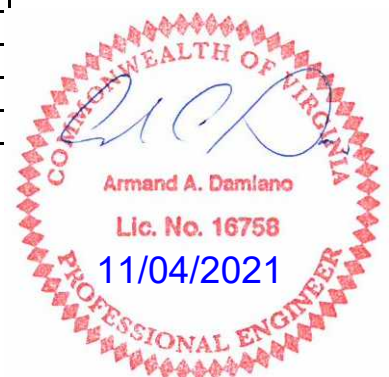
Anchor Bolt Length	60.0 in
Anchor Bolt Max. Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	127540 lbs
T = Anchorage Tensile Capacity	
A _b = Net Bearing Area	4.528 in ²
D _w = 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	28435 lbs
Computed Factor-of Safety	2.24 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	28435 lbs
Total Tensile Load	170610 lbs
Concrete Failure Surface Area	4002.39 in ²
Concrete Shear Strength	438440 psi
Computed Factor-of Safety	2.56 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	28435 lbs
Total Tensile Load	170610 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

16362-2-14 - VA - 80 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

11/04/21

General

Wind Vel.- mph	80	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		AASHTO Editon	6TH	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)	Member E (ksi)	Young's E (ksi)	Orientation (deg)
Shaft	0.2500	0.14	16.00	25.00	-	-	-	0	55	29000	29000	-
Traffic Arm #1	0.1793	0.14	12.00	40.00	18.00	-	2.10	0	55	29000	29000	180
Traffic Arm #2					-	-		0	55	29000	29000	90
Lum Arm #1	0.2760		2.88	24.00	24.00	-	5	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	11.50	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

	<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	0.16	0.23	0.38								9.89	0.00
GP II CSR	0.65	0.50	0.90				0.93					
GP III CSR	0.42	0.40	0.68				0.70				17.51	

Arm #1 Flange Bolt (Max.) CSR	0.20
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.41
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	0.43
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.49
Anchorage Capacity S.F.	1.96
Concrete Pull Out Capacity S.F.	2.24

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
3941	4601	97741	67604



16362-2-14 - VA - 80 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										



16362-2-14 - VA - 80 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	16.000	15.852	44.36	0.5286	0.53	1.405	13.74	0.80
2	I	1.06	1.06	15.852	15.704	43.94	0.5286	1.59	1.392	13.62	0.80
3	I	1.06	2.12	15.704	15.555	43.52	0.5286	2.65	1.379	13.50	0.80
4	I	1.06	3.18	15.555	15.407	43.10	0.5286	3.71	1.366	13.37	0.80
5	I	1.06	4.24	15.407	15.259	42.68	0.5286	4.76	1.353	13.25	0.80
6	I	1.06	5.29	15.259	15.111	42.26	0.5286	5.82	1.340	13.13	0.80
7	I	1.06	6.35	15.111	14.962	41.84	0.5285	6.88	1.327	13.00	0.80
8	I	1.06	7.41	14.962	14.814	41.42	0.5285	7.94	1.314	12.88	0.80
9	I	1.06	8.47	14.814	14.666	41.00	0.5285	9.00	1.301	12.76	0.80
10	I	1.06	9.53	14.666	14.518	40.58	0.5285	10.06	1.288	12.63	0.80
11	I	1.06	10.59	14.518	14.369	40.16	0.5285	11.12	1.274	12.51	0.80
12	I	1.06	11.65	14.369	14.221	39.74	0.5285	12.18	1.261	12.39	0.80
13	I	1.06	12.71	14.221	14.073	39.32	0.5285	13.23	1.248	12.26	1.00
14	I	1.06	13.76	14.073	13.925	38.91	0.5285	14.29	1.235	12.14	1.00
15	I	1.06	14.82	13.925	13.776	38.49	0.5285	15.35	1.222	12.02	1.00
16	I	1.06	15.88	13.776	13.628	38.07	0.5285	16.41	1.209	11.89	1.00
17	I	1.06	16.94	13.628	13.480	37.65	0.5284	17.47	1.196	11.77	1.00
18	J	3.00	18.00	13.480	13.060	104.39	1.4921	19.49	3.318	32.68	1.00
19	I	3.00	21.00	13.060	12.640	101.02	1.4918	22.49	3.213	31.69	1.00
20	J	1.00	24.00	12.640	12.500	32.93	0.4991	24.50	1.048	10.34	1.00
						936					

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)	383.37	227.23	0.00	180.38
Section Modulus (in^3)	48.68	34.35	0.00	
Cross-Section Area (in^2)	12.36	10.39	0.00	
Width-Thickness Ratio	64.00	53.92	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)	9.215	9.215	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.670
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-14 - VA - 80 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

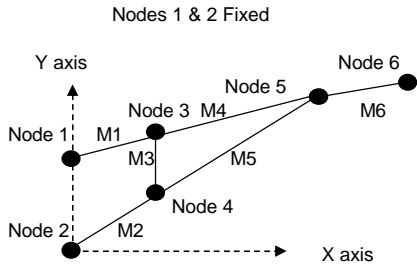
Shaft Analysis Continued

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	9.97	14.01	0.000	17.57	1.100	0.000	0.00
2	0.450	9.97	13.88	0.000	17.40	1.100	0.000	0.00
3	0.450	9.97	13.75	0.000	17.24	1.100	0.000	0.00
4	0.450	9.97	13.62	0.000	17.07	1.100	0.000	0.00
5	0.450	9.97	13.49	0.001	16.91	1.100	0.000	0.00
6	0.450	9.97	13.36	0.001	16.75	1.100	0.000	0.00
7	0.450	9.97	13.23	0.001	16.58	1.100	0.000	0.00
8	0.450	9.97	13.10	0.002	16.42	1.100	0.000	0.00
9	0.450	9.97	12.97	0.002	16.26	1.100	0.000	0.00
10	0.450	9.97	12.84	0.002	16.09	1.100	0.000	0.00
11	0.450	9.97	12.71	0.003	15.93	1.100	0.000	0.00
12	0.450	9.97	12.58	0.003	15.77	1.100	0.000	0.00
13	0.450	12.47	15.57	0.005	15.60	1.100	0.000	0.00
14	0.450	12.47	15.40	0.006	15.44	1.100	0.000	0.00
15	0.450	12.47	15.24	0.006	15.28	1.100	0.000	0.00
16	0.450	12.47	15.08	0.007	15.11	1.100	0.000	0.00
17	0.450	12.47	14.91	0.008	14.95	1.100	0.000	0.00
18	0.450	12.47	41.37	0.027	41.47	1.100	0.000	0.00
19	0.450	12.47	40.06	0.033	40.16	1.100	0.000	0.00
20	0.450	12.47	13.06	0.012	13.09	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.013	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.013	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.183	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-14 - VA - 80 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)
80									
Node #1	0	27	0	0	-33.67	-32.1	0	0	0
Node #2	0	0	0	0	-35.63	-33.9	0	0	0
Node #3	100	59.5	0	0	-66.63	-67	0	0	0
Node #4	100	48.8	0	0	-69.41	-69.7	0	0	0
Node #5	200	79	0	0	-94.35	-98.8	0	0	0
Node #6	288	87	0	0	-85.29	-90.6	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	0.276	105.15	2.10	2.258	-67.33	1.1	1	-64.05	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-71.25	1.1	1	-67.78	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.54	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-65.23	1.1	1.1	-68.27	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-66.89	1.1	1.1	-70.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-56.58	1.1	1.1	-59.21	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-60.92					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2180.2	lbs
P1y	-694.6	lbs
P1z	233.5	lbs
M1x	8700.6	in-lbs
M1y	-32862.2	in-lbs
M1z	-898.1	in-lbs
P2x	2180.2	lbs
P2y	1079.6	lbs
P2z	158.6	lbs
M2x	8937.3	in-lbs
M2y	-26660.6	in-lbs
M2z	-928.7	in-lbs

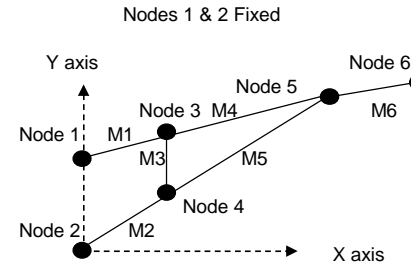
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1018	180	25256	-641	0.73
#2	1071	112	20749	-1246	0.93
#3	1489	513	10104	-511	0.39
#4	-1001	81	9678	-29	0.26
#5	1020	95	10774	-376	0.58
#6	4	110	8163	1	0.25

V09.19.15



16362-2-14 - VA - 80 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)
80									
Node #1	0	27	0	0	-40.85	-16.1	0	0	0
Node #2	0	0	0	0	-43.23	-17	0	0	0
Node #3	100	59.5	0	0	-81.04	-33.5	0	0	0
Node #4	100	48.8	0	0	-84.42	-34.9	0	0	0
Node #5	200	79	0	0	-114.49	-49.4	0	0	0
Node #6	288	87	0	0	-115.33	-45.3	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	0.276	105.15	2.10	2.258	-81.69	1.1	1	-32.03	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-86.45	1.1	1	-33.89	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.77	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-79.16	1.1	1.1	-34.13	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-81.16	1.1	1.1	-35.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-68.65	1.1	1.1	-29.60	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-30.46					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2797.7	lbs
P1y	-898.7	lbs
P1z	116.8	lbs
M1x	4351.1	in-lbs
M1y	-16433.7	in-lbs
M1z	-1426.8	in-lbs
P2x	2797.7	lbs
P2y	1378.1	lbs
P2z	79.4	lbs
M2x	4469.6	in-lbs
M2y	-13332.7	in-lbs
M2z	-1452.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1307	93	12670	-321	0.34
#2	1373	61	10427	-623	0.7
#3	1905	462	9337	-256	0.39
#4	-1287	51	4933	-15	0.11
#5	1311	56	5469	-188	0.49
#6	5	110	8115	1	0.25

V09.19.15



16362-2-14 - VA - 80 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	12.000	11.720	44.8	0.9961	1.00	1.977	1.977	19.57
2	I	2.00	2.00	11.720	11.440	43.7	0.9960	3.00	1.930	1.930	19.13
3	I	2.00	4.00	11.440	11.160	42.6	0.9959	5.00	1.883	1.883	18.69
4	I	2.00	6.00	11.160	10.880	41.6	0.9958	7.00	1.837	1.837	18.25
5	I	2.00	8.00	10.880	10.600	40.5	0.9957	9.00	1.790	1.790	17.81
6	I	2.00	10.00	10.600	10.320	39.4	0.9955	11.00	1.743	1.743	17.37
7	I	2.00	12.00	10.320	10.040	38.3	0.9954	13.00	1.697	1.697	16.93
8	I	2.00	14.00	10.040	9.760	37.3	0.9953	15.00	1.650	1.650	16.49
9	I	2.00	16.00	9.760	9.480	36.2	0.9951	17.00	1.603	1.603	16.05
10	I	2.00	18.00	9.480	9.200	35.1	0.9950	19.00	1.557	1.557	15.61
11	I	2.00	20.00	9.200	8.920	34.0	0.9948	20.99	1.510	1.510	15.17
12	I	2.00	22.00	8.920	8.640	33.0	0.9947	22.99	1.463	1.463	14.73
13	I	2.00	24.00	8.640	8.360	31.9	0.9945	24.99	1.417	1.417	14.29
14	I	2.00	26.00	8.360	8.080	30.8	0.9943	26.99	1.370	1.370	13.85
15	I	2.00	28.00	8.080	7.800	29.8	0.9941	28.99	1.323	1.323	13.41
16	I	2.00	30.00	7.800	7.520	28.7	0.9939	30.99	1.277	1.277	12.97
17	I	2.00	32.00	7.520	7.240	27.6	0.9937	32.99	1.230	1.230	12.53
18	I	2.00	34.00	7.240	6.960	26.5	0.9934	34.99	1.183	1.183	12.10
19	I	2.00	36.00	6.960	6.680	25.5	0.9932	36.99	1.137	1.137	11.66
20	I	2.00	38.00	6.680	6.400	24.4	0.9929	38.99	1.090	1.090	11.22
		<u>40.00</u>				<u>692</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)	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



16362-2-14 - VA - 80 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	12.47	24.65	24.71	1.100	0.000	0.00	0	0.787	0.00	0.00	
2	1.00	0.450	12.47	24.07	24.13	1.100	0.000	0.00	0	0.811	0.00	0.00	
3	1.00	0.450	12.47	23.49	23.54	1.100	0.000	0.00	0	0.838	0.00	0.00	
4	1.00	0.450	12.47	22.90	22.96	1.100	0.000	0.00	0	0.865	0.00	0.00	
5	1.00	0.450	12.47	22.32	22.38	1.100	0.000	0.00	0	0.895	0.00	0.00	
6	1.00	0.450	12.47	21.74	21.79	1.100	0.000	0.00	0	0.926	0.00	0.00	
7	1.00	0.450	12.47	21.16	21.21	1.100	0.000	0.00	0	0.959	0.00	0.00	
8	1.00	0.450	12.47	20.58	20.63	1.100	0.000	0.00	0	0.995	0.00	0.00	
9	1.00	0.450	12.47	19.99	20.04	1.100	0.000	0.00	0	1.033	0.00	0.00	
10	1.00	0.465	12.88	20.05	19.46	1.100	0.000	0.00	0	1.073	0.00	0.00	
11	1.00	0.484	13.4	20.23	18.88	1.100	0.000	0.00	0	1.100	0.00	0.00	
12	1.00	0.504	13.96	20.43	18.29	1.100	0.000	0.00	0	1.100	0.00	0.00	
13	1.00	0.526	14.56	20.63	17.71	1.100	0.000	0.00	1	1.100	0.00	0.00	
14	1.00	0.549	15.21	20.84	17.13	1.100	0.000	0.00	1	1.100	0.00	0.00	
15	1.00	0.574	15.91	21.05	16.54	1.100	0.000	0.00	1	1.100	0.00	0.00	
16	1.00	0.602	16.67	21.28	15.96	1.100	0.000	0.00	1	1.100	0.00	0.00	
17	1.00	0.632	17.49	21.51	15.38	1.100	0.000	0.00	1	1.100	0.00	0.00	
18	1.00	0.664	18.4	21.77	14.79	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.700	19.38	22.03	14.21	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.739	20.47	22.31	13.63	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	33.21	996.30	498.15	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #5	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	365.53	182.77	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



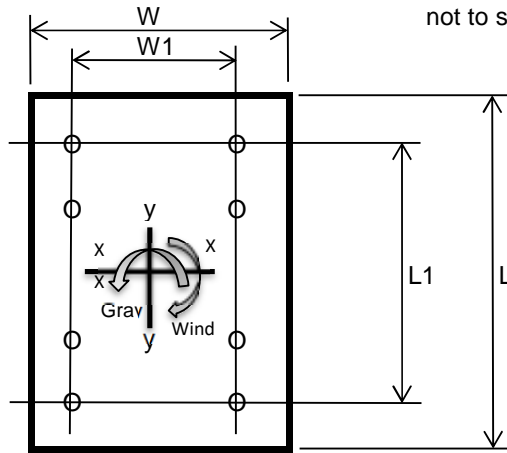
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1123	1908	-	lbs
Shear (Wind)	3205	1769	-	lbs
Torsion (Arm Rise)	6718	3709	-	ft-lbs
Moment (Gravity)	22366	39143	-	ft-lbs
Moment (Wind)	66134	35697	-	ft-lbs
Nat. Wind Moment	-	-	-	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	596.99	596.99	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1073.57	1073.57	in ⁴
Bolt Tensile Stress - ft	8.44	8.61	ksi
Bolt Shear Stress - fv	1.04	0.66	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.2	0.20	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	5.65	9.88	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	16.98	9.17	ksi
Combined applied stress for interaction (SRSS)	17.90	13.48	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-14 - VA - 80 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)					

Arm#1 Base											
Gp I	1123		1123	22366		22366		338	13647		0.38
Gp II	1123	3205	3397	22366	66134	69814	6718	1021	42598	2050	0.90
Gp III	1908	1769	2602	39143	35697	52977	3709	782	32325	1132	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		-



16362-2-14 - VA - 80 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)						

Shaft Base											
Gp I	2608		22366	0	22366		211		5513		0.16
Gp II	2608	4601	35248	91164	97741	67604	211	745	24093	8332	0.65
Gp III	3941	2681	35558	61990	71464	36432	319	434	17616	4490	0.42
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9966										

Shaft At Arm											
Gp I	1746		22366	0	22366		168		7813		0.23
Gp II	1746	3692	6718	30005	30748	67604	168	711	10742	11809	0.50
Gp III	2625	2060	3709	43128	43287	36432	253	397	15122	6364	0.40
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9966										



16362-2-14 - VA - 80 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	4601 lbs
Bending Moment	97741 ft-lbs
Torsion Moment	67604 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	16.00 in

ANALYSIS - ANCHOR BOLTS

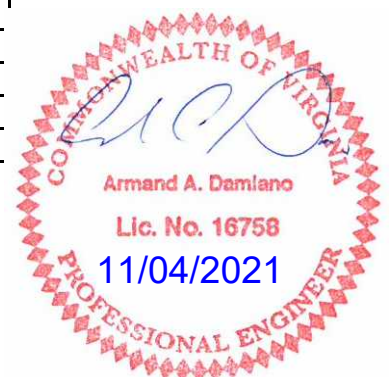
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1082.98 in ⁴
c Dist. (Section 5.17.7)	12.00 in
Bolt Tensile Stress	12.997 ksi
Bolt Direct Shear Stress	0.334 ksi
Bolt Torsion Shear Stress	4.899 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	12.997 ksi
$f_v =$	5.233 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.43 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	12.701 in
Dist. Shaft Face To Bolt Center	4 in
Design Moment	130 in-kip
Section Modulus of Failure Plane	8.46 in ³
Applied Plate Stress	15.37 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	12.052 in
Dist From Shaft To Nut Face	2.438 in
Design Moment	80 in-kip
Section Modulus of Failure Plane	8.03 in ³
Applied Plate Stress	9.97 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-14 - VA - 80 MPH - MP-3 Std. Loads - Type D - 40' Arm W/24' Lum.

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

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

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	32493 lbs
Computed Factor-of Safety	1.96 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	32493 lbs
Total Tensile Load	194958 lbs
Concrete Failure Surface Area	4002.39 in ²
Concrete Shear Strength	438440 psi
Computed Factor-of Safety	2.24 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	32493 lbs
Total Tensile Load	194958 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

16362-2-15 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

11/04/21

General

Wind Vel.- mph	80	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		AASHTO Editon	6TH	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	0.3125	0.14	19.50	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	0.2760		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	14.25	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	Root	Root	Arm #1	Arm #2
GP I CSR	0.23	0.30	0.43	0.34							19.71	0.00
GP II CSR	0.56	0.53	0.81	0.72			0.93					
GP III CSR	0.43	0.47	0.67	0.57			0.70				33.00	

Arm #1 Flange Bolt (Max.) CSR	0.41
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.58
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	4.5 ksi
Fatigue Allowable - Arm#1 to Flange	7 ksi
Fatigue Allowable - Arm#2 to Flange	-
Anchor Bolt Max. CSR	0.49
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.51
Anchorage Capacity S.F.	1.9
Concrete Pull Out Capacity S.F.	1.81

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
5960	5799	141454	136116



16362-2-15 - VA - 80 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										
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	#9										
	#10										
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	#16										
	#17										
	#18										
	#19										
	#20										



16362-2-15 - VA - 80 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	19.500	19.352	67.61	0.5287	0.53	1.714	16.65	0.80
2	I	1.06	1.06	19.352	19.204	67.08	0.5287	1.59	1.701	16.53	0.80
3	I	1.06	2.12	19.204	19.055	66.56	0.5287	2.65	1.688	16.41	0.80
4	I	1.06	3.18	19.055	18.907	66.03	0.5287	3.71	1.675	16.28	0.80
5	I	1.06	4.24	18.907	18.759	65.51	0.5287	4.76	1.662	16.16	0.80
6	I	1.06	5.29	18.759	18.611	64.99	0.5287	5.82	1.649	16.04	0.80
7	I	1.06	6.35	18.611	18.462	64.46	0.5287	6.88	1.636	15.91	0.80
8	I	1.06	7.41	18.462	18.314	63.94	0.5287	7.94	1.622	15.79	0.80
9	I	1.06	8.47	18.314	18.166	63.41	0.5287	9.00	1.609	15.67	0.80
10	I	1.06	9.53	18.166	18.018	62.89	0.5287	10.06	1.596	15.54	0.80
11	I	1.06	10.59	18.018	17.869	62.36	0.5287	11.12	1.583	15.42	0.80
12	I	1.06	11.65	17.869	17.721	61.84	0.5287	12.18	1.570	15.30	0.80
13	I	1.06	12.71	17.721	17.573	61.31	0.5287	13.23	1.557	15.17	1.00
14	I	1.06	13.76	17.573	17.425	60.79	0.5287	14.29	1.544	15.05	1.00
15	I	1.06	14.82	17.425	17.276	60.27	0.5287	15.35	1.531	14.93	1.00
16	I	1.06	15.88	17.276	17.128	59.74	0.5287	16.41	1.518	14.80	1.00
17	I	1.06	16.94	17.128	16.980	59.22	0.5286	17.47	1.505	14.68	1.00
18	J	3.00	18.00	16.980	16.560	164.94	1.4937	19.49	4.193	40.93	1.00
19	I	3.00	21.00	16.560	16.140	160.73	1.4936	22.49	4.088	39.94	1.00
20	J	1.00	24.00	16.140	16.000	52.64	0.4993	24.50	1.339	13.09	1.00
						1457					

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)	866.45	567.94	0.00	473.53
Section Modulus (in^3)	90.31	68.15	0.00	
Cross-Section Area (in^2)	18.83	16.35	0.00	
Width-Thickness Ratio	62.40	54.34	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)	14.296	14.296	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.754
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-15 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

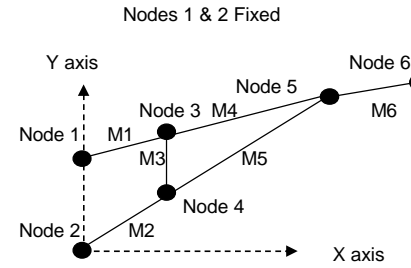
Shaft Analysis Continued

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	9.97	17.09	0.000	21.43	1.100	0.000	0.00
2	0.450	9.97	16.96	0.000	21.26	1.100	0.000	0.00
3	0.450	9.97	16.83	0.000	21.10	1.100	0.000	0.00
4	0.450	9.97	16.70	0.000	20.94	1.100	0.000	0.00
5	0.450	9.97	16.57	0.000	20.77	1.100	0.000	0.00
6	0.450	9.97	16.44	0.000	20.61	1.100	0.000	0.00
7	0.450	9.97	16.31	0.001	20.44	1.100	0.000	0.00
8	0.450	9.97	16.18	0.001	20.28	1.100	0.000	0.00
9	0.450	9.97	16.05	0.001	20.12	1.100	0.000	0.00
10	0.450	9.97	15.92	0.001	19.95	1.100	0.000	0.00
11	0.450	9.97	15.79	0.002	19.79	1.100	0.000	0.00
12	0.450	9.97	15.65	0.002	19.63	1.100	0.000	0.00
13	0.450	12.47	19.42	0.003	19.46	1.100	0.000	0.00
14	0.450	12.47	19.25	0.003	19.30	1.100	0.000	0.00
15	0.450	12.47	19.09	0.003	19.14	1.100	0.000	0.00
16	0.450	12.47	18.93	0.004	18.97	1.100	0.000	0.00
17	0.450	12.47	18.76	0.004	18.81	1.100	0.000	0.00
18	0.450	12.47	52.28	0.014	52.41	1.100	0.000	0.00
19	0.450	12.47	50.97	0.018	51.09	1.100	0.000	0.00
20	0.450	12.47	16.70	0.007	16.74	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.006	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.006	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.079	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-15 - VA - 80 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)
80									
Node #1	0	27	0	0	-33.67	-32.1	0	0	0
Node #2	0	0	0	0	-35.63	-33.9	0	0	0
Node #3	100	59.5	0	0	-66.63	-67	0	0	0
Node #4	100	48.8	0	0	-69.41	-69.7	0	0	0
Node #5	200	79	0	0	-94.35	-98.8	0	0	0
Node #6	288	87	0	0	-85.29	-90.6	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	0.276	105.15	2.10	2.258	-67.33	1.1	1	-64.05	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-71.25	1.1	1	-67.78	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.54	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-65.23	1.1	1.1	-68.27	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-66.89	1.1	1.1	-70.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-56.58	1.1	1.1	-59.21	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-60.92					

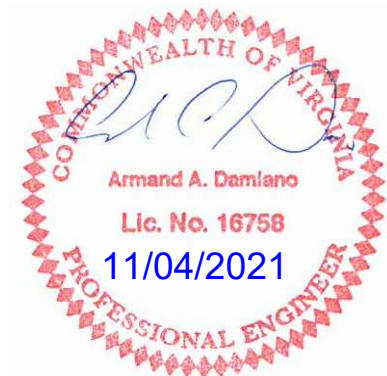
AASHTO Gp	2
Mntg Hght =	29.00
Datum =	1

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2180.2	lbs
P1y	-694.6	lbs
P1z	233.5	lbs
M1x	8700.6	in-lbs
M1y	-32862.2	in-lbs
M1z	-898.1	in-lbs
P2x	2180.2	lbs
P2y	1079.6	lbs
P2z	158.6	lbs
M2x	8937.3	in-lbs
M2y	-26660.6	in-lbs
M2z	-928.7	in-lbs

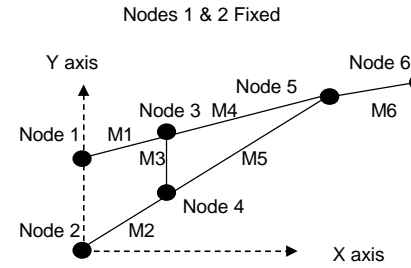
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1018	180	25256	-641	0.73
#2	1071	112	20749	-1246	0.93
#3	1489	513	10104	-511	0.39
#4	-1001	81	9678	-29	0.26
#5	1020	95	10774	-376	0.58
#6	4	110	8163	1	0.25

V09.19.15



16362-2-15 - VA - 80 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)
80									
Node #1	0	27	0	0	-40.85	-16.1	0	0	0
Node #2	0	0	0	0	-43.23	-17	0	0	0
Node #3	100	59.5	0	0	-81.04	-33.5	0	0	0
Node #4	100	48.8	0	0	-84.42	-34.9	0	0	0
Node #5	200	79	0	0	-114.49	-49.4	0	0	0
Node #6	288	87	0	0	-115.33	-45.3	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	0.276	105.15	2.10	2.258	-81.69	1.1	1	-32.03	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-86.45	1.1	1	-33.89	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.77	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-79.16	1.1	1.1	-34.13	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-81.16	1.1	1.1	-35.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-68.65	1.1	1.1	-29.60	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-30.46					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2797.7	lbs
P1y	-898.7	lbs
P1z	116.8	lbs
M1x	4351.1	in-lbs
M1y	-16433.7	in-lbs
M1z	-1426.8	in-lbs
P2x	2797.7	lbs
P2y	1378.1	lbs
P2z	79.4	lbs
M2x	4469.6	in-lbs
M2y	-13332.7	in-lbs
M2z	-1452.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1307	93	12670	-321	0.34
#2	1373	61	10427	-623	0.7
#3	1905	462	9337	-256	0.39
#4	-1287	51	4933	-15	0.11
#5	1311	56	5469	-188	0.49
#6	5	110	8115	1	0.25

V09.19.15



16362-2-15 - VA - 80 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



16362-2-15 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 60' 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	12.47	47.92	48.03	1.100	0.000	0.00	0	0.562	0.00	0.00	
2	1.00	0.450	12.47	46.61	46.72	1.100	0.000	0.00	0	0.582	0.00	0.00	
3	1.00	0.450	12.47	45.30	45.41	1.100	0.000	0.00	0	0.604	0.00	0.00	
4	1.00	0.450	12.47	43.99	44.09	1.100	0.000	0.00	0	0.628	0.00	0.00	
5	1.00	0.450	12.47	42.68	42.78	1.100	0.000	0.00	0	0.653	0.00	0.00	
6	1.00	0.450	12.47	41.37	41.47	1.100	0.000	0.00	0	0.680	0.00	0.00	
7	1.00	0.450	12.47	40.06	40.16	1.100	0.000	0.00	0	0.709	0.00	0.00	
8	1.00	0.450	12.47	35.81	35.90	1.100	0.000	0.00	0	0.711	0.00	0.00	
9	1.00	0.450	12.47	39.03	39.12	1.100	0.000	0.00	0	0.741	0.00	0.00	
10	1.00	0.450	12.47	37.69	37.79	1.100	0.000	0.00	0	0.776	0.00	0.00	
11	1.00	0.450	12.47	36.36	36.45	1.100	0.000	0.00	0	0.813	0.00	0.00	
12	1.00	0.450	12.47	35.03	35.11	1.100	0.000	0.00	0	0.853	0.00	0.00	
13	1.00	0.450	12.47	33.70	33.78	1.100	0.000	0.00	0	0.897	0.00	0.00	
14	1.00	0.450	12.47	32.37	32.44	1.100	0.000	0.00	0	0.946	0.00	0.00	
15	1.00	0.450	12.47	31.03	31.11	1.100	0.000	0.00	0	0.999	0.00	0.00	
16	1.00	0.458	12.69	30.23	29.77	1.100	0.000	0.00	1	1.057	0.00	0.00	
17	1.00	0.486	13.47	30.65	28.44	1.100	0.000	0.00	1	1.100	0.00	0.00	
18	1.00	0.518	14.34	31.09	27.10	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.553	15.31	31.56	25.77	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.593	16.41	32.08	24.43	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	0.000	0.00	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	365.53	182.77	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



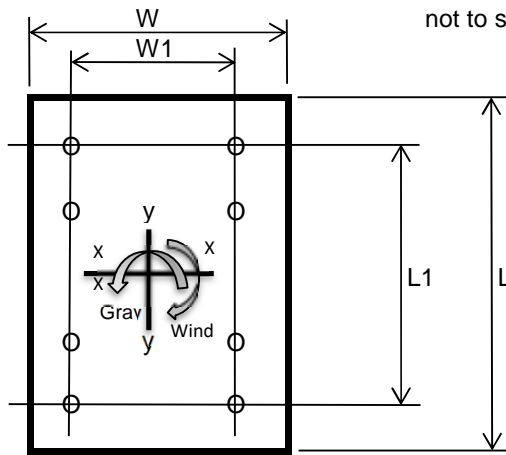
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2161	3337	-	lbs
Shear (Wind)	4297	2502	-	lbs
Torsion (Arm Rise)	13512	7868	-	ft-lbs
Moment (Gravity)	58769	96007	-	ft-lbs
Moment (Wind)	134647	76437	-	ft-lbs
Nat. Wind Moment	-	-	-	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	16.18	17.85	ksi
Bolt Shear Stress - fv	1.72	1.15	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Fv =	44.22	44.22	ksi
Allowable Shear Stress = Ft =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.38	0.41	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	9.97	16.28	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	23.22	13.19	ksi
Combined applied stress for interaction (SRSS)	25.27	20.95	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-15 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

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

SHAFT TO BASEPLATE

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

Tt - Thickness of shaft	0.3125	in
Dt - Shaft base diameter	19.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.333333	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.730769	
Kf - Fatigue stress concentration factor for finite life	2.31	
Ki - Fatigue stress concentration factor for infinite life	5.05	
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



16362-2-15 - VA - 80 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)	19.07	in
Shaft Thickness	0.313	in
Total Area	23.571	in ²
Ix	911	in ⁴
Iy	1023	in ⁴
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-2-15 - VA - 80 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	4297	4811	58769	134647	146914	13512	800	38226	1758	0.81
Gp III	3337	2502	4171	96007	76437	122720	7868	694	31931	1024	0.67
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	1273		1273	22969		22969		353	11914		0.34
Gp II	1273	2704	2989	22969	58957	63273	8501	829	32820	2205	0.72
Gp III	2084	1551	2598	39262	32847	51190	4876	720	26552	1265	0.57
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		-



16362-2-15 - VA - 80 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)						

Shaft Base											
Gp I	4167		58769	0	58769		221		7809		0.23
Gp II	4167	5799	76943	118697	141454	136116	221	616	18795	9043	0.56
Gp III	5960	3521	52910	123464	134324	77172	317	375	17848	5127	0.43
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9975										

Shaft At Arm											
Gp I	2924		58769	0	58769		179		10348		0.30
Gp II	2924	4809	13512	66498	67857	136116	179	589	11949	11984	0.53
Gp III	4194	2819	7868	100082	100391	77172	256	345	17677	6794	0.47
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9975										



16362-2-15 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	5799 lbs
Bending Moment	141454 ft-lbs
Torsion Moment	136116 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	19.50 in

ANALYSIS - ANCHOR BOLTS

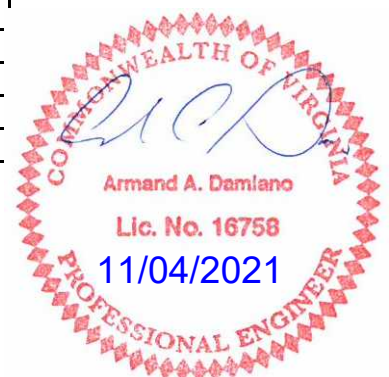
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	13.027 ksi
Bolt Direct Shear Stress	0.316 ksi
Bolt Torsion Shear Stress	6.829 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	13.027 ksi
$f_v =$	7.145 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.49 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	106 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	16.02 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	55 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	8.72 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-15 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 60' Arm W/24' Lum.

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	0 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	OK

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	32568 lbs
Computed Factor-of Safety	1.9 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	32568 lbs
Total Tensile Load	260544 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.81 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	32568 lbs
Total Tensile Load	260544 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

16362-2-16 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 65' Arm W/24' Lum.

11/04/21

General

Wind Vel.- mph	80	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		AASHTO Editon	6TH	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	0.3125	0.14	19.50	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	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	0.2760		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	14.25	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	0.27	0.35	0.47	0.33							24.24	0.00
GP II CSR	0.67	0.66	0.86	0.70			0.93					
GP III CSR	0.51	0.56	0.72	0.56			0.70				40.33	

Arm #1 Flange Bolt (Max.) CSR	0.49
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.66
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	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	0.00
Base Plate Max. CSR	0.58
Anchorage Capacity S.F.	1.67
Concrete Pull Out Capacity S.F.	1.59

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
6422	6418	161127	156510



16362-2-16 - VA - 80 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										
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	#12										
	#13										
	#14										
#15											
#16											
#17											
#18											
#19											
#20											



16362-2-16 - VA - 80 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	19.500	19.352	67.61	0.5287	0.53	1.714	16.65	0.80
2	I	1.06	1.06	19.352	19.204	67.08	0.5287	1.59	1.701	16.53	0.80
3	I	1.06	2.12	19.204	19.055	66.56	0.5287	2.65	1.688	16.41	0.80
4	I	1.06	3.18	19.055	18.907	66.03	0.5287	3.71	1.675	16.28	0.80
5	I	1.06	4.24	18.907	18.759	65.51	0.5287	4.76	1.662	16.16	0.80
6	I	1.06	5.29	18.759	18.611	64.99	0.5287	5.82	1.649	16.04	0.80
7	I	1.06	6.35	18.611	18.462	64.46	0.5287	6.88	1.636	15.91	0.80
8	I	1.06	7.41	18.462	18.314	63.94	0.5287	7.94	1.622	15.79	0.80
9	I	1.06	8.47	18.314	18.166	63.41	0.5287	9.00	1.609	15.67	0.80
10	I	1.06	9.53	18.166	18.018	62.89	0.5287	10.06	1.596	15.54	0.80
11	I	1.06	10.59	18.018	17.869	62.36	0.5287	11.12	1.583	15.42	0.80
12	I	1.06	11.65	17.869	17.721	61.84	0.5287	12.18	1.570	15.30	0.80
13	I	1.06	12.71	17.721	17.573	61.31	0.5287	13.23	1.557	15.17	1.00
14	I	1.06	13.76	17.573	17.425	60.79	0.5287	14.29	1.544	15.05	1.00
15	I	1.06	14.82	17.425	17.276	60.27	0.5287	15.35	1.531	14.93	1.00
16	I	1.06	15.88	17.276	17.128	59.74	0.5287	16.41	1.518	14.80	1.00
17	I	1.06	16.94	17.128	16.980	59.22	0.5286	17.47	1.505	14.68	1.00
18	J	3.00	18.00	16.980	16.560	164.94	1.4937	19.49	4.193	40.93	1.00
19	I	3.00	21.00	16.560	16.140	160.73	1.4936	22.49	4.088	39.94	1.00
20	J	1.00	24.00	16.140	16.000	52.64	0.4993	24.50	1.339	13.09	1.00
						<u>1457</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)	866.45	567.94	0.00	473.53
Section Modulus (in ³)	90.31	68.15	0.00	
Cross-Section Area (in ²)	18.83	16.35	0.00	
Width-Thickness Ratio	62.40	54.34	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)	14.296	14.296	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.901
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-16 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 65' Arm W/24' Lum.

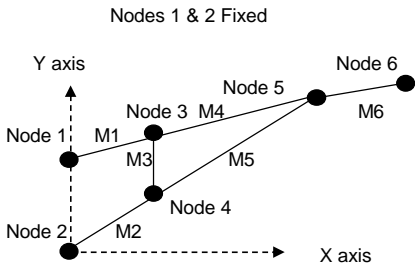
Shaft Analysis Continued

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	9.97	17.09	0.000	21.43	1.100	0.000	0.00
2	0.450	9.97	16.96	0.000	21.26	1.100	0.000	0.00
3	0.450	9.97	16.83	0.000	21.10	1.100	0.000	0.00
4	0.450	9.97	16.70	0.000	20.94	1.100	0.000	0.00
5	0.450	9.97	16.57	0.000	20.77	1.100	0.000	0.00
6	0.450	9.97	16.44	0.000	20.61	1.100	0.000	0.00
7	0.450	9.97	16.31	0.001	20.44	1.100	0.000	0.00
8	0.450	9.97	16.18	0.001	20.28	1.100	0.000	0.00
9	0.450	9.97	16.05	0.001	20.12	1.100	0.000	0.00
10	0.450	9.97	15.92	0.001	19.95	1.100	0.000	0.00
11	0.450	9.97	15.79	0.002	19.79	1.100	0.000	0.00
12	0.450	9.97	15.65	0.002	19.63	1.100	0.000	0.00
13	0.450	12.47	19.42	0.003	19.46	1.100	0.000	0.00
14	0.450	12.47	19.25	0.003	19.30	1.100	0.000	0.00
15	0.450	12.47	19.09	0.003	19.14	1.100	0.000	0.00
16	0.450	12.47	18.93	0.004	18.97	1.100	0.000	0.00
17	0.450	12.47	18.76	0.004	18.81	1.100	0.000	0.00
18	0.450	12.47	52.28	0.014	52.41	1.100	0.000	0.00
19	0.450	12.47	50.97	0.018	51.09	1.100	0.000	0.00
20	0.450	12.47	16.70	0.007	16.74	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.006	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.006	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.079	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-16 - VA - 80 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)
80									
Node #1	0	27	0	0	-33.67	-32.1	0	0	0
Node #2	0	0	0	0	-35.63	-33.9	0	0	0
Node #3	100	59.5	0	0	-66.63	-67	0	0	0
Node #4	100	48.8	0	0	-69.41	-69.7	0	0	0
Node #5	200	79	0	0	-94.35	-98.8	0	0	0
Node #6	288	87	0	0	-85.29	-90.6	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	0.276	105.15	2.10	2.258	-67.33	1.1	1	-64.05	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-71.25	1.1	1	-67.78	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.54	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-65.23	1.1	1.1	-68.27	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-66.89	1.1	1.1	-70.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-56.58	1.1	1.1	-59.21	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-60.92					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2180.2	lbs
P1y	-694.6	lbs
P1z	233.5	lbs
M1x	8700.6	in-lbs
M1y	-32862.2	in-lbs
M1z	-898.1	in-lbs
P2x	2180.2	lbs
P2y	1079.6	lbs
P2z	158.6	lbs
M2x	8937.3	in-lbs
M2y	-26660.6	in-lbs
M2z	-928.7	in-lbs

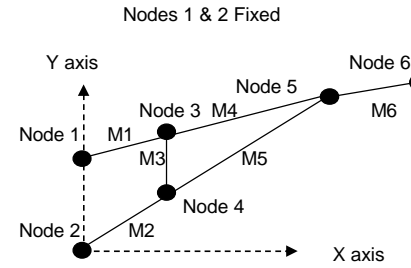
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1018	180	25256	-641	0.73
#2	1071	112	20749	-1246	0.93
#3	1489	513	10104	-511	0.39
#4	-1001	81	9678	-29	0.26
#5	1020	95	10774	-376	0.58
#6	4	110	8163	1	0.25

V09.19.15



16362-2-16 - VA - 80 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)
80									
Node #1	0	27	0	0	-40.85	-16.1	0	0	0
Node #2	0	0	0	0	-43.23	-17	0	0	0
Node #3	100	59.5	0	0	-81.04	-33.5	0	0	0
Node #4	100	48.8	0	0	-84.42	-34.9	0	0	0
Node #5	200	79	0	0	-114.49	-49.4	0	0	0
Node #6	288	87	0	0	-115.33	-45.3	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	0.276	105.15	2.10	2.258	-81.69	1.1	1	-32.03	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-86.45	1.1	1	-33.89	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.77	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-79.16	1.1	1.1	-34.13	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-81.16	1.1	1.1	-35.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-68.65	1.1	1.1	-29.60	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-30.46					

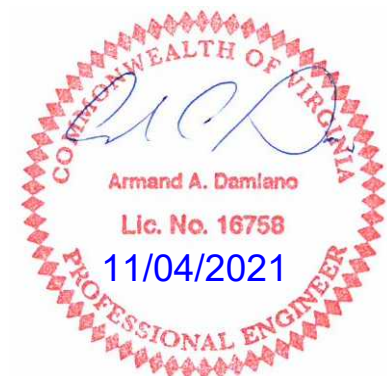
AASHTO Gp	3
Mntg Hght =	29.00
Datum =	1

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2797.7	lbs
P1y	-898.7	lbs
P1z	116.8	lbs
M1x	4351.1	in-lbs
M1y	-16433.7	in-lbs
M1z	-1426.8	in-lbs
P2x	2797.7	lbs
P2y	1378.1	lbs
P2z	79.4	lbs
M2x	4469.6	in-lbs
M2y	-13332.7	in-lbs
M2z	-1452.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1307	93	12670	-321	0.34
#2	1373	61	10427	-623	0.7
#3	1905	462	9337	-256	0.39
#4	-1287	51	4933	-15	0.11
#5	1311	56	5469	-188	0.49
#6	5	110	8115	1	0.25

V09.19.15



16362-2-16 - VA - 80 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	137.3	1.6173	1.62	4.348	4.348	42.51
2	I	3.25	3.25	15.825	15.370	133.3	1.6171	4.87	4.224	4.224	41.34
3	I	3.25	6.50	15.370	14.915	129.4	1.6169	8.12	4.101	4.101	40.18
4	I	3.25	9.75	14.915	14.460	125.4	1.6166	11.37	3.978	3.978	39.02
5	I	3.25	13.00	14.460	14.005	121.4	1.6163	14.62	3.855	3.855	37.86
6	I	3.25	16.25	14.005	13.550	117.5	1.6161	17.87	3.731	3.731	36.70
7	I	3.25	19.50	13.550	13.095	113.5	1.6158	21.12	3.608	3.608	35.54
8	I	3.25	22.75	13.095	12.640	109.6	1.6154	24.37	3.485	3.485	34.38
9	J	2.69	26.00	13.000	12.623	152.9	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>1829</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)	50.429	23.135
Cross-Section Area (in^2)	12.584	7.218
Width-Thickness Ratio	65.12	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



16362-2-16 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 65' 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	12.47	54.21	54.34	1.100	0.000	0.00	0	0.531	0.00	0.00	
2	1.00	0.450	12.47	52.68	52.80	1.100	0.000	0.00	0	0.551	0.00	0.00	
3	1.00	0.450	12.47	51.14	51.26	1.100	0.000	0.00	0	0.572	0.00	0.00	
4	1.00	0.450	12.47	49.60	49.72	1.100	0.000	0.00	0	0.596	0.00	0.00	
5	1.00	0.450	12.47	48.07	48.18	1.100	0.000	0.00	0	0.621	0.00	0.00	
6	1.00	0.450	12.47	46.53	46.64	1.100	0.000	0.00	0	0.647	0.00	0.00	
7	1.00	0.450	12.47	44.99	45.10	1.100	0.000	0.00	0	0.676	0.00	0.00	
8	1.00	0.450	12.47	43.46	43.56	1.100	0.000	0.00	0	0.707	0.00	0.00	
9	1.00	0.450	12.47	35.81	35.90	1.100	0.000	0.00	0	0.711	0.00	0.00	
10	1.00	0.450	12.47	42.51	42.61	1.100	0.000	0.00	0	0.743	0.00	0.00	
11	1.00	0.450	12.47	40.92	41.02	1.100	0.000	0.00	0	0.781	0.00	0.00	
12	1.00	0.450	12.47	39.34	39.43	1.100	0.000	0.00	0	0.822	0.00	0.00	
13	1.00	0.450	12.47	37.75	37.84	1.100	0.000	0.00	0	0.867	0.00	0.00	
14	1.00	0.450	12.47	36.17	36.25	1.100	0.000	0.00	0	0.916	0.00	0.00	
15	1.00	0.450	12.47	34.58	34.67	1.100	0.000	0.00	0	0.971	0.00	0.00	
16	1.00	0.450	12.47	33.00	33.08	1.100	0.000	0.00	0	1.033	0.00	0.00	
17	1.00	0.477	13.22	33.30	31.49	1.100	0.000	0.00	1	1.101	0.00	0.00	
18	1.00	0.510	14.14	33.82	29.90	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.548	15.18	34.38	28.31	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.591	16.36	34.97	26.72	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	0.000	0.00	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	33.23	365.53	182.77	1.200	0.000	0.00	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



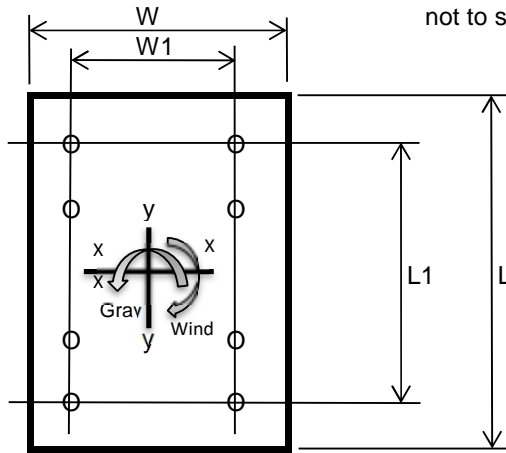
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2458	3799	-	lbs
Shear (Wind)	4905	2848	-	lbs
Torsion (Arm Rise)	16706	9699	-	ft-lbs
Moment (Gravity)	70215	113930	-	ft-lbs
Moment (Wind)	155040	88506	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	16.28	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	18.90	21.09	ksi
Bolt Shear Stress - fv	2.09	1.37	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	0.49	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	11.71	19.00	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	26.30	15.01	ksi
Combined applied stress for interaction (SRSS)	28.79	24.21	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-16 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 65' Arm W/24' Lum.

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

SHAFT TO BASEPLATE

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

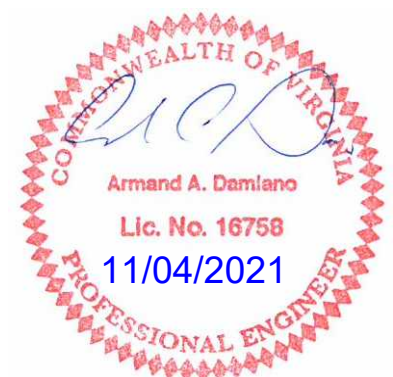
Tt - Thickness of shaft	0.3125	in
Dt - Shaft base diameter	19.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.333333	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.730769	
Kf - Fatigue stress concentration factor for finite life	2.31	
Ki - Fatigue stress concentration factor for infinite life	5.05	
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	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	1.80	
Ki - Fatigue stress concentration factor for infinite life	3.44	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-2-16 - VA - 80 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)	19.07	in
Shaft Thickness	0.313	in
Total Area	23.571	in ²
Ix	911	in ⁴
Iy	1023	in ⁴
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-2-16 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 65' 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	2458		2458	70215		70215		391	16709		0.47
Gp II	2458	4905	5487	70215	155040	170199	16706	873	40501	1988	0.86
Gp III	3799	2848	4748	113930	88506	144269	9699	755	34331	1154	0.72
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	1233		1233	22307		22307		342	11571		0.33
Gp II	1233	2536	2820	22307	57418	61600	8638	782	31951	2241	0.70
Gp III	1996	1467	2478	38171	32078	49861	4997	687	25862	1296	0.56
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		-



16362-2-16 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 65' 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)						

Shaft Base											
Gp I	4464		70215	0	70215		237		9329		0.27
Gp II	4464	6418	91213	132823	161127	156510	237	682	21409	10398	0.67
Gp III	6422	3874	60956	142995	155445	89241	341	412	20654	5929	0.51
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9972										

Shaft At Arm											
Gp I	3221		70215	0	70215		197		12364		0.35
Gp II	3221	5417	16706	77943	79713	156510	197	663	14036	13779	0.66
Gp III	4657	3164	9699	118004	118402	89241	285	387	20849	7857	0.56
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9972										



16362-2-16 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 65' Arm W/24' Lum.

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	6418 lbs
Bending Moment	161127 ft-lbs
Torsion Moment	156510 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	19.50 in

ANALYSIS - ANCHOR BOLTS

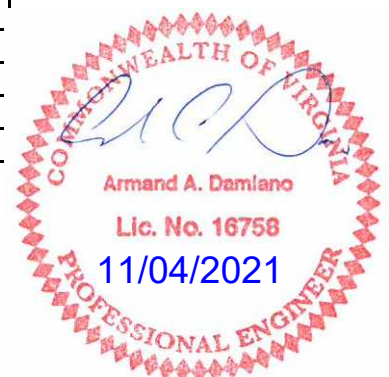
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	14.839 ksi
Bolt Direct Shear Stress	0.349 ksi
Bolt Torsion Shear Stress	7.852 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	14.839 ksi
$f_v =$	8.201 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.56 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	121 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	18.28 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	63 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	9.99 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-16 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 65' Arm W/24' Lum.

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	0 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	OK

ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation

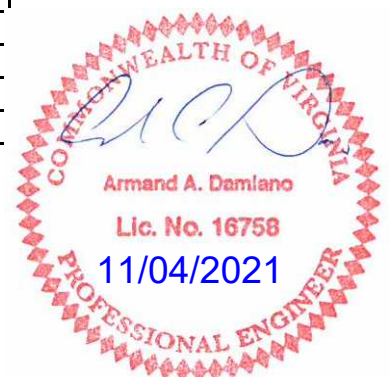
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A _b = Net Bearing Area	4.528 in ²
D _w = 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	37098 lbs
Computed Factor-of Safety	1.67 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	37098 lbs
Total Tensile Load	296784 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.59 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	37098 lbs
Total Tensile Load	296784 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

16362-2-17 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

11/04/21

General

Wind Vel.- mph	80	No	Roadway - mph	55	Fatigue Importance Factors	
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		AASHTO Editon	6TH	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	0.3125	0.14	19.50	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	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
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	14.25	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	Arm #1	Arm #2
GP I CSR	0.32	0.42	0.49	0.41					28.94	0.00
GP II CSR	0.72	0.78	0.86	0.79						
GP III CSR	0.57	0.66	0.74	0.66					47.45	
Nat.Wind (psi)	3092	619	6735	5792						

Arm #1 Flange Bolt (Max.) CSR	0.58
Arm #1 Flange Bolt Fatigue CSR	0.45
Arm #1 Flange Plate (Max.) CSR	0.74
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.72
Handhole at Toe (Fatigue) CSR	0.46
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	0.31
Base Plate Max. CSR	0.61
Anchorage Capacity S.F.	1.58
Concrete Pull Out Capacity S.F.	1.51

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
5963	6044	169694	177343



16362-2-17 - VA - 80 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	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											



16362-2-17 - VA - 80 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	19.500	19.352	67.61	0.5287	0.53	1.714	16.65	0.80
2	I	1.06	1.06	19.352	19.204	67.08	0.5287	1.59	1.701	16.53	0.80
3	I	1.06	2.12	19.204	19.055	66.56	0.5287	2.65	1.688	16.41	0.80
4	I	1.06	3.18	19.055	18.907	66.03	0.5287	3.71	1.675	16.28	0.80
5	I	1.06	4.24	18.907	18.759	65.51	0.5287	4.76	1.662	16.16	0.80
6	I	1.06	5.29	18.759	18.611	64.99	0.5287	5.82	1.649	16.04	0.80
7	I	1.06	6.35	18.611	18.462	64.46	0.5287	6.88	1.636	15.91	0.80
8	I	1.06	7.41	18.462	18.314	63.94	0.5287	7.94	1.622	15.79	0.80
9	I	1.06	8.47	18.314	18.166	63.41	0.5287	9.00	1.609	15.67	0.80
10	I	1.06	9.53	18.166	18.018	62.89	0.5287	10.06	1.596	15.54	0.80
11	I	1.06	10.59	18.018	17.869	62.36	0.5287	11.12	1.583	15.42	0.80
12	I	1.06	11.65	17.869	17.721	61.84	0.5287	12.18	1.570	15.30	0.80
13	I	1.06	12.71	17.721	17.573	61.31	0.5287	13.23	1.557	15.17	1.00
14	I	1.06	13.76	17.573	17.425	60.79	0.5287	14.29	1.544	15.05	1.00
15	I	1.06	14.82	17.425	17.276	60.27	0.5287	15.35	1.531	14.93	1.00
16	I	1.06	15.88	17.276	17.128	59.74	0.5287	16.41	1.518	14.80	1.00
17	I	1.06	16.94	17.128	16.980	59.22	0.5286	17.47	1.505	14.68	1.00
18	J	0.50	18.00	16.980	16.910	27.78	0.2498	18.25	0.706	6.89	1.00
19	I	0.50	18.50	16.910	16.840	27.66	0.2498	18.75	0.703	6.86	1.00
20	I	0.50	19.00	16.840	16.770	27.55	0.2498	19.25	0.700	6.83	1.00
						1161					

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)	866.45	567.94	0.00	546.74
Section Modulus (in^3)	90.31	68.15	0.00	
Cross-Section Area (in^2)	18.83	16.35	0.00	
Width-Thickness Ratio	62.40	54.34	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)	20.514	20.514	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	1.091
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-17 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 70' 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	9.97	17.09	0.000	21.43	1.100	4.576	7.84
2	0.450	9.97	16.96	0.000	21.26	1.100	4.576	7.78
3	0.450	9.97	16.83	0.000	21.10	1.100	4.576	7.72
4	0.450	9.97	16.70	0.000	20.94	1.100	4.576	7.66
5	0.450	9.97	16.57	0.000	20.77	1.100	4.576	7.60
6	0.450	9.97	16.44	0.000	20.61	1.100	4.576	7.54
7	0.450	9.97	16.31	0.000	20.44	1.100	4.576	7.48
8	0.450	9.97	16.18	0.001	20.28	1.100	4.576	7.42
9	0.450	9.97	16.05	0.001	20.12	1.100	4.576	7.36
10	0.450	9.97	15.92	0.001	19.95	1.100	4.576	7.30
11	0.450	9.97	15.79	0.001	19.79	1.100	4.576	7.24
12	0.450	9.97	15.65	0.001	19.63	1.100	4.576	7.19
13	0.450	12.47	19.42	0.002	19.46	1.100	4.576	7.13
14	0.450	12.47	19.25	0.002	19.30	1.100	4.576	7.07
15	0.450	12.47	19.09	0.002	19.14	1.100	4.576	7.01
16	0.450	12.47	18.93	0.003	18.97	1.100	4.576	6.95
17	0.450	12.47	18.76	0.003	18.81	1.100	4.576	6.89
18	0.450	12.47	8.80	0.002	8.83	1.100	4.576	3.23
19	0.450	12.47	8.77	0.002	8.79	1.100	4.576	3.22
20	0.450	12.47	8.73	0.002	8.75	1.100	4.576	3.20
Fix. #1	1.200	26.59	63.82	0.004	31.91	1.200	4.992	11.98
Fix. #2	1.200	26.59	63.82	0.004	31.91	1.200	4.992	11.98
Fix. #3	1.200	33.23	456.91	0.057	228.46	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-17 - VA - 80 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	167.1	1.8308	1.83	5.288	5.288	51.57
2	I	3.68	3.68	16.985	16.470	162.1	1.8306	5.51	5.130	5.130	50.08
3	I	3.68	7.36	16.470	15.954	157.0	1.8303	9.19	4.972	4.972	48.59
4	I	3.68	11.04	15.954	15.439	151.9	1.8299	12.87	4.814	4.814	47.10
5	I	3.68	14.72	15.439	14.924	146.8	1.8296	16.55	4.656	4.656	45.61
6	I	3.68	18.40	14.924	14.409	141.8	1.8292	20.23	4.498	4.498	44.12
7	J	2.92	22.08	14.790	14.381	193.4	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>2119</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)	58.397	31.467
Cross-Section Area (in^2)	13.541	8.620
Width-Thickness Ratio	70.00	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)	35.991	34.389
Allow. Shear Stress (ksi)	18.150	17.040



16362-2-17 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 70' 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	12.47	65.94	66.10	1.100	4.576	24.20	0	0.484	0.00	0.00	
2	1.00	0.450	12.47	63.97	64.12	1.100	4.576	23.47	0	0.503	0.00	0.00	
3	1.00	0.450	12.47	62.00	62.15	1.100	4.576	22.75	0	0.524	0.00	0.00	
4	1.00	0.450	12.47	60.03	60.17	1.100	4.576	22.03	0	0.546	0.00	0.00	
5	1.00	0.450	12.47	58.06	58.20	1.100	4.576	21.30	0	0.571	0.00	0.00	
6	1.00	0.450	12.47	56.09	56.22	1.100	4.576	20.58	0	0.597	0.00	0.00	
7	1.00	0.450	12.47	44.26	44.36	1.100	4.576	16.24	0	0.601	0.00	0.00	
8	1.00	0.450	12.47	50.86	50.98	1.100	4.576	18.66	0	0.626	0.00	0.00	
9	1.00	0.450	12.47	49.12	49.23	1.100	4.576	18.02	0	0.655	0.00	0.00	
10	1.00	0.450	12.47	47.37	47.49	1.100	4.576	17.38	0	0.686	0.00	0.00	
11	1.00	0.450	12.47	45.63	45.74	1.100	4.576	16.74	0	0.721	0.00	0.00	
12	1.00	0.450	12.47	43.89	43.99	1.100	4.576	16.10	0	0.758	0.00	0.00	
13	1.00	0.450	12.47	42.14	42.24	1.100	4.576	15.46	0	0.799	0.00	0.00	
14	1.00	0.450	12.47	40.40	40.50	1.100	4.576	14.83	0	0.844	0.00	0.00	
15	1.00	0.450	12.47	38.66	38.75	1.100	4.576	14.19	0	0.894	0.00	0.00	
16	1.00	0.450	12.47	36.91	37.00	1.100	4.576	13.55	0	0.949	0.00	0.00	
17	1.00	0.450	12.47	35.17	35.25	1.100	4.576	12.91	1	1.011	0.00	0.00	
18	1.00	0.468	12.97	34.77	33.51	1.100	4.576	12.27	1	1.080	0.00	0.00	
19	1.00	0.502	13.9	35.32	31.76	1.100	4.576	11.63	1	1.100	0.00	0.00	
20	1.00	0.540	14.96	35.92	30.01	1.100	4.576	10.99	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	31.34	329.07	164.54	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	33.23	365.53	182.77	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



16362-2-17 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

Flange Analysis - Arm #1

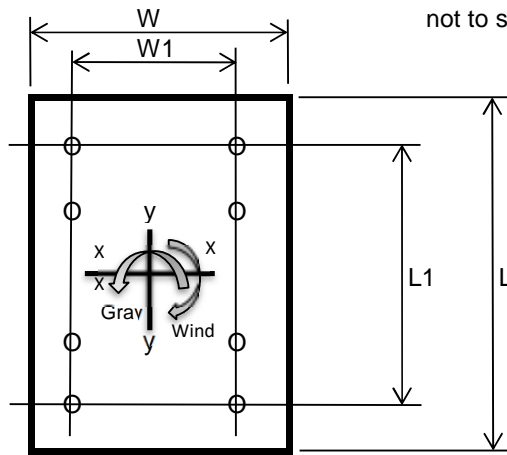
V06-21-16

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2748	4188	-	lbs
Shear (Wind)	5024	2977	-	lbs
Torsion (Arm Rise)	18428	10918	-	ft-lbs
Moment (Gravity)	85096	136462	-	ft-lbs
Moment (Wind)	177343	102775	-	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.	0.25	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	22.14	25.15	ksi
Bolt Shear Stress - fv	2.27	1.52	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	0.58	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	13.77	22.08	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	29.19	16.92	ksi
Combined applied stress for interaction (SRSS)	32.27	27.82	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-17 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

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

SHAFT TO BASEPLATE

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

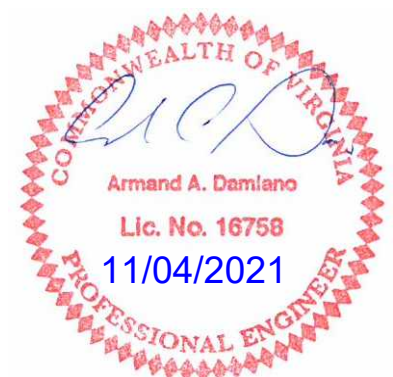
Tt - Thickness of shaft	0.3125	in
Dt - Shaft base diameter	19.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.333333	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.730769	
Kf - Fatigue stress concentration factor for finite life	2.31	
Ki - Fatigue stress concentration factor for infinite life	5.05	
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	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	1.76	
Ki - Fatigue stress concentration factor for infinite life	3.33	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-2-17 - VA - 80 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)	19.07	in
Shaft Thickness	0.313	in
Total Area	23.571	in ²
Ix	911	in ⁴
Iy	1023	in ⁴
Controlling Moment - Natural Wind Gust	23274	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	11.50	ksi
CSR	0.72	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	3.24	ksi
CSR	0.46	
Therefore	OK	



16362-2-17 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 70' 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	2748		2748	85096		85097		406	17487		0.49
Gp II	2748	5024	5727	85096	177343	196703	18428	846	40421	1894	0.86
Gp III	4188	2977	5139	136462	102775	170836	10918	760	35106	1122	0.74
Gp IV Natural		956	956		32774	32774	3507	142	6735	361	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	1710		1710	36287		36287		397	13839		0.41
Gp II	1710	3372	3782	36287	83811	91330	12370	878	34829	2359	0.79
Gp III	2742	1967	3375	60410	47848	77064	7214	784	29389	1376	0.66
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		-



16362-2-17 - VA - 80 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)						

Shaft Base											
Gp I	4074		85096	0	85096		216		11307		0.32
Gp II	4074	6044	106868	120239	160867	177343	216	643	21374	11782	0.72
Gp III	5963	3709	64496	156960	169694	102775	317	395	22547	6828	0.57
Gp IV Natural			23274	0	23274				3092		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9973										

Shaft At Arm											
Gp I	2831		85096	0	85096		173		14984		0.42
Gp II	2831	5050	18428	85116	87088	177343	173	618	15335	15614	0.78
Gp III	4271	3003	10918	136482	136918	102775	261	368	24109	9049	0.66
Gp IV Natural			3513	0	3513				619		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9973										



16362-2-17 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	6044 lbs
Bending Moment	169694 ft-lbs
Torsion Moment	177343 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	19.50 in

ANALYSIS - ANCHOR BOLTS

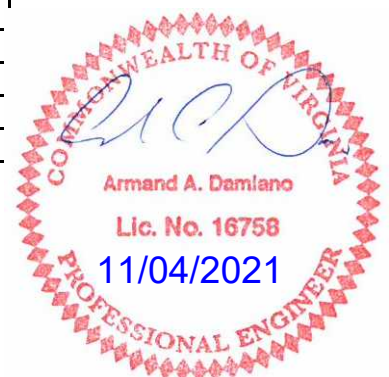
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	15.628 ksi
Bolt Direct Shear Stress	0.329 ksi
Bolt Torsion Shear Stress	8.897 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	15.628 ksi
$f_v =$	9.226 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.6 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	127 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	19.19 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	66 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	10.46 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-17 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 70' Arm

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	23274 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	2.15 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.31
Therefore	OK

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	39070 lbs
Computed Factor-of Safety	1.58 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	39070 lbs
Total Tensile Load	312560 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.51 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	39070 lbs
Total Tensile Load	312560 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

16362-2-18 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

11/04/21

General

Wind Vel.- mph	80	No	Roadway - mph	55	Fatigue Importance Factors	
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		AASHTO Editon	6TH	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	0.3125	0.14	19.50	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	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	0.2760		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	14.25	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	0.33	0.43	0.49	0.41							28.94	0.00
GP II CSR	0.76	0.82	0.86	0.79			0.93					
GP III CSR	0.60	0.68	0.74	0.66			0.70				47.45	
Nat.Wind (psi)	3194	644	6735	5792								

Arm #1 Flange Bolt (Max.) CSR	0.58
Arm #1 Flange Bolt Fatigue CSR	0.45
Arm #1 Flange Plate (Max.) CSR	0.74
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.74
Handhole at Toe (Fatigue) CSR	0.48
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	0.62	
Anchor Bolt Max. Fatigue Stress Ratio	0.32	
Base Plate Max. CSR	0.64	
Anchorage Capacity S.F.	1.51	
Concrete Pull Out Capacity S.F.	1.43	

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
6811	6539	178309	178813



16362-2-18 - VA - 80 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											



16362-2-18 - VA - 80 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	19.500	19.352	67.61	0.5287	0.53	1.714	16.65	0.80
2	I	1.06	1.06	19.352	19.204	67.08	0.5287	1.59	1.701	16.53	0.80
3	I	1.06	2.12	19.204	19.055	66.56	0.5287	2.65	1.688	16.41	0.80
4	I	1.06	3.18	19.055	18.907	66.03	0.5287	3.71	1.675	16.28	0.80
5	I	1.06	4.24	18.907	18.759	65.51	0.5287	4.76	1.662	16.16	0.80
6	I	1.06	5.29	18.759	18.611	64.99	0.5287	5.82	1.649	16.04	0.80
7	I	1.06	6.35	18.611	18.462	64.46	0.5287	6.88	1.636	15.91	0.80
8	I	1.06	7.41	18.462	18.314	63.94	0.5287	7.94	1.622	15.79	0.80
9	I	1.06	8.47	18.314	18.166	63.41	0.5287	9.00	1.609	15.67	0.80
10	I	1.06	9.53	18.166	18.018	62.89	0.5287	10.06	1.596	15.54	0.80
11	I	1.06	10.59	18.018	17.869	62.36	0.5287	11.12	1.583	15.42	0.80
12	I	1.06	11.65	17.869	17.721	61.84	0.5287	12.18	1.570	15.30	0.80
13	I	1.06	12.71	17.721	17.573	61.31	0.5287	13.23	1.557	15.17	1.00
14	I	1.06	13.76	17.573	17.425	60.79	0.5287	14.29	1.544	15.05	1.00
15	I	1.06	14.82	17.425	17.276	60.27	0.5287	15.35	1.531	14.93	1.00
16	I	1.06	15.88	17.276	17.128	59.74	0.5287	16.41	1.518	14.80	1.00
17	I	1.06	16.94	17.128	16.980	59.22	0.5286	17.47	1.505	14.68	1.00
18	J	3.00	18.00	16.980	16.560	164.94	1.4937	19.49	4.193	40.93	1.00
19	I	3.00	21.00	16.560	16.140	160.73	1.4936	22.49	4.088	39.94	1.00
20	J	1.00	24.00	16.140	16.000	52.64	0.4993	24.50	1.339	13.09	1.00
						1457					

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)	866.45	567.94	0.00	473.53
Section Modulus (in^3)	90.31	68.15	0.00	
Cross-Section Area (in^2)	18.83	16.35	0.00	
Width-Thickness Ratio	62.40	54.34	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)	14.296	14.296	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	1.091
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-18 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

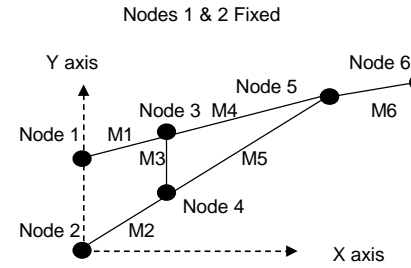
Shaft Analysis Continued

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	9.97	17.09	0.000	21.43	1.100	4.576	7.84
2	0.450	9.97	16.96	0.000	21.26	1.100	4.576	7.78
3	0.450	9.97	16.83	0.000	21.10	1.100	4.576	7.72
4	0.450	9.97	16.70	0.000	20.94	1.100	4.576	7.66
5	0.450	9.97	16.57	0.000	20.77	1.100	4.576	7.60
6	0.450	9.97	16.44	0.000	20.61	1.100	4.576	7.54
7	0.450	9.97	16.31	0.001	20.44	1.100	4.576	7.48
8	0.450	9.97	16.18	0.001	20.28	1.100	4.576	7.42
9	0.450	9.97	16.05	0.001	20.12	1.100	4.576	7.36
10	0.450	9.97	15.92	0.001	19.95	1.100	4.576	7.30
11	0.450	9.97	15.79	0.002	19.79	1.100	4.576	7.24
12	0.450	9.97	15.65	0.002	19.63	1.100	4.576	7.19
13	0.450	12.47	19.42	0.003	19.46	1.100	4.576	7.13
14	0.450	12.47	19.25	0.003	19.30	1.100	4.576	7.07
15	0.450	12.47	19.09	0.003	19.14	1.100	4.576	7.01
16	0.450	12.47	18.93	0.004	18.97	1.100	4.576	6.95
17	0.450	12.47	18.76	0.004	18.81	1.100	4.576	6.89
18	0.450	12.47	52.28	0.014	52.41	1.100	4.576	19.18
19	0.450	12.47	50.97	0.018	51.09	1.100	4.576	18.70
20	0.450	12.47	16.70	0.007	16.74	1.100	4.576	6.13
Fix. #1	1.200	26.59	63.82	0.006	31.91	1.200	4.992	11.98
Fix. #2	1.200	26.59	63.82	0.006	31.91	1.200	4.992	11.98
Fix. #3	1.200	33.23	456.91	0.079	228.46	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-18 - VA - 80 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)
80									
Node #1	0	27	0	0	-33.67	-32.1	0	0	0
Node #2	0	0	0	0	-35.63	-33.9	0	0	0
Node #3	100	59.5	0	0	-66.63	-67	0	0	0
Node #4	100	48.8	0	0	-69.41	-69.7	0	0	0
Node #5	200	79	0	0	-94.35	-98.8	0	0	0
Node #6	288	87	0	0	-85.29	-90.6	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	0.276	105.15	2.10	2.258	-67.33	1.1	1	-64.05	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-71.25	1.1	1	-67.78	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.54	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-65.23	1.1	1.1	-68.27	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-66.89	1.1	1.1	-70.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-56.58	1.1	1.1	-59.21	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-60.92					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2180.2	lbs
P1y	-694.6	lbs
P1z	233.5	lbs
M1x	8700.6	in-lbs
M1y	-32862.2	in-lbs
M1z	-898.1	in-lbs
P2x	2180.2	lbs
P2y	1079.6	lbs
P2z	158.6	lbs
M2x	8937.3	in-lbs
M2y	-26660.6	in-lbs
M2z	-928.7	in-lbs

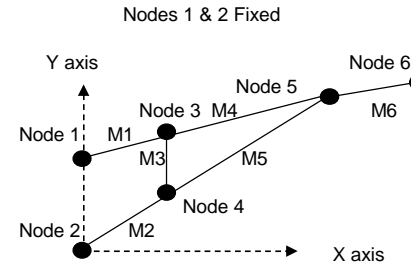
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1018	180	25256	-641	0.73
#2	1071	112	20749	-1246	0.93
#3	1489	513	10104	-511	0.39
#4	-1001	81	9678	-29	0.26
#5	1020	95	10774	-376	0.58
#6	4	110	8163	1	0.25

V09.19.15



16362-2-18 - VA - 80 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)
80									
Node #1	0	27	0	0	-40.85	-16.1	0	0	0
Node #2	0	0	0	0	-43.23	-17	0	0	0
Node #3	100	59.5	0	0	-81.04	-33.5	0	0	0
Node #4	100	48.8	0	0	-84.42	-34.9	0	0	0
Node #5	200	79	0	0	-114.49	-49.4	0	0	0
Node #6	288	87	0	0	-115.33	-45.3	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	0.276	105.15	2.10	2.258	-81.69	1.1	1	-32.03	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-86.45	1.1	1	-33.89	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.77	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-79.16	1.1	1.1	-34.13	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-81.16	1.1	1.1	-35.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-68.65	1.1	1.1	-29.60	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-30.46					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2797.7	lbs
P1y	-898.7	lbs
P1z	116.8	lbs
M1x	4351.1	in-lbs
M1y	-16433.7	in-lbs
M1z	-1426.8	in-lbs
P2x	2797.7	lbs
P2y	1378.1	lbs
P2z	79.4	lbs
M2x	4469.6	in-lbs
M2y	-13332.7	in-lbs
M2z	-1452.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1307	93	12670	-321	0.34
#2	1373	61	10427	-623	0.7
#3	1905	462	9337	-256	0.39
#4	-1287	51	4933	-15	0.11
#5	1311	56	5469	-188	0.49
#6	5	110	8115	1	0.25

V09.19.15



16362-2-18 - VA - 80 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	167.1	1.8308	1.83	5.288	5.288	51.57
2	I	3.68	3.68	16.985	16.470	162.1	1.8306	5.51	5.130	5.130	50.08
3	I	3.68	7.36	16.470	15.954	157.0	1.8303	9.19	4.972	4.972	48.59
4	I	3.68	11.04	15.954	15.439	151.9	1.8299	12.87	4.814	4.814	47.10
5	I	3.68	14.72	15.439	14.924	146.8	1.8296	16.55	4.656	4.656	45.61
6	I	3.68	18.40	14.924	14.409	141.8	1.8292	20.23	4.498	4.498	44.12
7	J	2.92	22.08	14.790	14.381	193.4	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>2119</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)	58.397	31.467
Cross-Section Area (in^2)	13.541	8.620
Width-Thickness Ratio	70.00	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)	35.991	34.389
Allow. Shear Stress (ksi)	18.150	17.040



16362-2-18 - VA - 80 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	12.47	65.94	66.10	1.100	4.576	24.20	0	0.484	0.00	0.00	
2	1.00	0.450	12.47	63.97	64.12	1.100	4.576	23.47	0	0.503	0.00	0.00	
3	1.00	0.450	12.47	62.00	62.15	1.100	4.576	22.75	0	0.524	0.00	0.00	
4	1.00	0.450	12.47	60.03	60.17	1.100	4.576	22.03	0	0.546	0.00	0.00	
5	1.00	0.450	12.47	58.06	58.20	1.100	4.576	21.30	0	0.571	0.00	0.00	
6	1.00	0.450	12.47	56.09	56.22	1.100	4.576	20.58	0	0.597	0.00	0.00	
7	1.00	0.450	12.47	44.26	44.36	1.100	4.576	16.24	0	0.601	0.00	0.00	
8	1.00	0.450	12.47	50.86	50.98	1.100	4.576	18.66	0	0.626	0.00	0.00	
9	1.00	0.450	12.47	49.12	49.23	1.100	4.576	18.02	0	0.655	0.00	0.00	
10	1.00	0.450	12.47	47.37	47.49	1.100	4.576	17.38	0	0.686	0.00	0.00	
11	1.00	0.450	12.47	45.63	45.74	1.100	4.576	16.74	0	0.721	0.00	0.00	
12	1.00	0.450	12.47	43.89	43.99	1.100	4.576	16.10	0	0.758	0.00	0.00	
13	1.00	0.450	12.47	42.14	42.24	1.100	4.576	15.46	0	0.799	0.00	0.00	
14	1.00	0.450	12.47	40.40	40.50	1.100	4.576	14.83	0	0.844	0.00	0.00	
15	1.00	0.450	12.47	38.66	38.75	1.100	4.576	14.19	0	0.894	0.00	0.00	
16	1.00	0.450	12.47	36.91	37.00	1.100	4.576	13.55	0	0.949	0.00	0.00	
17	1.00	0.450	12.47	35.17	35.25	1.100	4.576	12.91	1	1.011	0.00	0.00	
18	1.00	0.468	12.97	34.77	33.51	1.100	4.576	12.27	1	1.080	0.00	0.00	
19	1.00	0.502	13.9	35.32	31.76	1.100	4.576	11.63	1	1.100	0.00	0.00	
20	1.00	0.540	14.96	35.92	30.01	1.100	4.576	10.99	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	31.34	329.07	164.54	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	33.23	365.53	182.77	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

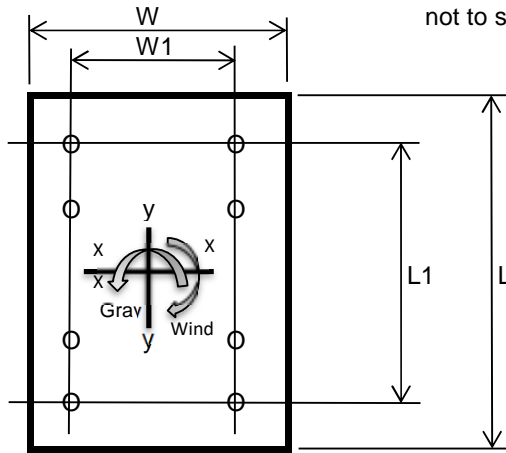
Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2748	4188	-	lbs
Shear (Wind)	5024	2977	-	lbs
Torsion (Arm Rise)	18428	10918	-	ft-lbs
Moment (Gravity)	85096	136462	-	ft-lbs
Moment (Wind)	177343	102775	-	ft-lbs
Nat. Wind Moment	-	-	32774	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs

Diameter of tube	17.50	in
Tube Wall Thick.	0.25	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 GpII	Results GpIII	
Bolt Tensile Stress Area	1.41	1.41	in ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	22.14	25.15	ksi
Bolt Shear Stress - fv	2.27	1.52	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	0.58	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis

Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	13.77	22.08	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	29.19	16.92	ksi
Combined applied stress for interaction (SRSS)	32.27	27.82	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-18 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

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

SHAFT TO BASEPLATE

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

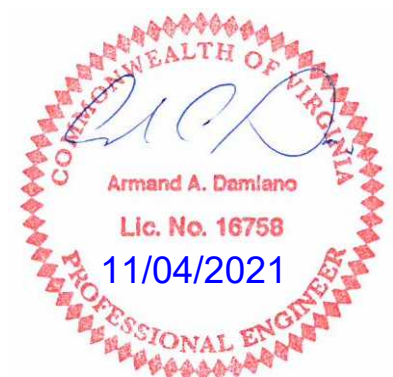
Tt - Thickness of shaft	0.3125	in
Dt - Shaft base diameter	19.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.333333	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.730769	
Kf - Fatigue stress concentration factor for finite life	2.31	
Ki - Fatigue stress concentration factor for infinite life	5.05	
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	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	1.76	
Ki - Fatigue stress concentration factor for infinite life	3.33	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-2-18 - VA - 80 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)	19.07	in
Shaft Thickness	0.313	in
Total Area	23.571	in ²
Ix	911	in ⁴
Iy	1023	in ⁴
Controlling Moment - Natural Wind Gust	24038	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	11.88	ksi
CSR	0.74	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	3.34	ksi
CSR	0.48	
Therefore	OK	



16362-2-18 - VA - 80 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	2748		2748	85096		85097		406	17487		0.49
Gp II	2748	5024	5727	85096	177343	196703	18428	846	40421	1894	0.86
Gp III	4188	2977	5139	136462	102775	170836	10918	760	35106	1122	0.74
Gp IV Natural		956	956		32774	32774	3507	142	6735	361	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#1 Joint											
Gp I	1710		1710	36287		36287		397	13839		0.41
Gp II	1710	3372	3782	36287	83811	91330	12370	878	34829	2359	0.79
Gp III	2742	1967	3375	60410	47848	77064	7214	784	29389	1376	0.66
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		-



16362-2-18 - VA - 80 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)						

Shaft Base											
Gp I	4754		85096	0	85096		252		11307		0.33
Gp II	4754	6539	106868	136691	173508	178813	252	695	23054	11879	0.76
Gp III	6811	4005	64496	166236	178309	103510	362	426	23692	6877	0.60
Gp IV Natural			24038	0	24038				3194		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9970										

Shaft At Arm											
Gp I	3511		85096	0	85096		215		14984		0.43
Gp II	3511	5536	18428	92825	94637	178813	215	677	16664	15743	0.82
Gp III	5046	3293	10918	140537	140960	103510	309	403	24821	9113	0.68
Gp IV Natural			3659	0	3659				644		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9970										



16362-2-18 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	6539 lbs
Bending Moment	178309 ft-lbs
Torsion Moment	178813 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	19.50 in

ANALYSIS - ANCHOR BOLTS

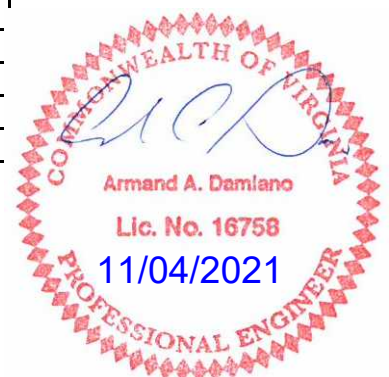
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	16.421 ksi
Bolt Direct Shear Stress	0.356 ksi
Bolt Torsion Shear Stress	8.971 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	16.421 ksi
$f_v =$	9.327 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.62 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	134 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	20.25 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	70 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	11.1 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-18 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 70' Arm w/24' Arm

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	24038 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	2.22 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.32
Therefore	OK

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	41053 lbs
Computed Factor-of Safety	1.51 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	41053 lbs
Total Tensile Load	328424 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.43 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	41053 lbs
Total Tensile Load	328424 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

16362-2-19 - VA - 80 MPH - MP-3 Std. Loads - Type C - 49/49' Arms

11/04/21

General

Wind Vel.- mph	80	No	Roadway - mph	55	Fatigue Importance Factors	
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		AASHTO Editon	6TH	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	19.00	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.2391	0.14	13.00	49.00	18.00	-	2.57	0	55	29000	180
Traffic Arm #2	0.2391	0.14	13.00	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	14.25	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	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	0.19	0.25	0.43		0.43						13.53	13.53
GP II CSR	0.48	0.42	0.85		0.85							
GP III CSR	0.39	0.38	0.67		0.67						22.27	22.27
Nat.Wind (psi)	2523	386	6293		6293							

Arm #1 Flange Bolt (Max.) CSR	0.28
Arm #1 Flange Bolt Fatigue CSR	0.22
Arm #1 Flange Plate (Max.) CSR	0.42
Arm #2 Flange Bolt (Max.) CSR	0.28
Arm #2 Flange Bolt Fatigue CSR	0.22
Arm #2 Flange Plate (Max.) CSR	0.42
Handhole at Root (Fatigue) CSR	0.59
Handhole at Toe (Fatigue) CSR	0.38
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	7	ksi
Anchor Bolt Max. CSR	0.48	
Anchor Bolt Max. Fatigue Stress Ratio	0.29	
Base Plate Max. CSR	0.55	
Anchorage Capacity S.F.	1.88	
Concrete Pull Out Capacity S.F.	1.79	

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
7268	4737	142960	132838



16362-2-19 - VA - 80 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										



16362-2-19 - VA - 80 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	19.000	18.852	78.74	0.5287	0.53	1.670	16.24	0.80
2	I	1.06	1.06	18.852	18.704	78.11	0.5287	1.59	1.657	16.11	0.80
3	I	1.06	2.12	18.704	18.555	77.48	0.5287	2.65	1.644	15.99	0.80
4	I	1.06	3.18	18.555	18.407	76.85	0.5287	3.71	1.631	15.87	0.80
5	I	1.06	4.24	18.407	18.259	76.22	0.5287	4.76	1.618	15.74	0.80
6	I	1.06	5.29	18.259	18.111	75.59	0.5287	5.82	1.605	15.62	0.80
7	I	1.06	6.35	18.111	17.962	74.97	0.5287	6.88	1.591	15.50	0.80
8	I	1.06	7.41	17.962	17.814	74.34	0.5287	7.94	1.578	15.37	0.80
9	I	1.06	8.47	17.814	17.666	73.71	0.5287	9.00	1.565	15.25	0.80
10	I	1.06	9.53	17.666	17.518	73.08	0.5287	10.06	1.552	15.13	0.80
11	I	1.06	10.59	17.518	17.369	72.45	0.5287	11.12	1.539	15.00	0.80
12	I	1.06	11.65	17.369	17.221	71.82	0.5287	12.18	1.526	14.88	0.80
13	I	1.06	12.71	17.221	17.073	71.19	0.5286	13.23	1.513	14.76	1.00
14	I	1.06	13.76	17.073	16.925	70.56	0.5286	14.29	1.500	14.63	1.00
15	I	1.06	14.82	16.925	16.776	69.93	0.5286	15.35	1.487	14.51	1.00
16	I	1.06	15.88	16.776	16.628	69.30	0.5286	16.41	1.474	14.39	1.00
17	I	1.06	16.94	16.628	16.480	68.67	0.5286	17.47	1.461	14.27	1.00
18	J	0.50	18.00	16.480	16.410	32.21	0.2498	18.25	0.685	6.69	1.00
19	I	0.50	18.50	16.410	16.340	32.07	0.2498	18.75	0.682	6.67	1.00
20	I	0.50	19.00	16.340	16.270	31.93	0.2498	19.25	0.679	6.64	1.00
						1350					

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)	950.95	614.83	614.83	591.09
Section Modulus (in^3)	102.12	76.35	76.35	
Cross-Section Area (in^2)	21.93	18.96	18.96	
Width-Thickness Ratio	50.67	43.95	43.95	
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)	19.914	19.914	19.914	
Allow. Shear Stress (ksi)	18.150	18.150	18.150	

Shaft Deflection From Arm#1 GP I Load (in)	0.460
Shaft Deflection From Arm#2 GP I Load (in)	0.460



16362-2-19 - VA - 80 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	9.97	16.65	0.000	20.87	1.100	4.576	7.64
2	0.450	9.97	16.52	0.000	20.71	1.100	4.576	7.58
3	0.450	9.97	16.39	0.000	20.55	1.100	4.576	7.52
4	0.450	9.97	16.26	0.000	20.38	1.100	4.576	7.46
5	0.450	9.97	16.13	0.000	20.22	1.100	4.576	7.40
6	0.450	9.97	16.00	0.000	20.06	1.100	4.576	7.34
7	0.450	9.97	15.87	0.000	19.89	1.100	4.576	7.28
8	0.450	9.97	15.74	0.001	19.73	1.100	4.576	7.22
9	0.450	9.97	15.61	0.001	19.57	1.100	4.576	7.16
10	0.450	9.97	15.48	0.001	19.40	1.100	4.576	7.10
11	0.450	9.97	15.35	0.001	19.24	1.100	4.576	7.04
12	0.450	9.97	15.21	0.001	19.08	1.100	4.576	6.98
13	0.450	12.47	18.87	0.002	18.91	1.100	4.576	6.92
14	0.450	12.47	18.70	0.002	18.75	1.100	4.576	6.86
15	0.450	12.47	18.54	0.002	18.59	1.100	4.576	6.80
16	0.450	12.47	18.38	0.002	18.42	1.100	4.576	6.74
17	0.450	12.47	18.21	0.003	18.26	1.100	4.576	6.68
18	0.450	12.47	8.54	0.001	8.57	1.100	4.576	3.14
19	0.450	12.47	8.51	0.001	8.53	1.100	4.576	3.12
20	0.450	12.47	8.47	0.001	8.49	1.100	4.576	3.11
Fix. #1	1.200	26.59	63.82	0.004	31.91	1.200	4.992	11.98
Fix. #2	1.200	26.59	63.82	0.004	31.91	1.200	4.992	11.98
Fix. #3	1.200	33.23	456.91	0.052	228.46	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-19 - VA - 80 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	13.000	12.657	78.8	1.2195	1.22	2.619	2.619	25.84
2	I	2.45	2.45	12.657	12.314	76.7	1.2194	3.67	2.549	2.549	25.18
3	I	2.45	4.90	12.314	11.971	74.5	1.2192	6.12	2.479	2.479	24.52
4	I	2.45	7.35	11.971	11.628	72.4	1.2191	8.57	2.409	2.409	23.86
5	I	2.45	9.80	11.628	11.285	70.2	1.2189	11.02	2.339	2.339	23.20
6	I	2.45	12.25	11.285	10.942	68.1	1.2187	13.47	2.269	2.269	22.54
7	I	2.45	14.70	10.942	10.599	65.9	1.2185	15.92	2.199	2.199	21.88
8	I	2.45	17.15	10.599	10.256	63.8	1.2183	18.37	2.129	2.129	21.22
9	I	2.45	19.60	10.256	9.913	61.7	1.2181	20.82	2.059	2.059	20.56
10	I	2.45	22.05	9.913	9.570	59.5	1.2178	23.27	1.989	1.989	19.90
11	I	2.45	24.50	9.570	9.227	57.4	1.2175	25.72	1.919	1.919	19.24
12	I	2.45	26.95	9.227	8.884	55.2	1.2173	28.17	1.849	1.849	18.58
13	I	2.45	29.40	8.884	8.541	53.1	1.2170	30.62	1.779	1.779	17.92
14	I	2.45	31.85	8.541	8.198	50.9	1.2166	33.07	1.709	1.709	17.26
15	I	2.45	34.30	8.198	7.855	48.8	1.2163	35.52	1.639	1.639	16.60
16	I	2.45	36.75	7.855	7.512	46.6	1.2159	37.97	1.569	1.569	15.94
17	I	2.45	39.20	7.512	7.169	44.5	1.2155	40.42	1.499	1.499	15.28
18	I	2.45	41.65	7.169	6.826	42.3	1.2150	42.86	1.429	1.429	14.62
19	I	2.45	44.10	6.826	6.483	40.2	1.2145	45.31	1.359	1.359	13.96
20	I	2.45	46.55	6.483	6.140	38.0	1.2139	47.76	1.289	1.289	13.30
		<u>49.00</u>				<u>1169</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)	30.564	0.000
Cross-Section Area (in^2)	9.581	0.000
Width-Thickness Ratio	54.37	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



16362-2-19 - VA - 80 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	12.47	32.66	32.74	1.100	4.576	11.99	0	0.710	0.00	0.00	
2	1.00	0.450	12.47	31.79	31.86	1.100	4.576	11.66	0	0.736	0.00	0.00	
3	1.00	0.450	12.47	30.91	30.99	1.100	4.576	11.34	0	0.763	0.00	0.00	
4	1.00	0.450	12.47	30.04	30.11	1.100	4.576	11.02	0	0.792	0.00	0.00	
5	1.00	0.450	12.47	29.17	29.24	1.100	4.576	10.70	0	0.823	0.00	0.00	
6	1.00	0.450	12.47	28.29	28.36	1.100	4.576	10.38	0	0.856	0.00	0.00	
7	1.00	0.450	12.47	27.42	27.49	1.100	4.576	10.06	0	0.891	0.00	0.00	
8	1.00	0.450	12.47	26.55	26.61	1.100	4.576	9.74	0	0.930	0.00	0.00	
9	1.00	0.450	12.47	25.67	25.74	1.100	4.576	9.42	0	0.971	0.00	0.00	
10	1.00	0.450	12.47	24.80	24.86	1.100	4.576	9.10	0	1.016	0.00	0.00	
11	1.00	0.461	12.78	24.52	23.99	1.100	4.576	8.78	0	1.064	0.00	0.00	
12	1.00	0.484	13.41	24.79	23.11	1.100	4.576	8.46	0	1.100	0.00	0.00	
13	1.00	0.509	14.1	25.08	22.24	1.100	4.576	8.14	0	1.100	0.00	0.00	
14	1.00	0.536	14.85	25.38	21.36	1.100	4.576	7.82	0	1.100	0.00	0.00	
15	1.00	0.566	15.68	25.70	20.48	1.100	4.576	7.50	1	1.100	0.00	0.00	
16	1.00	0.599	16.6	26.04	19.61	1.100	4.576	7.18	1	1.100	0.00	0.00	
17	1.00	0.636	17.62	26.41	18.73	1.100	4.576	6.86	1	1.100	0.00	0.00	
18	1.00	0.677	18.75	26.79	17.86	1.100	4.576	6.54	1	1.100	0.00	0.00	
19	1.00	0.723	20.01	27.19	16.98	1.100	4.576	6.22	1	1.100	0.00	0.00	
20	1.00	0.774	21.44	27.63	16.11	1.100	4.576	5.90	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	33.21	996.30	498.15	1.199	4.990	149.70	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	31.34	329.07	164.54	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	365.53	182.77	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



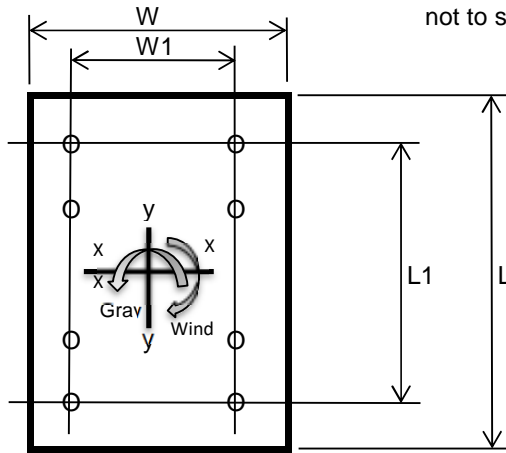
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1687	2656	-	lbs
Shear (Wind)	3844	2137	-	lbs
Torsion (Arm Rise)	9869	5487	-	ft-lbs
Moment (Gravity)	39191	63506	-	ft-lbs
Moment (Wind)	93945	51038	-	ft-lbs
Nat. Wind Moment	-	-	16026	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	13.00	in
Tube Wall Thick.	0.2391	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	11.10	11.83	ksi
Bolt Shear Stress - fv	1.32	0.85	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Fv =	44.22	44.22	ksi
Allowable Shear Stress = Ft =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.26	0.28	CSR
Therefore	OK	OK	
Natural Wind Bolt Tensile Stress	1.52	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.22	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	7.06	11.44	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	17.22	9.36	ksi
Combined applied stress for interaction (SRSS)	18.61	14.78	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-19 - VA - 80 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	13.000	12.657	78.8	1.2195	1.22	2.619	2.619	25.84
2	I	2.45	2.45	12.657	12.314	76.7	1.2194	3.67	2.549	2.549	25.18
3	I	2.45	4.90	12.314	11.971	74.5	1.2192	6.12	2.479	2.479	24.52
4	I	2.45	7.35	11.971	11.628	72.4	1.2191	8.57	2.409	2.409	23.86
5	I	2.45	9.80	11.628	11.285	70.2	1.2189	11.02	2.339	2.339	23.20
6	I	2.45	12.25	11.285	10.942	68.1	1.2187	13.47	2.269	2.269	22.54
7	I	2.45	14.70	10.942	10.599	65.9	1.2185	15.92	2.199	2.199	21.88
8	I	2.45	17.15	10.599	10.256	63.8	1.2183	18.37	2.129	2.129	21.22
9	I	2.45	19.60	10.256	9.913	61.7	1.2181	20.82	2.059	2.059	20.56
10	I	2.45	22.05	9.913	9.570	59.5	1.2178	23.27	1.989	1.989	19.90
11	I	2.45	24.50	9.570	9.227	57.4	1.2175	25.72	1.919	1.919	19.24
12	I	2.45	26.95	9.227	8.884	55.2	1.2173	28.17	1.849	1.849	18.58
13	I	2.45	29.40	8.884	8.541	53.1	1.2170	30.62	1.779	1.779	17.92
14	I	2.45	31.85	8.541	8.198	50.9	1.2166	33.07	1.709	1.709	17.26
15	I	2.45	34.30	8.198	7.855	48.8	1.2163	35.52	1.639	1.639	16.60
16	I	2.45	36.75	7.855	7.512	46.6	1.2159	37.97	1.569	1.569	15.94
17	I	2.45	39.20	7.512	7.169	44.5	1.2155	40.42	1.499	1.499	15.28
18	I	2.45	41.65	7.169	6.826	42.3	1.2150	42.86	1.429	1.429	14.62
19	I	2.45	44.10	6.826	6.483	40.2	1.2145	45.31	1.359	1.359	13.96
20	I	2.45	46.55	6.483	6.140	38.0	1.2139	47.76	1.289	1.289	13.30
		49.00				1169					

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)	30.564	0.000
Cross-Section Area (in^2)	9.581	0.000
Width-Thickness Ratio	54.37	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



16362-2-19 - VA - 80 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	12.47	32.66	32.74	1.100	4.576	11.99	0	0.710	0.00	0.00	
2	1.00	0.450	12.47	31.79	31.86	1.100	4.576	11.66	0	0.736	0.00	0.00	
3	1.00	0.450	12.47	30.91	30.99	1.100	4.576	11.34	0	0.763	0.00	0.00	
4	1.00	0.450	12.47	30.04	30.11	1.100	4.576	11.02	0	0.792	0.00	0.00	
5	1.00	0.450	12.47	29.17	29.24	1.100	4.576	10.70	0	0.823	0.00	0.00	
6	1.00	0.450	12.47	28.29	28.36	1.100	4.576	10.38	0	0.856	0.00	0.00	
7	1.00	0.450	12.47	27.42	27.49	1.100	4.576	10.06	0	0.891	0.00	0.00	
8	1.00	0.450	12.47	26.55	26.61	1.100	4.576	9.74	0	0.930	0.00	0.00	
9	1.00	0.450	12.47	25.67	25.74	1.100	4.576	9.42	0	0.971	0.00	0.00	
10	1.00	0.450	12.47	24.80	24.86	1.100	4.576	9.10	0	1.016	0.00	0.00	
11	1.00	0.461	12.78	24.52	23.99	1.100	4.576	8.78	0	1.064	0.00	0.00	
12	1.00	0.484	13.41	24.79	23.11	1.100	4.576	8.46	0	1.100	0.00	0.00	
13	1.00	0.509	14.10	25.08	22.24	1.100	4.576	8.14	0	1.100	0.00	0.00	
14	1.00	0.536	14.85	25.38	21.36	1.100	4.576	7.82	0	1.100	0.00	0.00	
15	1.00	0.566	15.68	25.70	20.48	1.100	4.576	7.50	1	1.100	0.00	0.00	
16	1.00	0.599	16.60	26.04	19.61	1.100	4.576	7.18	1	1.100	0.00	0.00	
17	1.00	0.636	17.62	26.41	18.73	1.100	4.576	6.86	1	1.100	0.00	0.00	
18	1.00	0.677	18.75	26.79	17.86	1.100	4.576	6.54	1	1.100	0.00	0.00	
19	1.00	0.723	20.01	27.19	16.98	1.100	4.576	6.22	1	1.100	0.00	0.00	
20	1.00	0.774	21.44	27.63	16.11	1.100	4.576	5.90	1	1.100	0.00	0.00	
Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	33.21	996.30	498.15	1.199	4.990	149.70	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	31.34	329.07	164.54	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	365.53	182.77	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



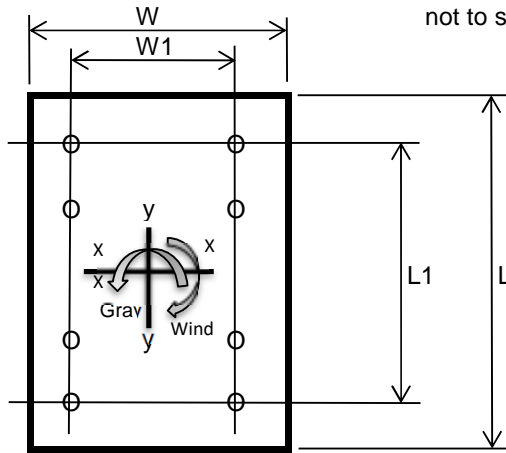
Flange Analysis - Arm #2

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1687	2656	-	lbs
Shear (Wind)	3844	2137	-	lbs
Torsion (Arm Rise)	9869	5487	-	ft-lbs
Moment (Gravity)	39191	63506	-	ft-lbs
Moment (Wind)	93945	51038	-	ft-lbs
Nat. Wind Moment	-	-	16026	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	13.00	in
Tube Wall Thick.	0.2391	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	11.10	11.83	ksi
Bolt Shear Stress - fv	1.32	0.85	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.26	0.28	CSR
Therefore	OK	OK	
Natural Wind Bolt Tensile Stress	1.52	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.22	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	7.06	11.44	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	17.22	9.36	ksi
Combined applied stress for interaction (SRSS)	18.61	14.78	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-19 - VA - 80 MPH - MP-3 Std. Loads - Type C - 49'/49' Arms

Fatigue Allowable - Shaft to Baseplate Weld & 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	19.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.368421	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.75	
Kf - Fatigue stress concentration factor for finite life	2.58	
Ki - Fatigue stress concentration factor for infinite life	6.07	
Fatigue Allowable	4.5	ksi

ARM 1 TO SIMPLEX PLATE

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

Tt - Thickness of arm inboard	0.2391	in
Dt - Arm base diameter	13.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.45	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.461538	
Kf - Fatigue stress concentration factor for finite life	1.89	
Ki - Fatigue stress concentration factor for infinite life	3.64	
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	0.2391	in
Dt - Arm base diameter	13.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.447677	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.461538	
Kf - Fatigue stress concentration factor for finite life	1.89	
Ki - Fatigue stress concentration factor for infinite life	3.64	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-2-19 - VA - 80 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)	18.57	in
Shaft Thickness	0.375	in
Total Area	26.1281	in ²
Ix	988	in ⁴
Iy	1065	in ⁴
Controlling Moment - Natural Wind Gust	21469	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	9.49	ksi
CSR	0.59	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.65	ksi
CSR	0.38	
Therefore	OK	



16362-2-19 - VA - 80 MPH - MP-3 Std. Loads - Type C - 49'/49' Arms

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	1687		1687	39191		39192		353	15388		0.43
Gp II	1687	3844	4198	39191	93945	101793	9869	877	39966	1938	0.85
Gp III	2656	2137	3410	63506	51038	81474	5487	712	31988	1078	0.67
Gp IV Natural		674	674		16026	16026	1731	141	6293	340	-
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	1687		1687	39191		39192		353	15388		0.43
Gp II	1687	3844	4198	39191	93945	101793	9869	877	39966	1938	0.85
Gp III	2656	2137	3410	63506	51038	81474	5487	712	31988	1078	0.67
Gp IV Natural		674	674		16026	16026	1731	141	6293	340	-
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		-



16362-2-19 - VA - 80 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)						

Shaft Base											
Gp I	4889		39191	39191	55425		223		6513		0.19
Gp II	4889	4737	87861	112774	142960	132838	223	433	16800	7805	0.48
Gp III	7268	2787	92914	103667	139212	72167	331	255	16359	4240	0.39
Gp IV Natural			16392	13865	21469				2523		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9970										

Shaft At Arm											
Gp I	3471		39191	39191	55425		183		8711		0.25
Gp II	3471	3869	46047	46310	65307	132838	183	409	10264	10439	0.42
Gp III	5409	2162	67318	67472	95311	72167	285	229	14980	5671	0.38
Gp IV Natural			1738	1731	2453				386		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9970										



16362-2-19 - VA - 80 MPH - MP-3 Std. Loads - Type C - 49/49' Arms

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	4737 lbs
Bending Moment	142960 ft-lbs
Torsion Moment	132838 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	19.00 in

ANALYSIS - ANCHOR BOLTS

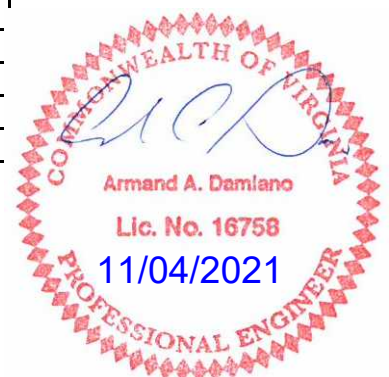
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	13.166 ksi
Bolt Direct Shear Stress	0.258 ksi
Bolt Torsion Shear Stress	6.665 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	13.166 ksi
$f_v =$	6.923 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.48 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.5 in
Design Moment	116 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	17.53 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.938 in
Design Moment	64 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	10.15 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-19 - VA - 80 MPH - MP-3 Std. Loads - Type C - 49/49' Arms

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	21469 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	1.98 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.29
Therefore	OK

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	32915 lbs
Computed Factor-of Safety	1.88 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	32915 lbs
Total Tensile Load	263320 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.79 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	32915 lbs
Total Tensile Load	263320 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

16362-2-20 - VA - 80 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

11/04/21

General

Wind Vel.- mph	80	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		AASHTO Editon	6TH	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	19.00	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.2391	0.14	13.00	49.00	18.00	-	2.57	0	55	29000	180
Traffic Arm #2	0.2391	0.14	13.00	49.00	18.00	-	2.57	0	55	29000	270
Lum Arm #1	0.2760		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	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	14.25	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	8
Bolt Diameter	1.50	1.50
Flange Plate Length (V)	27.00	27.00
Flange Plate Width (H)	27.00	27.00
Spac. Between Bolt (V)	22.50	22.50
Spac. Between Bolt (H)	22.50	22.50
Flange Plate Thk.	2.25	2.25
Flange Plate Yield (Fy)	50.00	50.00
Gusset Thk.	0.500	0.500
Plate Center Hole	6.00	6.00
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	0.19	0.25	0.43		0.43						13.53	13.53
GP II CSR	0.51	0.45	0.85		0.85		0.93					
GP III CSR	0.41	0.39	0.67		0.67		0.70				22.27	22.27
Nat.Wind (psi)	2590	402	6293		6293							

Arm #1 Flange Bolt (Max.) CSR	0.28
Arm #1 Flange Bolt Fatigue CSR	0.22
Arm #1 Flange Plate (Max.) CSR	0.42
Arm #2 Flange Bolt (Max.) CSR	0.28
Arm #2 Flange Bolt Fatigue CSR	0.22
Arm #2 Flange Plate (Max.) CSR	0.42
Handhole at Root (Fatigue) CSR	0.61
Handhole at Toe (Fatigue) CSR	0.39
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	0.51	
Anchor Bolt Max. Fatigue Stress Ratio	0.29	
Base Plate Max. CSR	0.61	
Anchorage Capacity S.F.	1.72	
Concrete Pull Out Capacity S.F.	1.63	

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
8160	5220	156559	134308



16362-2-20 - VA - 80 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										



16362-2-20 - VA - 80 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	19.000	18.852	78.74	0.5287	0.53	1.670	16.24	0.80
2	I	1.06	1.06	18.852	18.704	78.11	0.5287	1.59	1.657	16.11	0.80
3	I	1.06	2.12	18.704	18.555	77.48	0.5287	2.65	1.644	15.99	0.80
4	I	1.06	3.18	18.555	18.407	76.85	0.5287	3.71	1.631	15.87	0.80
5	I	1.06	4.24	18.407	18.259	76.22	0.5287	4.76	1.618	15.74	0.80
6	I	1.06	5.29	18.259	18.111	75.59	0.5287	5.82	1.605	15.62	0.80
7	I	1.06	6.35	18.111	17.962	74.97	0.5287	6.88	1.591	15.50	0.80
8	I	1.06	7.41	17.962	17.814	74.34	0.5287	7.94	1.578	15.37	0.80
9	I	1.06	8.47	17.814	17.666	73.71	0.5287	9.00	1.565	15.25	0.80
10	I	1.06	9.53	17.666	17.518	73.08	0.5287	10.06	1.552	15.13	0.80
11	I	1.06	10.59	17.518	17.369	72.45	0.5287	11.12	1.539	15.00	0.80
12	I	1.06	11.65	17.369	17.221	71.82	0.5287	12.18	1.526	14.88	0.80
13	I	1.06	12.71	17.221	17.073	71.19	0.5286	13.23	1.513	14.76	1.00
14	I	1.06	13.76	17.073	16.925	70.56	0.5286	14.29	1.500	14.63	1.00
15	I	1.06	14.82	16.925	16.776	69.93	0.5286	15.35	1.487	14.51	1.00
16	I	1.06	15.88	16.776	16.628	69.30	0.5286	16.41	1.474	14.39	1.00
17	I	1.06	16.94	16.628	16.480	68.67	0.5286	17.47	1.461	14.27	1.00
18	J	3.00	18.00	16.480	16.060	191.16	1.4935	19.49	4.068	39.75	1.00
19	I	3.00	21.00	16.060	15.640	186.11	1.4934	22.49	3.963	38.76	1.00
20	J	1.00	24.00	15.640	15.500	60.91	0.4993	24.50	1.298	12.70	1.00
						1692					

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)	950.95	614.83	614.83	509.28
Section Modulus (in ³)	102.12	76.35	76.35	
Cross-Section Area (in ²)	21.93	18.96	18.96	
Width-Thickness Ratio	50.67	43.95	43.95	
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)	13.388	13.388	13.388	
Allow. Shear Stress (ksi)	18.150	18.150	18.150	

Shaft Deflection From Arm#1 GP I Load (in)	0.460
Shaft Deflection From Arm#2 GP I Load (in)	0.460



16362-2-20 - VA - 80 MPH - MP-3 Std. Loads - Type F - 49/49' Arms w/24' Lum.

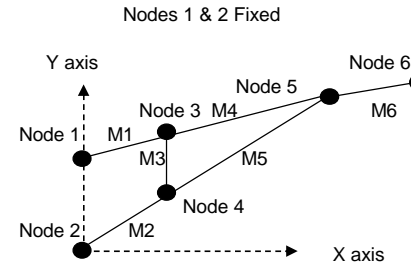
Shaft Analysis Continued

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	9.97	16.65	0.000	20.87	1.100	4.576	7.64
2	0.450	9.97	16.52	0.000	20.71	1.100	4.576	7.58
3	0.450	9.97	16.39	0.000	20.55	1.100	4.576	7.52
4	0.450	9.97	16.26	0.000	20.38	1.100	4.576	7.46
5	0.450	9.97	16.13	0.000	20.22	1.100	4.576	7.40
6	0.450	9.97	16.00	0.000	20.06	1.100	4.576	7.34
7	0.450	9.97	15.87	0.001	19.89	1.100	4.576	7.28
8	0.450	9.97	15.74	0.001	19.73	1.100	4.576	7.22
9	0.450	9.97	15.61	0.001	19.57	1.100	4.576	7.16
10	0.450	9.97	15.48	0.001	19.40	1.100	4.576	7.10
11	0.450	9.97	15.35	0.001	19.24	1.100	4.576	7.04
12	0.450	9.97	15.21	0.002	19.08	1.100	4.576	6.98
13	0.450	12.47	18.87	0.002	18.91	1.100	4.576	6.92
14	0.450	12.47	18.70	0.003	18.75	1.100	4.576	6.86
15	0.450	12.47	18.54	0.003	18.59	1.100	4.576	6.80
16	0.450	12.47	18.38	0.003	18.42	1.100	4.576	6.74
17	0.450	12.47	18.21	0.004	18.26	1.100	4.576	6.68
18	0.450	12.47	50.72	0.013	50.84	1.100	4.576	18.61
19	0.450	12.47	49.41	0.016	49.53	1.100	4.576	18.13
20	0.450	12.47	16.18	0.006	16.22	1.100	4.576	5.94
Fix. #1	1.200	26.59	63.82	0.005	31.91	1.200	4.992	11.98
Fix. #2	1.200	26.59	63.82	0.005	31.91	1.200	4.992	11.98
Fix. #3	1.200	33.23	456.91	0.072	228.46	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-20 - VA - 80 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)
80									
Node #1	0	27	0	0	-33.67	-32.1	0	0	0
Node #2	0	0	0	0	-35.63	-33.9	0	0	0
Node #3	100	59.5	0	0	-66.63	-67	0	0	0
Node #4	100	48.8	0	0	-69.41	-69.7	0	0	0
Node #5	200	79	0	0	-94.35	-98.8	0	0	0
Node #6	288	87	0	0	-85.29	-90.6	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	0.276	105.15	2.10	2.258	-67.33	1.1	1	-64.05	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-71.25	1.1	1	-67.78	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.54	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-65.23	1.1	1.1	-68.27	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-66.89	1.1	1.1	-70.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-56.58	1.1	1.1	-59.21	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-60.92					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2180.2	lbs
P1y	-694.6	lbs
P1z	233.5	lbs
M1x	8700.6	in-lbs
M1y	-32862.2	in-lbs
M1z	-898.1	in-lbs
P2x	2180.2	lbs
P2y	1079.6	lbs
P2z	158.6	lbs
M2x	8937.3	in-lbs
M2y	-26660.6	in-lbs
M2z	-928.7	in-lbs

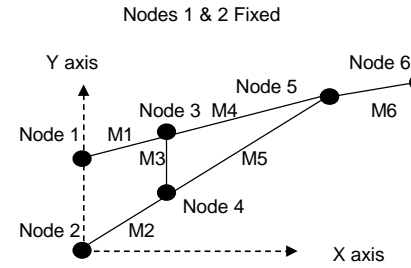
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1018	180	25256	-641	0.73
#2	1071	112	20749	-1246	0.93
#3	1489	513	10104	-511	0.39
#4	-1001	81	9678	-29	0.26
#5	1020	95	10774	-376	0.58
#6	4	110	8163	1	0.25

V09.19.15



16362-2-20 - VA - 80 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)
80									
Node #1	0	27	0	0	-40.85	-16.1	0	0	0
Node #2	0	0	0	0	-43.23	-17	0	0	0
Node #3	100	59.5	0	0	-81.04	-33.5	0	0	0
Node #4	100	48.8	0	0	-84.42	-34.9	0	0	0
Node #5	200	79	0	0	-114.49	-49.4	0	0	0
Node #6	288	87	0	0	-115.33	-45.3	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	0.276	105.15	2.10	2.258	-81.69	1.1	1	-32.03	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-86.45	1.1	1	-33.89	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.77	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-79.16	1.1	1.1	-34.13	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-81.16	1.1	1.1	-35.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-68.65	1.1	1.1	-29.60	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-30.46					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2797.7	lbs
P1y	-898.7	lbs
P1z	116.8	lbs
M1x	4351.1	in-lbs
M1y	-16433.7	in-lbs
M1z	-1426.8	in-lbs
P2x	2797.7	lbs
P2y	1378.1	lbs
P2z	79.4	lbs
M2x	4469.6	in-lbs
M2y	-13332.7	in-lbs
M2z	-1452.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1307	93	12670	-321	0.34
#2	1373	61	10427	-623	0.7
#3	1905	462	9337	-256	0.39
#4	-1287	51	4933	-15	0.11
#5	1311	56	5469	-188	0.49
#6	5	110	8115	1	0.25

V09.19.15



16362-2-20 - VA - 80 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	13.000	12.657	78.8	1.2195	1.22	2.619	2.619	25.84
2	I	2.45	2.45	12.657	12.314	76.7	1.2194	3.67	2.549	2.549	25.18
3	I	2.45	4.90	12.314	11.971	74.5	1.2192	6.12	2.479	2.479	24.52
4	I	2.45	7.35	11.971	11.628	72.4	1.2191	8.57	2.409	2.409	23.86
5	I	2.45	9.80	11.628	11.285	70.2	1.2189	11.02	2.339	2.339	23.20
6	I	2.45	12.25	11.285	10.942	68.1	1.2187	13.47	2.269	2.269	22.54
7	I	2.45	14.70	10.942	10.599	65.9	1.2185	15.92	2.199	2.199	21.88
8	I	2.45	17.15	10.599	10.256	63.8	1.2183	18.37	2.129	2.129	21.22
9	I	2.45	19.60	10.256	9.913	61.7	1.2181	20.82	2.059	2.059	20.56
10	I	2.45	22.05	9.913	9.570	59.5	1.2178	23.27	1.989	1.989	19.90
11	I	2.45	24.50	9.570	9.227	57.4	1.2175	25.72	1.919	1.919	19.24
12	I	2.45	26.95	9.227	8.884	55.2	1.2173	28.17	1.849	1.849	18.58
13	I	2.45	29.40	8.884	8.541	53.1	1.2170	30.62	1.779	1.779	17.92
14	I	2.45	31.85	8.541	8.198	50.9	1.2166	33.07	1.709	1.709	17.26
15	I	2.45	34.30	8.198	7.855	48.8	1.2163	35.52	1.639	1.639	16.60
16	I	2.45	36.75	7.855	7.512	46.6	1.2159	37.97	1.569	1.569	15.94
17	I	2.45	39.20	7.512	7.169	44.5	1.2155	40.42	1.499	1.499	15.28
18	I	2.45	41.65	7.169	6.826	42.3	1.2150	42.86	1.429	1.429	14.62
19	I	2.45	44.10	6.826	6.483	40.2	1.2145	45.31	1.359	1.359	13.96
20	I	2.45	46.55	6.483	6.140	38.0	1.2139	47.76	1.289	1.289	13.30
		<u>49.00</u>				<u>1169</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)	30.564	0.000
Cross-Section Area (in^2)	9.581	0.000
Width-Thickness Ratio	54.37	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



16362-2-20 - VA - 80 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	12.47	32.66	32.74	1.100	4.576	11.99	0	0.710	0.00	0.00	
2	1.00	0.450	12.47	31.79	31.86	1.100	4.576	11.66	0	0.736	0.00	0.00	
3	1.00	0.450	12.47	30.91	30.99	1.100	4.576	11.34	0	0.763	0.00	0.00	
4	1.00	0.450	12.47	30.04	30.11	1.100	4.576	11.02	0	0.792	0.00	0.00	
5	1.00	0.450	12.47	29.17	29.24	1.100	4.576	10.70	0	0.823	0.00	0.00	
6	1.00	0.450	12.47	28.29	28.36	1.100	4.576	10.38	0	0.856	0.00	0.00	
7	1.00	0.450	12.47	27.42	27.49	1.100	4.576	10.06	0	0.891	0.00	0.00	
8	1.00	0.450	12.47	26.55	26.61	1.100	4.576	9.74	0	0.930	0.00	0.00	
9	1.00	0.450	12.47	25.67	25.74	1.100	4.576	9.42	0	0.971	0.00	0.00	
10	1.00	0.450	12.47	24.80	24.86	1.100	4.576	9.10	0	1.016	0.00	0.00	
11	1.00	0.461	12.78	24.52	23.99	1.100	4.576	8.78	0	1.064	0.00	0.00	
12	1.00	0.484	13.41	24.79	23.11	1.100	4.576	8.46	0	1.100	0.00	0.00	
13	1.00	0.509	14.1	25.08	22.24	1.100	4.576	8.14	0	1.100	0.00	0.00	
14	1.00	0.536	14.85	25.38	21.36	1.100	4.576	7.82	0	1.100	0.00	0.00	
15	1.00	0.566	15.68	25.70	20.48	1.100	4.576	7.50	1	1.100	0.00	0.00	
16	1.00	0.599	16.6	26.04	19.61	1.100	4.576	7.18	1	1.100	0.00	0.00	
17	1.00	0.636	17.62	26.41	18.73	1.100	4.576	6.86	1	1.100	0.00	0.00	
18	1.00	0.677	18.75	26.79	17.86	1.100	4.576	6.54	1	1.100	0.00	0.00	
19	1.00	0.723	20.01	27.19	16.98	1.100	4.576	6.22	1	1.100	0.00	0.00	
20	1.00	0.774	21.44	27.63	16.11	1.100	4.576	5.90	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	33.21	996.30	498.15	1.199	4.990	149.70	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	31.34	329.07	164.54	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	365.53	182.77	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



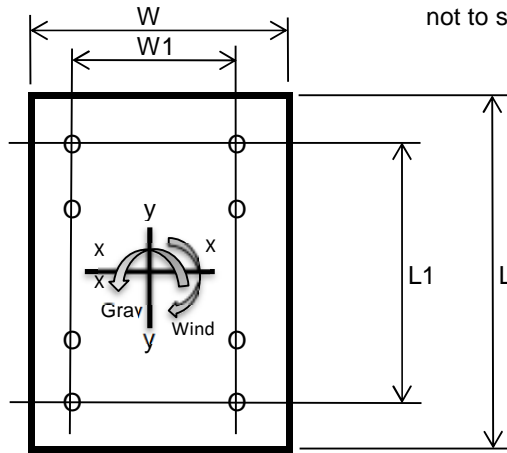
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1687	2656	-	lbs
Shear (Wind)	3844	2137	-	lbs
Torsion (Arm Rise)	9869	5487	-	ft-lbs
Moment (Gravity)	39191	63506	-	ft-lbs
Moment (Wind)	93945	51038	-	ft-lbs
Nat. Wind Moment	-	-	16026	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	13.00	in
Tube Wall Thick.	0.2391	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	11.10	11.83	ksi
Bolt Shear Stress - fv	1.32	0.85	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.26	0.28	CSR
Therefore	OK	OK	
Natural Wind Bolt Tensile Stress	1.52	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.22	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	7.06	11.44	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	17.22	9.36	ksi
Combined applied stress for interaction (SRSS)	18.61	14.78	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-20 - VA - 80 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	13.000	12.657	78.8	1.2195	1.22	2.619	2.619	25.84
2	I	2.45	2.45	12.657	12.314	76.7	1.2194	3.67	2.549	2.549	25.18
3	I	2.45	4.90	12.314	11.971	74.5	1.2192	6.12	2.479	2.479	24.52
4	I	2.45	7.35	11.971	11.628	72.4	1.2191	8.57	2.409	2.409	23.86
5	I	2.45	9.80	11.628	11.285	70.2	1.2189	11.02	2.339	2.339	23.20
6	I	2.45	12.25	11.285	10.942	68.1	1.2187	13.47	2.269	2.269	22.54
7	I	2.45	14.70	10.942	10.599	65.9	1.2185	15.92	2.199	2.199	21.88
8	I	2.45	17.15	10.599	10.256	63.8	1.2183	18.37	2.129	2.129	21.22
9	I	2.45	19.60	10.256	9.913	61.7	1.2181	20.82	2.059	2.059	20.56
10	I	2.45	22.05	9.913	9.570	59.5	1.2178	23.27	1.989	1.989	19.90
11	I	2.45	24.50	9.570	9.227	57.4	1.2175	25.72	1.919	1.919	19.24
12	I	2.45	26.95	9.227	8.884	55.2	1.2173	28.17	1.849	1.849	18.58
13	I	2.45	29.40	8.884	8.541	53.1	1.2170	30.62	1.779	1.779	17.92
14	I	2.45	31.85	8.541	8.198	50.9	1.2166	33.07	1.709	1.709	17.26
15	I	2.45	34.30	8.198	7.855	48.8	1.2163	35.52	1.639	1.639	16.60
16	I	2.45	36.75	7.855	7.512	46.6	1.2159	37.97	1.569	1.569	15.94
17	I	2.45	39.20	7.512	7.169	44.5	1.2155	40.42	1.499	1.499	15.28
18	I	2.45	41.65	7.169	6.826	42.3	1.2150	42.86	1.429	1.429	14.62
19	I	2.45	44.10	6.826	6.483	40.2	1.2145	45.31	1.359	1.359	13.96
20	I	2.45	46.55	6.483	6.140	38.0	1.2139	47.76	1.289	1.289	13.30
		49.00				1169					

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)	30.564	0.000
Cross-Section Area (in^2)	9.581	0.000
Width-Thickness Ratio	54.37	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



16362-2-20 - VA - 80 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	12.47	32.66	32.74	1.100	4.576	11.99	0	0.710	0.00	0.00	
2	1.00	0.450	12.47	31.79	31.86	1.100	4.576	11.66	0	0.736	0.00	0.00	
3	1.00	0.450	12.47	30.91	30.99	1.100	4.576	11.34	0	0.763	0.00	0.00	
4	1.00	0.450	12.47	30.04	30.11	1.100	4.576	11.02	0	0.792	0.00	0.00	
5	1.00	0.450	12.47	29.17	29.24	1.100	4.576	10.70	0	0.823	0.00	0.00	
6	1.00	0.450	12.47	28.29	28.36	1.100	4.576	10.38	0	0.856	0.00	0.00	
7	1.00	0.450	12.47	27.42	27.49	1.100	4.576	10.06	0	0.891	0.00	0.00	
8	1.00	0.450	12.47	26.55	26.61	1.100	4.576	9.74	0	0.930	0.00	0.00	
9	1.00	0.450	12.47	25.67	25.74	1.100	4.576	9.42	0	0.971	0.00	0.00	
10	1.00	0.450	12.47	24.80	24.86	1.100	4.576	9.10	0	1.016	0.00	0.00	
11	1.00	0.461	12.78	24.52	23.99	1.100	4.576	8.78	0	1.064	0.00	0.00	
12	1.00	0.484	13.41	24.79	23.11	1.100	4.576	8.46	0	1.100	0.00	0.00	
13	1.00	0.509	14.10	25.08	22.24	1.100	4.576	8.14	0	1.100	0.00	0.00	
14	1.00	0.536	14.85	25.38	21.36	1.100	4.576	7.82	0	1.100	0.00	0.00	
15	1.00	0.566	15.68	25.70	20.48	1.100	4.576	7.50	1	1.100	0.00	0.00	
16	1.00	0.599	16.60	26.04	19.61	1.100	4.576	7.18	1	1.100	0.00	0.00	
17	1.00	0.636	17.62	26.41	18.73	1.100	4.576	6.86	1	1.100	0.00	0.00	
18	1.00	0.677	18.75	26.79	17.86	1.100	4.576	6.54	1	1.100	0.00	0.00	
19	1.00	0.723	20.01	27.19	16.98	1.100	4.576	6.22	1	1.100	0.00	0.00	
20	1.00	0.774	21.44	27.63	16.11	1.100	4.576	5.90	1	1.100	0.00	0.00	
Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	33.21	996.30	498.15	1.199	4.990	149.70	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	31.34	329.07	164.54	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	365.53	182.77	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



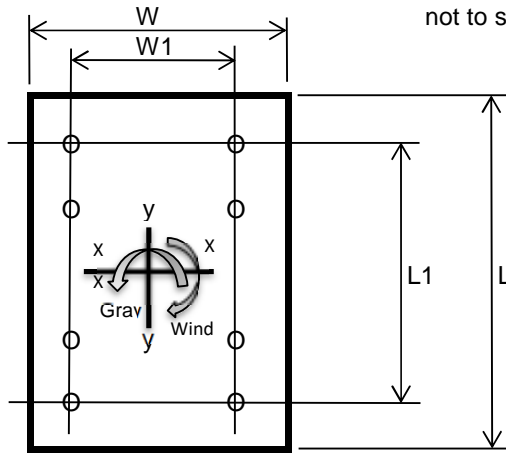
Flange Analysis - Arm #2

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1687	2656	-	lbs
Shear (Wind)	3844	2137	-	lbs
Torsion (Arm Rise)	9869	5487	-	ft-lbs
Moment (Gravity)	39191	63506	-	ft-lbs
Moment (Wind)	93945	51038	-	ft-lbs
Nat. Wind Moment	-	-	16026	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	13.00	in
Tube Wall Thick.	0.2391	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	11.10	11.83	ksi
Bolt Shear Stress - fv	1.32	0.85	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.26	0.28	CSR
Therefore	OK	OK	
Natural Wind Bolt Tensile Stress	1.52	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.22	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	7.06	11.44	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	17.22	9.36	ksi
Combined applied stress for interaction (SRSS)	18.61	14.78	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-20 - VA - 80 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

Fatigue Allowable - Shaft to Baseplate Weld & 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	19.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.368421	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.75	
Kf - Fatigue stress concentration factor for finite life	2.58	
Ki - Fatigue stress concentration factor for infinite life	6.07	
Fatigue Allowable	4.5	ksi

ARM 1 TO SIMPLEX PLATE

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

Tt - Thickness of arm inboard	0.2391	in
Dt - Arm base diameter	13.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.45	
Dop - Baseplate center hole diameter	6.00	in
Cop - Center hole to arm diameter ratio	0.461538	
Kf - Fatigue stress concentration factor for finite life	1.89	
Ki - Fatigue stress concentration factor for infinite life	3.64	
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	0.2391	in
Dt - Arm base diameter	13.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.447677	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.461538	
Kf - Fatigue stress concentration factor for finite life	1.89	
Ki - Fatigue stress concentration factor for infinite life	3.64	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-2-20 - VA - 80 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)	18.57	in
Shaft Thickness	0.375	in
Total Area	26.1281	in ²
Ix	988	in ⁴
Iy	1065	in ⁴
Controlling Moment - Natural Wind Gust	22040	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	9.74	ksi
CSR	0.61	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.72	ksi
CSR	0.39	
Therefore	OK	



16362-2-20 - VA - 80 MPH - MP-3 Std. Loads - Type F - 49'/49' 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)					

Arm#1 Base											
Gp I	1687		1687	39191		39192		353	15388		0.43
Gp II	1687	3844	4198	39191	93945	101793	9869	877	39966	1938	0.85
Gp III	2656	2137	3410	63506	51038	81474	5487	712	31988	1078	0.67
Gp IV Natural		674	674		16026	16026	1731	141	6293	340	-
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	1687		1687	39191		39192		353	15388		0.43
Gp II	1687	3844	4198	39191	93945	101793	9869	877	39966	1938	0.85
Gp III	2656	2137	3410	63506	51038	81474	5487	712	31988	1078	0.67
Gp IV Natural		674	674		16026	16026	1731	141	6293	340	-
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		-



16362-2-20 - VA - 80 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)						

Shaft Base											
Gp I	5616		39191	39191	55425		256		6513		0.19
Gp II	5616	5220	78718	135330	156559	134308	256	477	18398	7892	0.51
Gp III	8160	3075	90564	114851	146262	72902	372	281	17188	4283	0.41
Gp IV Natural			17132	13865	22040				2590		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9967										

Shaft At Arm											
Gp I	4198		39191	39191	55425		221		8711		0.25
Gp II	4198	4352	45535	54467	70994	134308	221	459	11158	10554	0.45
Gp III	6230	2450	67318	71515	98215	72902	329	259	15436	5729	0.39
Gp IV Natural			1879	1731	2555				402		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9967										



16362-2-20 - VA - 80 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	5220 lbs
Bending Moment	156559 ft-lbs
Torsion Moment	134308 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	19.00 in

ANALYSIS - ANCHOR BOLTS

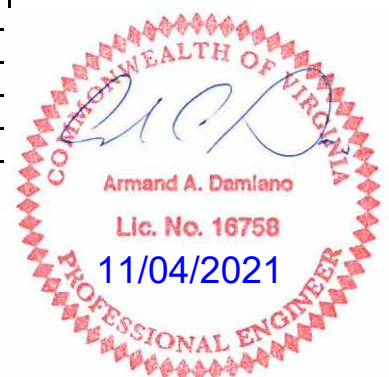
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	14.418 ksi
Bolt Direct Shear Stress	0.284 ksi
Bolt Torsion Shear Stress	6.738 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	14.418 ksi
$f_v =$	7.022 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.51 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.5 in
Design Moment	127 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	19.19 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.938 in
Design Moment	70 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	11.1 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-20 - VA - 80 MPH - MP-3 Std. Loads - Type F - 49'/49' Arms w/24' Lum.

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	22040 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	2.03 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.29
Therefore	OK

ANCHORAGE CAPACITY CHECK - Drilled Pier Foundation

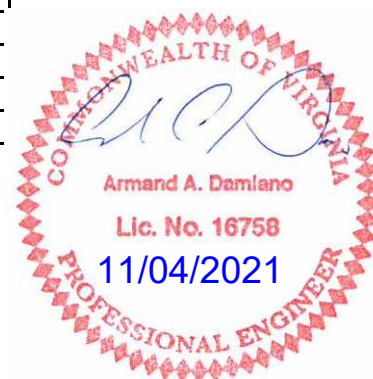
Anchor Bolt Length	60.0 in
Anchor Bolt Projection above Fdn.	11 in
Minimum Embedment Length	30 in
Foundation Diameter	48 in
Concrete Cover (in)	4 in
f'c = 28 Day Concrete Comp. Strength	3000 psi
Vertical Reinforcing Bar Size #	8
Rebar Yield Strength fy	60 ksi
Capacity Reduction For Group Action	50%
$T = 140 A_b \sqrt{f'_c} [0.7 + \ln(2C' / (D_w - D))]$	124231 lbs
T = Anchorage Tensile Capacity	
A _b = Net Bearing Area	4.528 in ²
D _w = 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	36045 lbs
Computed Factor-of Safety	1.72 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	36045 lbs
Total Tensile Load	288360 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.63 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	36045 lbs
Total Tensile Load	288360 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

16362-2-21 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

11/04/21

General

Wind Vel. - mph	80	No	Roadway - mph	55	Fatigue Importance Factors	
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		AASHTO Editon	6TH	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	0.3125	0.14	19.50	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.2391	0.14	13.00	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	14.25	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	0.16	0.21	0.45								15.24	0.00
GP II CSR	0.42	0.33	0.94									
GP III CSR	0.30	0.30	0.73								25.08	
Nat.Wind (psi)	2299	331	6962									

Arm #1 Flange Bolt (Max.) CSR	0.29
Arm #1 Flange Bolt Fatigue CSR	0.24
Arm #1 Flange Plate (Max.) CSR	0.47
Arm #2 Flange Bolt (Max.) CSR	-
Arm #2 Flange Bolt Fatigue CSR	-
Arm #2 Flange Plate (Max.) CSR	-
Handhole at Root (Fatigue) CSR	0.53
Handhole at Toe (Fatigue) CSR	0.34
Minimum Qty of Vertical Reinf. Bars	5

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	0.38	
Anchor Bolt Max. Fatigue Stress Ratio	0.23	
Base Plate Max. CSR	0.41	
Anchorage Capacity S.F.	2.4	
Concrete Pull Out Capacity S.F.	2.28	

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
4496	5113	112402	105102



16362-2-21 - VA - 80 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										



16362-2-21 - VA - 80 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	19.500	19.352	67.61	0.5287	0.53	1.714	16.65	0.80
2	I	1.06	1.06	19.352	19.204	67.08	0.5287	1.59	1.701	16.53	0.80
3	I	1.06	2.12	19.204	19.055	66.56	0.5287	2.65	1.688	16.41	0.80
4	I	1.06	3.18	19.055	18.907	66.03	0.5287	3.71	1.675	16.28	0.80
5	I	1.06	4.24	18.907	18.759	65.51	0.5287	4.76	1.662	16.16	0.80
6	I	1.06	5.29	18.759	18.611	64.99	0.5287	5.82	1.649	16.04	0.80
7	I	1.06	6.35	18.611	18.462	64.46	0.5287	6.88	1.636	15.91	0.80
8	I	1.06	7.41	18.462	18.314	63.94	0.5287	7.94	1.622	15.79	0.80
9	I	1.06	8.47	18.314	18.166	63.41	0.5287	9.00	1.609	15.67	0.80
10	I	1.06	9.53	18.166	18.018	62.89	0.5287	10.06	1.596	15.54	0.80
11	I	1.06	10.59	18.018	17.869	62.36	0.5287	11.12	1.583	15.42	0.80
12	I	1.06	11.65	17.869	17.721	61.84	0.5287	12.18	1.570	15.30	0.80
13	I	1.06	12.71	17.721	17.573	61.31	0.5287	13.23	1.557	15.17	1.00
14	I	1.06	13.76	17.573	17.425	60.79	0.5287	14.29	1.544	15.05	1.00
15	I	1.06	14.82	17.425	17.276	60.27	0.5287	15.35	1.531	14.93	1.00
16	I	1.06	15.88	17.276	17.128	59.74	0.5287	16.41	1.518	14.80	1.00
17	I	1.06	16.94	17.128	16.980	59.22	0.5286	17.47	1.505	14.68	1.00
18	J	0.50	18.00	16.980	16.910	27.78	0.2498	18.25	0.706	6.89	1.00
19	I	0.50	18.50	16.910	16.840	27.66	0.2498	18.75	0.703	6.86	1.00
20	I	0.50	19.00	16.840	16.770	27.55	0.2498	19.25	0.700	6.83	1.00
						1161					

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)	866.45	567.94	0.00	546.74
Section Modulus (in^3)	90.31	68.15	0.00	
Cross-Section Area (in^2)	18.83	16.35	0.00	
Width-Thickness Ratio	62.40	54.34	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)	20.514	20.514	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.529
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-21 - VA - 80 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	9.97	17.09	0.000	21.43	1.100	4.576	7.84
2	0.450	9.97	16.96	0.000	21.26	1.100	4.576	7.78
3	0.450	9.97	16.83	0.000	21.10	1.100	4.576	7.72
4	0.450	9.97	16.70	0.000	20.94	1.100	4.576	7.66
5	0.450	9.97	16.57	0.000	20.77	1.100	4.576	7.60
6	0.450	9.97	16.44	0.000	20.61	1.100	4.576	7.54
7	0.450	9.97	16.31	0.000	20.44	1.100	4.576	7.48
8	0.450	9.97	16.18	0.001	20.28	1.100	4.576	7.42
9	0.450	9.97	16.05	0.001	20.12	1.100	4.576	7.36
10	0.450	9.97	15.92	0.001	19.95	1.100	4.576	7.30
11	0.450	9.97	15.79	0.001	19.79	1.100	4.576	7.24
12	0.450	9.97	15.65	0.001	19.63	1.100	4.576	7.19
13	0.450	12.47	19.42	0.002	19.46	1.100	4.576	7.13
14	0.450	12.47	19.25	0.002	19.30	1.100	4.576	7.07
15	0.450	12.47	19.09	0.002	19.14	1.100	4.576	7.01
16	0.450	12.47	18.93	0.003	18.97	1.100	4.576	6.95
17	0.450	12.47	18.76	0.003	18.81	1.100	4.576	6.89
18	0.450	12.47	8.80	0.002	8.83	1.100	4.576	3.23
19	0.450	12.47	8.77	0.002	8.79	1.100	4.576	3.22
20	0.450	12.47	8.73	0.002	8.75	1.100	4.576	3.20
Fix. #1	1.200	26.59	63.82	0.004	31.91	1.200	4.992	11.98
Fix. #2	1.200	26.59	63.82	0.004	31.91	1.200	4.992	11.98
Fix. #3	1.200	33.23	456.91	0.057	228.46	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-21 - VA - 80 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	13.000	12.650	80.4	1.2443	1.24	2.672	2.672	26.36
2	I	2.50	2.50	12.650	12.300	78.2	1.2442	3.74	2.599	2.599	25.67
3	I	2.50	5.00	12.300	11.950	76.0	1.2440	6.24	2.526	2.526	24.99
4	I	2.50	7.50	11.950	11.600	73.7	1.2438	8.74	2.453	2.453	24.30
5	I	2.50	10.00	11.600	11.250	71.5	1.2436	11.24	2.380	2.380	23.61
6	I	2.50	12.50	11.250	10.900	69.2	1.2434	13.74	2.307	2.307	22.92
7	I	2.50	15.00	10.900	10.550	67.0	1.2432	16.24	2.234	2.234	22.24
8	I	2.50	17.50	10.550	10.200	64.8	1.2430	18.74	2.161	2.161	21.55
9	I	2.50	20.00	10.200	9.850	62.5	1.2427	21.24	2.089	2.089	20.86
10	I	2.50	22.50	9.850	9.500	60.3	1.2425	23.74	2.016	2.016	20.17
11	I	2.50	25.00	9.500	9.150	58.1	1.2422	26.24	1.943	1.943	19.49
12	I	2.50	27.50	9.150	8.800	55.8	1.2419	28.74	1.870	1.870	18.80
13	I	2.50	30.00	8.800	8.450	53.6	1.2415	31.24	1.797	1.797	18.11
14	I	2.50	32.50	8.450	8.100	51.3	1.2412	33.74	1.724	1.724	17.43
15	I	2.50	35.00	8.100	7.750	49.1	1.2408	36.24	1.651	1.651	16.74
16	I	2.50	37.50	7.750	7.400	46.9	1.2404	38.74	1.578	1.578	16.05
17	I	2.50	40.00	7.400	7.050	44.6	1.2399	41.24	1.505	1.505	15.36
18	I	2.50	42.50	7.050	6.700	42.4	1.2394	43.74	1.432	1.432	14.68
19	I	2.50	45.00	6.700	6.350	40.2	1.2388	46.24	1.359	1.359	13.99
20	I	2.50	47.50	6.350	6.000	37.9	1.2382	48.74	1.286	1.286	13.30
		<u>50.00</u>				<u>1184</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)	30.564	0.000
Cross-Section Area (in^2)	9.581	0.000
Width-Thickness Ratio	54.37	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



16362-2-21 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 50' 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	12.47	33.32	33.40	1.100	4.576	12.23	0	0.710	0.00	0.00	
2	1.00	0.450	12.47	32.41	32.49	1.100	4.576	11.89	0	0.737	0.00	0.00	
3	1.00	0.450	12.47	31.50	31.58	1.100	4.576	11.56	0	0.764	0.00	0.00	
4	1.00	0.450	12.47	30.59	30.66	1.100	4.576	11.23	0	0.794	0.00	0.00	
5	1.00	0.450	12.47	29.68	29.75	1.100	4.576	10.89	0	0.826	0.00	0.00	
6	1.00	0.450	12.47	28.77	28.84	1.100	4.576	10.56	0	0.860	0.00	0.00	
7	1.00	0.450	12.47	27.86	27.93	1.100	4.576	10.22	0	0.896	0.00	0.00	
8	1.00	0.450	12.47	26.95	27.02	1.100	4.576	9.89	0	0.936	0.00	0.00	
9	1.00	0.450	12.47	26.04	26.11	1.100	4.576	9.56	0	0.979	0.00	0.00	
10	1.00	0.450	12.47	25.13	25.20	1.100	4.576	9.22	0	1.025	0.00	0.00	
11	1.00	0.466	12.91	25.08	24.28	1.100	4.576	8.89	0	1.075	0.00	0.00	
12	1.00	0.490	13.57	25.37	23.37	1.100	4.576	8.56	0	1.100	0.00	0.00	
13	1.00	0.516	14.29	25.68	22.46	1.100	4.576	8.22	0	1.100	0.00	0.00	
14	1.00	0.544	15.08	26.00	21.55	1.100	4.576	7.89	0	1.100	0.00	0.00	
15	1.00	0.576	15.95	26.33	20.64	1.100	4.576	7.56	1	1.100	0.00	0.00	
16	1.00	0.611	16.91	26.69	19.73	1.100	4.576	7.22	1	1.100	0.00	0.00	
17	1.00	0.649	17.98	27.06	18.82	1.100	4.576	6.89	1	1.100	0.00	0.00	
18	1.00	0.693	19.18	27.47	17.90	1.100	4.576	6.55	1	1.100	0.00	0.00	
19	1.00	0.741	20.53	27.91	16.99	1.100	4.576	6.22	1	1.100	0.00	0.00	
20	1.00	0.796	22.05	28.37	16.08	1.100	4.576	5.89	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	31.34	329.07	164.54	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	365.53	182.77	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



16362-2-21 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

Flange Analysis - Arm #1

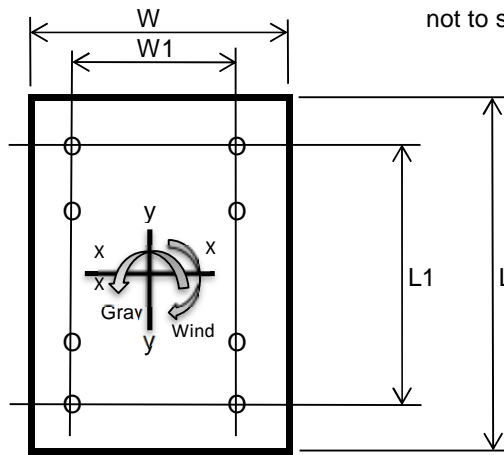
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Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1725	2721	-	lbs
Shear (Wind)	4111	2271	-	lbs
Torsion (Arm Rise)	10772	5951	-	ft-lbs
Moment (Gravity)	41262	67082	-	ft-lbs
Moment (Wind)	105102	56647	-	ft-lbs
Nat. Wind Moment	-	-	17732	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	13.00	in
Tube Wall Thick.	0.2391	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	12.16	12.60	ksi
Bolt Shear Stress - fv	1.43	0.91	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.29	0.29	CSR
Therefore	OK	OK	
Natural Wind Bolt Tensile Stress	1.68	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.24	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	7.44	12.09	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	19.26	10.38	ksi
Combined applied stress for interaction (SRSS)	20.65	15.93	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-21 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

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

SHAFT TO BASEPLATE

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

Tt - Thickness of shaft	0.3125	in
Dt - Shaft base diameter	19.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.333333	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.730769	
Kf - Fatigue stress concentration factor for finite life	2.31	
Ki - Fatigue stress concentration factor for infinite life	5.05	
Fatigue Allowable	4.5	ksi

ARM 1 TO SIMPLEX PLATE

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

Tt - Thickness of arm inboard	0.2391	in
Dt - Arm base diameter	13.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.45	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.461538	
Kf - Fatigue stress concentration factor for finite life	1.89	
Ki - Fatigue stress concentration factor for infinite life	3.64	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-2-21 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

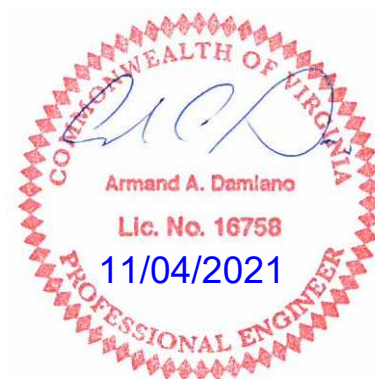
Hand Hole Stresses

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)	19.07	in
Shaft Thickness	0.313	in
Total Area	23.571	in ²
Ix	911	in ⁴
Iy	1023	in ⁴
Controlling Moment - Natural Wind Gust	17304	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	8.55	ksi
CSR	0.53	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.41	ksi
CSR	0.34	
Therefore	OK	



16362-2-21 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 50' 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	1725		1725	41262		41263		361	16201		0.45
Gp II	1725	4111	4459	41262	105102	112912	10772	931	44331	2115	0.94
Gp III	2721	2271	3545	67082	56647	87800	5951	741	34472	1169	0.73
Gp IV Natural		715	715		17732	17732	1873	150	6962	368	-
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		-



16362-2-21 - VA - 80 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)						

Shaft Base											
Gp I	3051		41262	0	41262		162		5482		0.16
Gp II	3051	5113	58217	96151	112402	105102	162	544	14935	6982	0.42
Gp III	4496	2990	46833	84047	96214	56647	239	318	12784	3763	0.30
Gp IV Natural			17304	0	17304				2299		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9982										

Shaft At Arm											
Gp I	1808		41262	0	41262		111		7266		0.21
Gp II	1808	4137	10772	41282	42664	105102	111	506	7513	9253	0.33
Gp III	2804	2298	5951	67102	67365	56647	171	281	11862	4987	0.30
Gp IV Natural			1880	0	1880				331		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9982										



16362-2-2A - VA - 80 MPH - MP-3 Std. Loads-Type B1 w/50' Arm
Weld Analysis

Page S4

INPUTS

	Gp II	GpIII		Arm Dimensions		
Applied Loads To Flange Connection						
Vert. Shr	1725	2721	lbs	Diameter (d)	13.0	in
Horz. Shr	4111	2271	lbs	Tube Wall Thk	0.2391	in
Torsion Moment	10772	5951	ft-lbs	Plate Thk (D)	2.25	in
Gravity Moment	41262	67082	ft-lbs	Plate Yield (Fy)	50	ksi
Wind Moment	105102	56647	ft-lbs			
Applied Loads To Base Plate Connection				Shaft Dimensions		
Axial	0	0	lbs	Diameter (d)	19.0	in
Shear	0	0	lbs	Tube Wall Thk	0.3125	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.	18.0	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)

$$F_v = 0.27 \times 58000 = 15660 \text{ psi}$$

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

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

$$F_v = 0.27 \times 65000 = 17550 \text{ psi}$$

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

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

Method: Weld As A Line

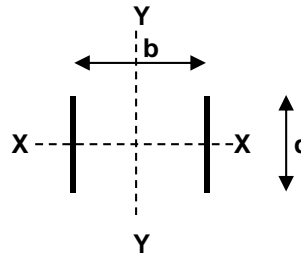


16362-2-2A - VA - 80 MPH - MP-3 Std. Loads-Type B1 w/50' Arm
 Weld Analysis - Continued

ARM CONNECTING PLATES

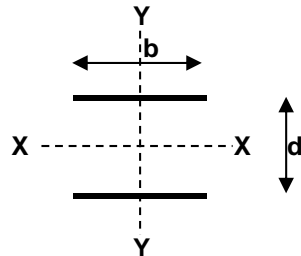
Side Plates

Vertical Length (d)	26.50	in
Horz. Dist Between Plates (b)	16.48	in
Thickness	0.5	in
Weld Size	0.313	in
Weld Throat (t ₁)	0.221	in
A ₁ = A _{w1} * t ₁ = 2 * d * t ₁	=	11.73 in ²
S _{x1} = S _{wx1} * t ₁ = (d ² / 3) * t ₁	=	51.80 in ³
S _{y1} = S _{wy1} * t ₁ = b * d * t ₁	=	96.64 in ³
J ₁ = J _{w1} * t ₁ = t ₁ * d(3b ² + d ²) / 6	=	1482.70 in ⁴



Top & Bottom Plates

Vert. Dist Between Plates (d)	26.50	in
Horz. Length (b)	25.89	in
Thickness	0.5	in
Weld Size	0.313	in
Weld Throat (t ₂)	0.221	in
A ₂ = A _{w2} * t ₂ = t ₂ * 2 * b	=	11.5 in ²
S _{x2} = S _{wx2} * t ₂ = t ₂ * b * d	=	151.8 in ³
S _{y2} = S _{wy2} * t ₂ = t ₂ * (b ² / 3)	=	49.4 in ³
J ₂ = J _{w2} * t ₂ = t ₂ * (b ³ + 3bd ²) / 6	=	2651.2 in ⁴



Combined Analysis

σ ₁ = Gravity Mom / (S _{x1} + S _{x2})	=	2432.0	Gp II	3954.0	psi
σ ₂ = Wind Mom / (S _{y1} + S _{y2})	=	8635.0	Gp III	4654.0	psi
σ ₂ = [Tor. Mom * C / (J ₁ + J ₂)] + [Res. Shr / (A ₁ + A ₂)]	=	681.0		423.0	psi
Res. Weld Stress = σ _r = Sqrt[(σ ₁ + σ ₂) ² + σ ₃ ²]	=	11088		8619	psi
Allowable: E70 Electrodes * AASHTO Gp Factor	=	23341.5		23341.5	psi
Actual Weld Stress vs. Allowable		Passes		Passes	



16362-2-21 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	5113 lbs
Bending Moment	112402 ft-lbs
Torsion Moment	105102 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	19.50 in

ANALYSIS - ANCHOR BOLTS

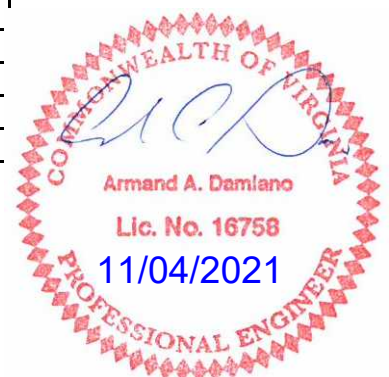
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	10.352 ksi
Bolt Direct Shear Stress	0.278 ksi
Bolt Torsion Shear Stress	5.273 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	10.352 ksi
$f_v =$	5.551 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.38 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	85 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	12.84 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	44 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	6.98 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-21 - VA - 80 MPH - MP-3 Std. Loads - Type B 1 - 50' Arm

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	17304 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	1.6 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.23
Therefore	OK

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	25880 lbs
Computed Factor-of Safety	2.4 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	25880 lbs
Total Tensile Load	207040 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	2.28 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	25880 lbs
Total Tensile Load	207040 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	5 Qty.



MAST ARM POLE ANALYSIS TO AASHTO

16362-2-22 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

11/04/21

General

Wind Vel.- mph	80	No	Roadway - mph	55	Fatigue Importance Factors	
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		AASHTO Editon	6TH	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	0.3125	0.14	19.50	25.00	-	-	-	0	55	29000	-
Traffic Arm #1	0.2391	0.14	13.00	50.00	18.00	-	2.62	0	55	29000	180
Traffic Arm #2						-		0	55	29000	90
Lum Arm #1	0.2760		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	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	14.25	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	0.16	0.21	0.45								15.24	0.00
GP II CSR	0.46	0.36	0.94				0.93					
GP III CSR	0.33	0.32	0.73				0.70				25.08	
Nat.Wind (psi)	2401	357	6962									

Arm #1 Flange Bolt (Max.) CSR	0.29
Arm #1 Flange Bolt Fatigue CSR	0.24
Arm #1 Flange Plate (Max.) CSR	0.47
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	0.36
Minimum Qty of Vertical Reinf. Bars	5

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	0.42
Anchor Bolt Max. Fatigue Stress Ratio	0.24
Base Plate Max. CSR	0.45
Anchorage Capacity S.F.	2.12
Concrete Pull Out Capacity S.F.	2.02

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
5344	5609	126762	106571



16362-2-22 - VA - 80 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										



16362-2-22 - VA - 80 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	19.500	19.352	67.61	0.5287	0.53	1.714	16.65	0.80
2	I	1.06	1.06	19.352	19.204	67.08	0.5287	1.59	1.701	16.53	0.80
3	I	1.06	2.12	19.204	19.055	66.56	0.5287	2.65	1.688	16.41	0.80
4	I	1.06	3.18	19.055	18.907	66.03	0.5287	3.71	1.675	16.28	0.80
5	I	1.06	4.24	18.907	18.759	65.51	0.5287	4.76	1.662	16.16	0.80
6	I	1.06	5.29	18.759	18.611	64.99	0.5287	5.82	1.649	16.04	0.80
7	I	1.06	6.35	18.611	18.462	64.46	0.5287	6.88	1.636	15.91	0.80
8	I	1.06	7.41	18.462	18.314	63.94	0.5287	7.94	1.622	15.79	0.80
9	I	1.06	8.47	18.314	18.166	63.41	0.5287	9.00	1.609	15.67	0.80
10	I	1.06	9.53	18.166	18.018	62.89	0.5287	10.06	1.596	15.54	0.80
11	I	1.06	10.59	18.018	17.869	62.36	0.5287	11.12	1.583	15.42	0.80
12	I	1.06	11.65	17.869	17.721	61.84	0.5287	12.18	1.570	15.30	0.80
13	I	1.06	12.71	17.721	17.573	61.31	0.5287	13.23	1.557	15.17	1.00
14	I	1.06	13.76	17.573	17.425	60.79	0.5287	14.29	1.544	15.05	1.00
15	I	1.06	14.82	17.425	17.276	60.27	0.5287	15.35	1.531	14.93	1.00
16	I	1.06	15.88	17.276	17.128	59.74	0.5287	16.41	1.518	14.80	1.00
17	I	1.06	16.94	17.128	16.980	59.22	0.5286	17.47	1.505	14.68	1.00
18	J	3.00	18.00	16.980	16.560	164.94	1.4937	19.49	4.193	40.93	1.00
19	I	3.00	21.00	16.560	16.140	160.73	1.4936	22.49	4.088	39.94	1.00
20	J	1.00	24.00	16.140	16.000	52.64	0.4993	24.50	1.339	13.09	1.00
						1457					

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)	866.45	567.94	0.00	473.53
Section Modulus (in^3)	90.31	68.15	0.00	
Cross-Section Area (in^2)	18.83	16.35	0.00	
Width-Thickness Ratio	62.40	54.34	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)	14.296	14.296	0.000	
Allow. Shear Stress (ksi)	18.150	18.150	0.000	

Shaft Deflection From Arm#1 GP I Load (in)	0.529
Shaft Deflection From Arm#2 GP I Load (in)	0.000



16362-2-22 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

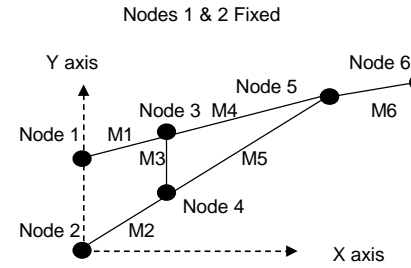
Shaft Analysis Continued

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	9.97	17.09	0.000	21.43	1.100	4.576	7.84
2	0.450	9.97	16.96	0.000	21.26	1.100	4.576	7.78
3	0.450	9.97	16.83	0.000	21.10	1.100	4.576	7.72
4	0.450	9.97	16.70	0.000	20.94	1.100	4.576	7.66
5	0.450	9.97	16.57	0.000	20.77	1.100	4.576	7.60
6	0.450	9.97	16.44	0.000	20.61	1.100	4.576	7.54
7	0.450	9.97	16.31	0.001	20.44	1.100	4.576	7.48
8	0.450	9.97	16.18	0.001	20.28	1.100	4.576	7.42
9	0.450	9.97	16.05	0.001	20.12	1.100	4.576	7.36
10	0.450	9.97	15.92	0.001	19.95	1.100	4.576	7.30
11	0.450	9.97	15.79	0.002	19.79	1.100	4.576	7.24
12	0.450	9.97	15.65	0.002	19.63	1.100	4.576	7.19
13	0.450	12.47	19.42	0.003	19.46	1.100	4.576	7.13
14	0.450	12.47	19.25	0.003	19.30	1.100	4.576	7.07
15	0.450	12.47	19.09	0.003	19.14	1.100	4.576	7.01
16	0.450	12.47	18.93	0.004	18.97	1.100	4.576	6.95
17	0.450	12.47	18.76	0.004	18.81	1.100	4.576	6.89
18	0.450	12.47	52.28	0.014	52.41	1.100	4.576	19.18
19	0.450	12.47	50.97	0.018	51.09	1.100	4.576	18.70
20	0.450	12.47	16.70	0.007	16.74	1.100	4.576	6.13
Fix. #1	1.200	26.59	63.82	0.006	31.91	1.200	4.992	11.98
Fix. #2	1.200	26.59	63.82	0.006	31.91	1.200	4.992	11.98
Fix. #3	1.200	33.23	456.91	0.079	228.46	1.200	4.992	68.64
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-2-22 - VA - 80 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)
80									
Node #1	0	27	0	0	-33.67	-32.1	0	0	0
Node #2	0	0	0	0	-35.63	-33.9	0	0	0
Node #3	100	59.5	0	0	-66.63	-67	0	0	0
Node #4	100	48.8	0	0	-69.41	-69.7	0	0	0
Node #5	200	79	0	0	-94.35	-98.8	0	0	0
Node #6	288	87	0	0	-85.29	-90.6	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	0.276	105.15	2.10	2.258	-67.33	1.1	1	-64.05	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-71.25	1.1	1	-67.78	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-0.68	1.1	1	-1.54	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-65.23	1.1	1.1	-68.27	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-66.89	1.1	1.1	-70.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-56.58	1.1	1.1	-59.21	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-57.00	1	1.1	-60.92					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2180.2	lbs
P1y	-694.6	lbs
P1z	233.5	lbs
M1x	8700.6	in-lbs
M1y	-32862.2	in-lbs
M1z	-898.1	in-lbs
P2x	2180.2	lbs
P2y	1079.6	lbs
P2z	158.6	lbs
M2x	8937.3	in-lbs
M2y	-26660.6	in-lbs
M2z	-928.7	in-lbs

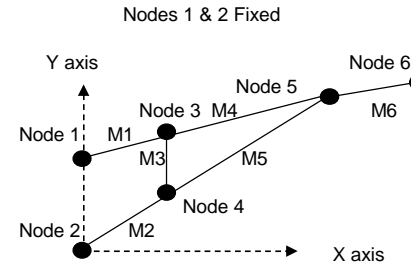
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1018	180	25256	-641	0.73
#2	1071	112	20749	-1246	0.93
#3	1489	513	10104	-511	0.39
#4	-1001	81	9678	-29	0.26
#5	1020	95	10774	-376	0.58
#6	4	110	8163	1	0.25

V09.19.15



16362-2-22 - VA - 80 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)
80									
Node #1	0	27	0	0	-40.85	-16.1	0	0	0
Node #2	0	0	0	0	-43.23	-17	0	0	0
Node #3	100	59.5	0	0	-81.04	-33.5	0	0	0
Node #4	100	48.8	0	0	-84.42	-34.9	0	0	0
Node #5	200	79	0	0	-114.49	-49.4	0	0	0
Node #6	288	87	0	0	-115.33	-45.3	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	0.276	105.15	2.10	2.258	-81.69	1.1	1	-32.03	1.936	1.936	3.872	11000000	29000000
Member #2	2.88	0.276	111.27	2.23	2.258	-86.45	1.1	1	-33.89	1.936	1.936	3.872	11000000	29000000
Member #3	0.68	0.1296	10.70	0.05	0.225	-1.22	1.1	1	-0.77	0.01	0.01	0.02	11000000	29000000
Member #4	2.88	0.276	101.88	2.04	2.258	-79.16	1.1	1.1	-34.13	1.936	1.936	3.872	11000000	29000000
Member #5	2.88	0.276	104.46	2.09	2.258	-81.16	1.1	1.1	-35.00	1.936	1.936	3.872	11000000	29000000
Member #6	2.88	0.276	88.36	1.77	2.258	-68.65	1.1	1.1	-29.60	1.936	1.936	3.872	11000000	29000000
Fixture Node 6				2		-81.00	1	1.1	-30.46					

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	2576 psi
Fa Member 3	12654 psi
Fa Member 4	21600 psi
Fa Member 5	2923 psi
Fa Member 6	4086 psi

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-2797.7	lbs
P1y	-898.7	lbs
P1z	116.8	lbs
M1x	4351.1	in-lbs
M1y	-16433.7	in-lbs
M1z	-1426.8	in-lbs
P2x	2797.7	lbs
P2y	1378.1	lbs
P2z	79.4	lbs
M2x	4469.6	in-lbs
M2y	-13332.7	in-lbs
M2z	-1452.7	in-lbs

RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1307	93	12670	-321	0.34
#2	1373	61	10427	-623	0.7
#3	1905	462	9337	-256	0.39
#4	-1287	51	4933	-15	0.11
#5	1311	56	5469	-188	0.49
#6	5	110	8115	1	0.25

V09.19.15



16362-2-22 - VA - 80 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	13.000	12.650	80.4	1.2443	1.24	2.672	2.672	26.36
2	I	2.50	2.50	12.650	12.300	78.2	1.2442	3.74	2.599	2.599	25.67
3	I	2.50	5.00	12.300	11.950	76.0	1.2440	6.24	2.526	2.526	24.99
4	I	2.50	7.50	11.950	11.600	73.7	1.2438	8.74	2.453	2.453	24.30
5	I	2.50	10.00	11.600	11.250	71.5	1.2436	11.24	2.380	2.380	23.61
6	I	2.50	12.50	11.250	10.900	69.2	1.2434	13.74	2.307	2.307	22.92
7	I	2.50	15.00	10.900	10.550	67.0	1.2432	16.24	2.234	2.234	22.24
8	I	2.50	17.50	10.550	10.200	64.8	1.2430	18.74	2.161	2.161	21.55
9	I	2.50	20.00	10.200	9.850	62.5	1.2427	21.24	2.089	2.089	20.86
10	I	2.50	22.50	9.850	9.500	60.3	1.2425	23.74	2.016	2.016	20.17
11	I	2.50	25.00	9.500	9.150	58.1	1.2422	26.24	1.943	1.943	19.49
12	I	2.50	27.50	9.150	8.800	55.8	1.2419	28.74	1.870	1.870	18.80
13	I	2.50	30.00	8.800	8.450	53.6	1.2415	31.24	1.797	1.797	18.11
14	I	2.50	32.50	8.450	8.100	51.3	1.2412	33.74	1.724	1.724	17.43
15	I	2.50	35.00	8.100	7.750	49.1	1.2408	36.24	1.651	1.651	16.74
16	I	2.50	37.50	7.750	7.400	46.9	1.2404	38.74	1.578	1.578	16.05
17	I	2.50	40.00	7.400	7.050	44.6	1.2399	41.24	1.505	1.505	15.36
18	I	2.50	42.50	7.050	6.700	42.4	1.2394	43.74	1.432	1.432	14.68
19	I	2.50	45.00	6.700	6.350	40.2	1.2388	46.24	1.359	1.359	13.99
20	I	2.50	47.50	6.350	6.000	37.9	1.2382	48.74	1.286	1.286	13.30
		<u>50.00</u>				<u>1184</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)	30.564	0.000
Cross-Section Area (in^2)	9.581	0.000
Width-Thickness Ratio	54.37	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



16362-2-22 - VA - 80 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	12.47	33.32	33.40	1.100	4.576	12.23	0	0.710	0.00	0.00	
2	1.00	0.450	12.47	32.41	32.49	1.100	4.576	11.89	0	0.737	0.00	0.00	
3	1.00	0.450	12.47	31.50	31.58	1.100	4.576	11.56	0	0.764	0.00	0.00	
4	1.00	0.450	12.47	30.59	30.66	1.100	4.576	11.23	0	0.794	0.00	0.00	
5	1.00	0.450	12.47	29.68	29.75	1.100	4.576	10.89	0	0.826	0.00	0.00	
6	1.00	0.450	12.47	28.77	28.84	1.100	4.576	10.56	0	0.860	0.00	0.00	
7	1.00	0.450	12.47	27.86	27.93	1.100	4.576	10.22	0	0.896	0.00	0.00	
8	1.00	0.450	12.47	26.95	27.02	1.100	4.576	9.89	0	0.936	0.00	0.00	
9	1.00	0.450	12.47	26.04	26.11	1.100	4.576	9.56	0	0.979	0.00	0.00	
10	1.00	0.450	12.47	25.13	25.20	1.100	4.576	9.22	0	1.025	0.00	0.00	
11	1.00	0.466	12.91	25.08	24.28	1.100	4.576	8.89	0	1.075	0.00	0.00	
12	1.00	0.490	13.57	25.37	23.37	1.100	4.576	8.56	0	1.100	0.00	0.00	
13	1.00	0.516	14.29	25.68	22.46	1.100	4.576	8.22	0	1.100	0.00	0.00	
14	1.00	0.544	15.08	26.00	21.55	1.100	4.576	7.89	0	1.100	0.00	0.00	
15	1.00	0.576	15.95	26.33	20.64	1.100	4.576	7.56	1	1.100	0.00	0.00	
16	1.00	0.611	16.91	26.69	19.73	1.100	4.576	7.22	1	1.100	0.00	0.00	
17	1.00	0.649	17.98	27.06	18.82	1.100	4.576	6.89	1	1.100	0.00	0.00	
18	1.00	0.693	19.18	27.47	17.90	1.100	4.576	6.55	1	1.100	0.00	0.00	
19	1.00	0.741	20.53	27.91	16.99	1.100	4.576	6.22	1	1.100	0.00	0.00	
20	1.00	0.796	22.05	28.37	16.08	1.100	4.576	5.89	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	5.017	188.14	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	4.992	68.64	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	4.718	35.39	1	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	4.992	43.43	1	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	33.23	16.62	1.200	4.992	4.99	1	1.200	0.00	0.00	0.00
Fix. #10	1.00	1.132	31.34	329.07	164.54	1.132	4.708	49.43	1	1.132	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	365.53	182.77	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

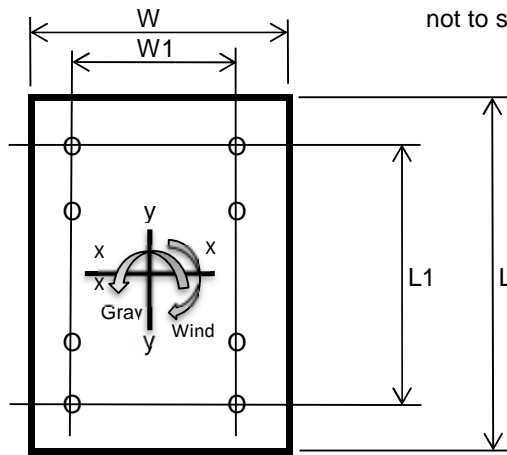
Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1725	2721	-	lbs
Shear (Wind)	4111	2271	-	lbs
Torsion (Arm Rise)	10772	5951	-	ft-lbs
Moment (Gravity)	41262	67082	-	ft-lbs
Moment (Wind)	105102	56647	-	ft-lbs
Nat. Wind Moment	-	-	17732	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs

Diameter of tube	13.00	in
Tube Wall Thick.	0.2391	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	12.16	12.60	ksi
Bolt Shear Stress - fv	1.43	0.91	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.29	0.29	CSR
Therefore	OK	OK	
Natural Wind Bolt Tensile Stress	1.68	ksi	
Galloping Bolt Tensile Stress	0	ksi	
Truck Gust Bolt Tensile Stress	0	ksi	
Allowable Fatigue Stress	7	ksi	
Max. Stress Ratio	0.24	OK	

Plate Analysis

Stress from gravity loads = $2P \cdot e / (W t^2 / 6)$	7.44	12.09	ksi
Stress from wind loads = $4P \cdot e / (L t^2 / 6)$	19.26	10.38	ksi
Combined applied stress for interaction (SRSS)	20.65	15.93	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-2-22 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

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

SHAFT TO BASEPLATE

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

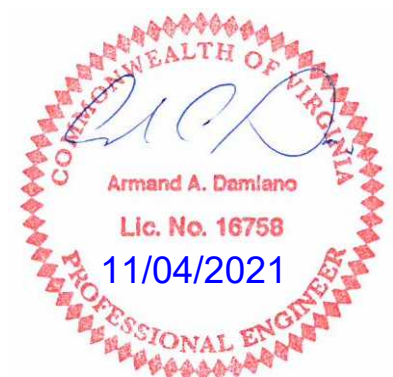
Tt - Thickness of shaft	0.3125	in
Dt - Shaft base diameter	19.50	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.333333	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.730769	
Kf - Fatigue stress concentration factor for finite life	2.31	
Ki - Fatigue stress concentration factor for infinite life	5.05	
Fatigue Allowable	4.5	ksi

ARM 1 TO SIMPLEX PLATE

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

Tt - Thickness of arm inboard	0.2391	in
Dt - Arm base diameter	13.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.45	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.461538	
Kf - Fatigue stress concentration factor for finite life	1.89	
Ki - Fatigue stress concentration factor for infinite life	3.64	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-2-22 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

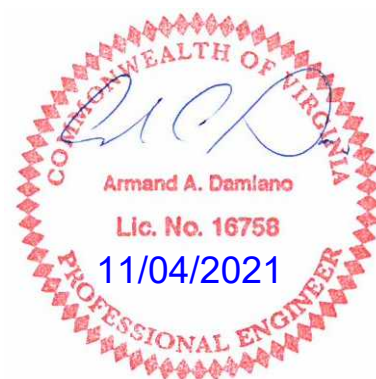
Hand Hole Stresses

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)	19.07	in
Shaft Thickness	0.313	in
Total Area	23.571	in ²
Ix	911	in ⁴
Iy	1023	in ⁴
Controlling Moment - Natural Wind Gust	18067	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	8.93	ksi
CSR	0.56	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	2.51	ksi
CSR	0.36	
Therefore	OK	



16362-2-22 - VA - 80 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	1725		1725	41262		41263		361	16201		0.45
Gp II	1725	4111	4459	41262	105102	112912	10772	931	44331	2115	0.94
Gp III	2721	2271	3545	67082	56647	87800	5951	741	34472	1169	0.73
Gp IV Natural		715	715		17732	17732	1873	150	6962	368	-
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		-



16362-2-22 - VA - 80 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)						

Shaft Base											
Gp I	3731		41262	0	41262		198		5482		0.16
Gp II	3731	5609	58217	112603	126762	106571	198	596	16843	7080	0.46
Gp III	5344	3286	46833	93323	104415	57382	284	350	13874	3812	0.33
Gp IV Natural			18067	0	18067				2401		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9979										

Shaft At Arm											
Gp I	2488		41262	0	41262		152		7266		0.21
Gp II	2488	4623	10772	48991	50161	106571	152	566	8833	9383	0.36
Gp III	3579	2588	5951	71156	71404	57382	219	317	12573	5052	0.32
Gp IV Natural			2025	0	2025				357		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9979										



16362-2-22 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	5609 lbs
Bending Moment	126762 ft-lbs
Torsion Moment	106571 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	19.50 in

ANALYSIS - ANCHOR BOLTS

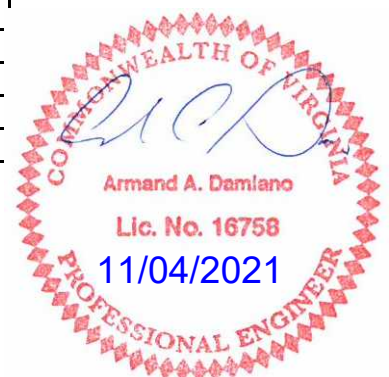
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	11.674 ksi
Bolt Direct Shear Stress	0.305 ksi
Bolt Torsion Shear Stress	5.347 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	11.674 ksi
$f_v =$	5.652 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.42 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.25 in
Design Moment	95 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	14.36 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.688 in
Design Moment	50 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	7.93 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-2-22 - VA - 80 MPH - MP-3 Std. Loads - Type E1 - 50' Arm w/24' Arm

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	18067 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	1.67 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0.24
Therefore	OK

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	29185 lbs
Computed Factor-of Safety	2.12 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	29185 lbs
Total Tensile Load	233480 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	2.02 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	29185 lbs
Total Tensile Load	233480 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	5 Qty.



MAST ARM POLE ANALYSIS TO AASHTO

16362-1-23 - VA - 80 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

11/04/21

General

Wind Vel. - mph	80	No	Roadway - mph	55	Fatigue Importance Factors	
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		AASHTO Editon	6TH	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	19.00	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	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	0.1793	0.14	13.00	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
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	14.25	in	Vertical Reinforcing Bar Size #	8
Weld Type	Full Pen.		Rebar Yield Strength fy	60
				ksi

Flange Simplex

Arm #1 Arm #2

Hand Hole

Flange Bolt Qty.	8	8	Handhole Width	6.00	in		
Bolt Diameter	1.50	in	1.50	in	Handhole Height	24.50	in
Flange Plate Length (V)	27.00	in	27.00	in	Height To C.L.	37	in
Flange Plate Width (H)	27.00	in	27.00	in	Radial Orientation	0	Deg.
Spac. Between Bolt (V)	22.50	in	22.50	in	Rim Thickness	0.75	in
Spac. Between Bolt (H)	22.50	in	22.50	in	Rim Depth	5.00	in
Flange Plate Thk.	2.25	in	2.25	in	Rim Projection	1.00	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.					

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	0.30	0.40	0.49	0.41	0.35						28.19	6.70
GP II CSR	0.67	0.73	0.86	0.79	0.79							
GP III CSR	0.56	0.63	0.74	0.66	0.62						46.24	11.73

Arm #1 Flange Bolt (Max.) CSR	0.58
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.74
Arm #2 Flange Bolt (Max.) CSR	0.18
Arm #2 Flange Bolt Fatigue CSR	0.00
Arm #2 Flange Plate (Max.) CSR	0.29
Handhole at Root (Fatigue) CSR	0.00
Handhole at Toe (Fatigue) CSR	0.00
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	0.66	
Anchor Bolt Max. Fatigue Stress Ratio	0.00	
Base Plate Max. CSR	0.74	
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)
	8159	5918	190733	189265



16362-1-23 - VA - 80 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			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			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 - 80 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	19.000	18.852	78.74	0.5287	0.53	1.670	16.24	0.80
2	I	1.06	1.06	18.852	18.704	78.11	0.5287	1.59	1.657	16.11	0.80
3	I	1.06	2.12	18.704	18.555	77.48	0.5287	2.65	1.644	15.99	0.80
4	I	1.06	3.18	18.555	18.407	76.85	0.5287	3.71	1.631	15.87	0.80
5	I	1.06	4.24	18.407	18.259	76.22	0.5287	4.76	1.618	15.74	0.80
6	I	1.06	5.29	18.259	18.111	75.59	0.5287	5.82	1.605	15.62	0.80
7	I	1.06	6.35	18.111	17.962	74.97	0.5287	6.88	1.591	15.50	0.80
8	I	1.06	7.41	17.962	17.814	74.34	0.5287	7.94	1.578	15.37	0.80
9	I	1.06	8.47	17.814	17.666	73.71	0.5287	9.00	1.565	15.25	0.80
10	I	1.06	9.53	17.666	17.518	73.08	0.5287	10.06	1.552	15.13	0.80
11	I	1.06	10.59	17.518	17.369	72.45	0.5287	11.12	1.539	15.00	0.80
12	I	1.06	11.65	17.369	17.221	71.82	0.5287	12.18	1.526	14.88	0.80
13	I	1.06	12.71	17.221	17.073	71.19	0.5286	13.23	1.513	14.76	1.00
14	I	1.06	13.76	17.073	16.925	70.56	0.5286	14.29	1.500	14.63	1.00
15	I	1.06	14.82	16.925	16.776	69.93	0.5286	15.35	1.487	14.51	1.00
16	I	1.06	15.88	16.776	16.628	69.30	0.5286	16.41	1.474	14.39	1.00
17	I	1.06	16.94	16.628	16.480	68.67	0.5286	17.47	1.461	14.27	1.00
18	J	0.50	18.00	16.480	16.410	32.21	0.2498	18.25	0.685	6.69	1.00
19	I	0.50	18.50	16.410	16.340	32.07	0.2498	18.75	0.682	6.67	1.00
20	I	0.50	19.00	16.340	16.270	31.93	0.2498	19.25	0.679	6.64	1.00
						1350					

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)	950.95	614.83	614.83	591.09
Section Modulus (in ³)	102.12	76.35	76.35	
Cross-Section Area (in ²)	21.93	18.96	18.96	
Width-Thickness Ratio	50.67	43.95	43.95	
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)	19.914	19.914	19.914	
Allow. Shear Stress (ksi)	18.150	18.150	18.150	

Shaft Deflection From Arm#1 GP I Load (in)	0.999
Shaft Deflection From Arm#2 GP I Load (in)	0.281



16362-1-23 - VA - 80 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	9.97	16.65	0.000	20.87	1.100	0.000	0.00
2	0.450	9.97	16.52	0.000	20.71	1.100	0.000	0.00
3	0.450	9.97	16.39	0.000	20.55	1.100	0.000	0.00
4	0.450	9.97	16.26	0.000	20.38	1.100	0.000	0.00
5	0.450	9.97	16.13	0.000	20.22	1.100	0.000	0.00
6	0.450	9.97	16.00	0.000	20.06	1.100	0.000	0.00
7	0.450	9.97	15.87	0.000	19.89	1.100	0.000	0.00
8	0.450	9.97	15.74	0.001	19.73	1.100	0.000	0.00
9	0.450	9.97	15.61	0.001	19.57	1.100	0.000	0.00
10	0.450	9.97	15.48	0.001	19.40	1.100	0.000	0.00
11	0.450	9.97	15.35	0.001	19.24	1.100	0.000	0.00
12	0.450	9.97	15.21	0.001	19.08	1.100	0.000	0.00
13	0.450	12.47	18.87	0.002	18.91	1.100	0.000	0.00
14	0.450	12.47	18.70	0.002	18.75	1.100	0.000	0.00
15	0.450	12.47	18.54	0.002	18.59	1.100	0.000	0.00
16	0.450	12.47	18.38	0.002	18.42	1.100	0.000	0.00
17	0.450	12.47	18.21	0.003	18.26	1.100	0.000	0.00
18	0.450	12.47	8.54	0.001	8.57	1.100	0.000	0.00
19	0.450	12.47	8.51	0.001	8.53	1.100	0.000	0.00
20	0.450	12.47	8.47	0.001	8.49	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.052	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-1-23 - VA - 80 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	167.1	1.8308	1.83	5.288	5.288	51.57
2	I	3.68	3.68	16.985	16.470	162.1	1.8306	5.51	5.130	5.130	50.08
3	I	3.68	7.36	16.470	15.954	157.0	1.8303	9.19	4.972	4.972	48.59
4	I	3.68	11.04	15.954	15.439	151.9	1.8299	12.87	4.814	4.814	47.10
5	I	3.68	14.72	15.439	14.924	146.8	1.8296	16.55	4.656	4.656	45.61
6	I	3.68	18.40	14.924	14.409	141.8	1.8292	20.23	4.498	4.498	44.12
7	J	2.92	22.08	14.790	14.381	193.4	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>2119</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)	58.397	31.467
Cross-Section Area (in^2)	13.541	8.620
Width-Thickness Ratio	70.00	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)	35.991	34.389
Allow. Shear Stress (ksi)	18.150	17.040



16362-1-23 - VA - 80 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

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	12.47	65.94	66.10	1.100	0.000	0.00	0	0.484	0.00	0.00	
2	1.00	0.450	12.47	63.97	64.12	1.100	0.000	0.00	0	0.503	0.00	0.00	
3	1.00	0.450	12.47	62.00	62.15	1.100	0.000	0.00	0	0.524	0.00	0.00	
4	1.00	0.450	12.47	60.03	60.17	1.100	0.000	0.00	0	0.546	0.00	0.00	
5	1.00	0.450	12.47	58.06	58.20	1.100	0.000	0.00	0	0.571	0.00	0.00	
6	1.00	0.450	12.47	56.09	56.22	1.100	0.000	0.00	0	0.597	0.00	0.00	
7	1.00	0.450	12.47	44.26	44.36	1.100	0.000	0.00	0	0.601	0.00	0.00	
8	1.00	0.450	12.47	50.86	50.98	1.100	0.000	0.00	0	0.626	0.00	0.00	
9	1.00	0.450	12.47	49.12	49.23	1.100	0.000	0.00	0	0.655	0.00	0.00	
10	1.00	0.450	12.47	47.37	47.49	1.100	0.000	0.00	0	0.686	0.00	0.00	
11	1.00	0.450	12.47	45.63	45.74	1.100	0.000	0.00	0	0.721	0.00	0.00	
12	1.00	0.450	12.47	43.89	43.99	1.100	0.000	0.00	0	0.758	0.00	0.00	
13	1.00	0.450	12.47	42.14	42.24	1.100	0.000	0.00	0	0.799	0.00	0.00	
14	1.00	0.450	12.47	40.40	40.50	1.100	0.000	0.00	0	0.844	0.00	0.00	
15	1.00	0.450	12.47	38.66	38.75	1.100	0.000	0.00	0	0.894	0.00	0.00	
16	1.00	0.450	12.47	36.91	37.00	1.100	0.000	0.00	0	0.949	0.00	0.00	
17	1.00	0.450	12.47	35.17	35.25	1.100	0.000	0.00	1	1.011	0.00	0.00	
18	1.00	0.468	12.97	34.77	33.51	1.100	0.000	0.00	1	1.080	0.00	0.00	
19	1.00	0.502	13.9	35.32	31.76	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.540	14.96	35.92	30.01	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	0.000	0.00	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	33.23	365.53	182.77	1.200	0.000	0.00	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 - 80 MPH - MP-3 Standard Loads - Type C - 70/40' Arms

Flange Analysis - Arm #1

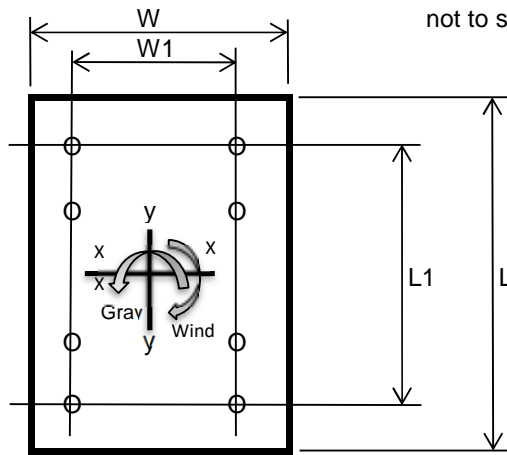
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Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2748	4188	-	lbs
Shear (Wind)	5024	2977	-	lbs
Torsion (Arm Rise)	18428	10918	-	ft-lbs
Moment (Gravity)	85096	136462	-	ft-lbs
Moment (Wind)	177343	102775	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	17.50	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	22.14	25.15	ksi
Bolt Shear Stress - fv	2.27	1.52	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	0.58	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	13.77	22.08	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	29.19	16.92	ksi
Combined applied stress for interaction (SRSS)	32.27	27.82	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-1-23 - VA - 80 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	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
		40.00				768					

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)	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



16362-1-23 - VA - 80 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	12.47	26.73	26.79	1.100	0.000	0.00	0	0.708	0.00	0.00	
2	1.00	0.450	12.47	26.15	26.21	1.100	0.000	0.00	0	0.729	0.00	0.00	
3	1.00	0.450	12.47	25.56	25.63	1.100	0.000	0.00	0	0.750	0.00	0.00	
4	1.00	0.450	12.47	24.98	25.04	1.100	0.000	0.00	0	0.773	0.00	0.00	
5	1.00	0.450	12.47	24.40	24.46	1.100	0.000	0.00	0	0.797	0.00	0.00	
6	1.00	0.450	12.47	23.82	23.88	1.100	0.000	0.00	0	0.822	0.00	0.00	
7	1.00	0.450	12.47	23.24	23.29	1.100	0.000	0.00	0	0.849	0.00	0.00	
8	1.00	0.450	12.47	22.65	22.71	1.100	0.000	0.00	0	0.878	0.00	0.00	
9	1.00	0.450	12.47	22.07	22.13	1.100	0.000	0.00	0	0.908	0.00	0.00	
10	1.00	0.450	12.47	21.49	21.54	1.100	0.000	0.00	0	0.940	0.00	0.00	
11	1.00	0.450	12.47	20.91	20.96	1.100	0.000	0.00	0	0.974	0.00	0.00	
12	1.00	0.450	12.47	20.33	20.38	1.100	0.000	0.00	0	1.011	0.00	0.00	
13	1.00	0.455	12.60	19.95	19.79	1.100	0.000	0.00	1	1.050	0.00	0.00	
14	1.00	0.473	13.10	20.13	19.21	1.100	0.000	0.00	1	1.091	0.00	0.00	
15	1.00	0.492	13.63	20.31	18.63	1.100	0.000	0.00	1	1.100	0.00	0.00	
16	1.00	0.513	14.21	20.51	18.04	1.100	0.000	0.00	1	1.100	0.00	0.00	
17	1.00	0.535	14.83	20.71	17.46	1.100	0.000	0.00	1	1.100	0.00	0.00	
18	1.00	0.560	15.50	20.93	16.88	1.100	0.000	0.00	1	1.100	0.00	0.00	
19	1.00	0.586	16.23	21.15	16.29	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.614	17.01	21.38	15.71	1.100	0.000	0.00	1	1.100	0.00	0.00	
Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	33.21	996.30	498.15	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #5	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #8	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #9	1.00	1.200	33.23	365.53	182.77	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



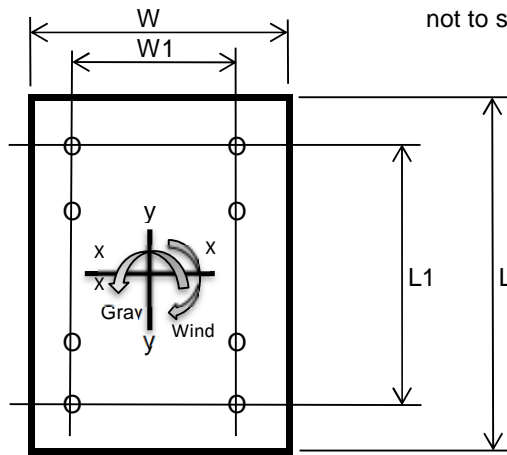
Flange Analysis - Arm #2

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	1199	2016	-	lbs
Shear (Wind)	3219	1811	-	lbs
Torsion (Arm Rise)	6749	3796	-	ft-lbs
Moment (Gravity)	23899	41305	-	ft-lbs
Moment (Wind)	66135	36531	-	ft-lbs
Nat. Wind Moment	-	-	-	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)	2.25
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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	7.46	7.83	ksi
Bolt Shear Stress - fv	0.95	0.62	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.18	0.18	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	4.33	7.49	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	12.19	6.74	ksi
Combined applied stress for interaction (SRSS)	12.94	10.08	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-1-23 - VA - 80 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

Fatigue Allowable - Shaft to Baseplate Weld & 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	19.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.368421	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.75	
Kf - Fatigue stress concentration factor for finite life	2.58	
Ki - Fatigue stress concentration factor for infinite life	6.07	
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	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	1.76	
Ki - Fatigue stress concentration factor for infinite life	3.33	
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	0.1793	in
Dt - Arm base diameter	13.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.447677	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.461538	
Kf - Fatigue stress concentration factor for finite life	1.79	
Ki - Fatigue stress concentration factor for infinite life	3.16	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-1-23 - VA - 80 MPH - MP-3 Standard Loads - Type C - 70'40' Arms

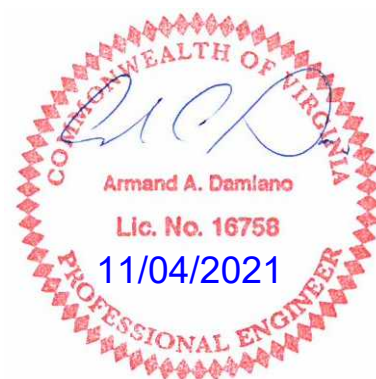
Hand Hole Stresses

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)	18.57	in
Shaft Thickness	0.375	in
Total Area	26.1281	in ²
Ix	988	in ⁴
Iy	1065	in ⁴
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-1-23 - VA - 80 MPH - MP-3 Standard Loads - Type C - 70'/40' 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	2748		2748	85096		85097		406	17487		0.49
Gp II	2748	5024	5727	85096	177343	196703	18428	846	40421	1894	0.86
Gp III	4188	2977	5139	136462	102775	170836	10918	760	35106	1122	0.74
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		-

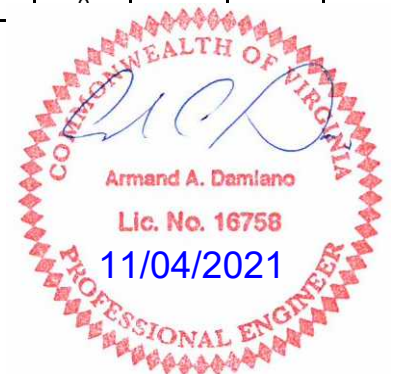
Arm#1 Joint											
Gp I	1710		1710	36287		36287		397	13839		0.41
Gp II	1710	3372	3782	36287	83811	91330	12370	878	34829	2359	0.79
Gp III	2742	1967	3375	60410	47848	77064	7214	784	29389	1376	0.66
Gp IV Natural		0	0		0	0	0	0	0	0	-
Gp IV Truck	0		0	0		0		0	0		-
Gp IV Gallop	0		0	0		0		0	0		-

Arm#2 Base											
Gp I	1199		1199	23899		23900		333	12397		0.35
Gp II	1199	3219	3436	23899	66135	70322	6749	953	36475	1751	0.79
Gp III	2016	1811	2710	41305	36531	55142	3796	751	28602	985	0.62
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		-



16362-1-23 - VA - 80 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)						

Shaft Base											
Gp I	5461		85096	23899	88389		249		10387		0.30
Gp II	5461	5918	111969	134414	174941	189265	249	540	20558	11121	0.67
Gp III	8159	3627	82762	171842	190733	109040	372	331	22414	6407	0.56
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9965										

Shaft At Arm											
Gp I	4043		85096	23899	88389		213		13892		0.40
Gp II	4043	5050	38016	89454	97197	189265	213	533	15276	14873	0.73
Gp III	6300	3002	49159	139118	147548	109040	332	317	23190	8569	0.63
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9965										



16362-1-23 - VA - 80 MPH - MP-3 Standard Loads - Type C - 70'40' Arms

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	5918 lbs
Bending Moment	190733 ft-lbs
Torsion Moment	189265 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	19.00 in

ANALYSIS - ANCHOR BOLTS

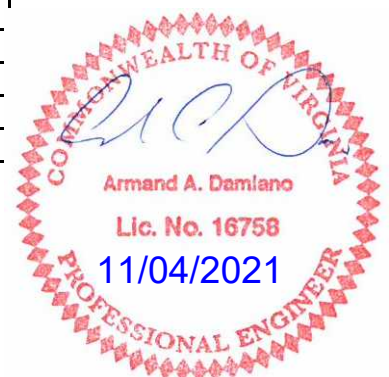
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	17.565 ksi
Bolt Direct Shear Stress	0.322 ksi
Bolt Torsion Shear Stress	9.495 ksi
Combined Bolt Stress	
$F_v = .3 F_y \text{ * Allowable Increase Factor}$	21.945 ksi
$F_t = .5 F_y \text{ * Allowable Increase Factor}$	36.575 ksi
$f_t =$	17.565 ksi
$f_v =$	9.817 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.66 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.5 in
Design Moment	154 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	23.27 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.938 in
Design Moment	86 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	13.63 ksi
Allowable Plate Stress = $.66 F_y \text{ * Allow. Incr.}$	31.6 ksi
Therefore	OK



16362-1-23 - VA - 80 MPH - MP-3 Standard Loads - Type C - 70'/40' Arms

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	0 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	OK

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	43913 lbs
Computed Factor-of Safety	1.41 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	43913 lbs
Total Tensile Load	351304 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.34 OK

LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	43913 lbs
Total Tensile Load	351304 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

16362-1-24 - VA - 80 MPH - MP-3 Standard Loads - Type C - 70'/30' Arms

11/04/21

General

Wind Vel. - mph	80	No	Roadway - mph	55	Fatigue Importance Factors	
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		AASHTO Editon	6TH	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	19.00	19.50	-	-	-	0	55	29000	-
Traffic Arm #1	0.2500	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	0.1793	0.14	13.00	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	14.25	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	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	0.29	0.39	0.49	0.41	0.23						28.18	2.42
GP II CSR	0.63	0.69	0.86	0.79	0.53							
GP III CSR	0.53	0.60	0.74	0.66	0.40						46.23	4.26

Arm #1 Flange Bolt (Max.) CSR	0.58
Arm #1 Flange Bolt Fatigue CSR	0.00
Arm #1 Flange Plate (Max.) CSR	0.74
Arm #2 Flange Bolt (Max.) CSR	0.12
Arm #2 Flange Bolt Fatigue CSR	0.00
Arm #2 Flange Plate (Max.) CSR	0.20
Handhole at Root (Fatigue) CSR	0.00
Handhole at Toe (Fatigue) CSR	0.00
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	0.63
Anchor Bolt Max. Fatigue Stress Ratio	0.00
Base Plate Max. CSR	0.70
Anchorage Capacity S.F.	1.49
Concrete Pull Out Capacity S.F.	1.41

Ground Line Reactions

Axial (lbs)	Shear (lbs)	Bending (ft-lbs)	Torsion (ft-lbs)
7796	5918	180909	182772



16362-1-24 - VA - 80 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		2.5	3	1	7.5
	#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	1	3	22
	#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										



16362-1-24 - VA - 80 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	19.000	18.852	78.74	0.5287	0.53	1.670	16.24	0.80
2	I	1.06	1.06	18.852	18.704	78.11	0.5287	1.59	1.657	16.11	0.80
3	I	1.06	2.12	18.704	18.555	77.48	0.5287	2.65	1.644	15.99	0.80
4	I	1.06	3.18	18.555	18.407	76.85	0.5287	3.71	1.631	15.87	0.80
5	I	1.06	4.24	18.407	18.259	76.22	0.5287	4.76	1.618	15.74	0.80
6	I	1.06	5.29	18.259	18.111	75.59	0.5287	5.82	1.605	15.62	0.80
7	I	1.06	6.35	18.111	17.962	74.97	0.5287	6.88	1.591	15.50	0.80
8	I	1.06	7.41	17.962	17.814	74.34	0.5287	7.94	1.578	15.37	0.80
9	I	1.06	8.47	17.814	17.666	73.71	0.5287	9.00	1.565	15.25	0.80
10	I	1.06	9.53	17.666	17.518	73.08	0.5287	10.06	1.552	15.13	0.80
11	I	1.06	10.59	17.518	17.369	72.45	0.5287	11.12	1.539	15.00	0.80
12	I	1.06	11.65	17.369	17.221	71.82	0.5287	12.18	1.526	14.88	0.80
13	I	1.06	12.71	17.221	17.073	71.19	0.5286	13.23	1.513	14.76	1.00
14	I	1.06	13.76	17.073	16.925	70.56	0.5286	14.29	1.500	14.63	1.00
15	I	1.06	14.82	16.925	16.776	69.93	0.5286	15.35	1.487	14.51	1.00
16	I	1.06	15.88	16.776	16.628	69.30	0.5286	16.41	1.474	14.39	1.00
17	I	1.06	16.94	16.628	16.480	68.67	0.5286	17.47	1.461	14.27	1.00
18	J	0.50	18.00	16.480	16.410	32.21	0.2498	18.25	0.685	6.69	1.00
19	I	0.50	18.50	16.410	16.340	32.07	0.2498	18.75	0.682	6.67	1.00
20	I	0.50	19.00	16.340	16.270	31.93	0.2498	19.25	0.679	6.64	1.00
						1350					

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)	950.95	614.83	614.83	591.09
Section Modulus (in^3)	102.12	76.35	76.35	
Cross-Section Area (in^2)	21.93	18.96	18.96	
Width-Thickness Ratio	50.67	43.95	43.95	
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)	19.914	19.914	19.914	
Allow. Shear Stress (ksi)	18.150	18.150	18.150	

Shaft Deflection From Arm#1 GP I Load (in)	0.999
Shaft Deflection From Arm#2 GP I Load (in)	0.179



16362-1-24 - VA - 80 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	9.97	16.65	0.000	20.87	1.100	0.000	0.00
2	0.450	9.97	16.52	0.000	20.71	1.100	0.000	0.00
3	0.450	9.97	16.39	0.000	20.55	1.100	0.000	0.00
4	0.450	9.97	16.26	0.000	20.38	1.100	0.000	0.00
5	0.450	9.97	16.13	0.000	20.22	1.100	0.000	0.00
6	0.450	9.97	16.00	0.000	20.06	1.100	0.000	0.00
7	0.450	9.97	15.87	0.000	19.89	1.100	0.000	0.00
8	0.450	9.97	15.74	0.001	19.73	1.100	0.000	0.00
9	0.450	9.97	15.61	0.001	19.57	1.100	0.000	0.00
10	0.450	9.97	15.48	0.001	19.40	1.100	0.000	0.00
11	0.450	9.97	15.35	0.001	19.24	1.100	0.000	0.00
12	0.450	9.97	15.21	0.001	19.08	1.100	0.000	0.00
13	0.450	12.47	18.87	0.002	18.91	1.100	0.000	0.00
14	0.450	12.47	18.70	0.002	18.75	1.100	0.000	0.00
15	0.450	12.47	18.54	0.002	18.59	1.100	0.000	0.00
16	0.450	12.47	18.38	0.002	18.42	1.100	0.000	0.00
17	0.450	12.47	18.21	0.003	18.26	1.100	0.000	0.00
18	0.450	12.47	8.54	0.001	8.57	1.100	0.000	0.00
19	0.450	12.47	8.51	0.001	8.53	1.100	0.000	0.00
20	0.450	12.47	8.47	0.001	8.49	1.100	0.000	0.00
Fix. #1	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #2	1.200	26.59	63.82	0.004	31.91	1.200	0.000	0.00
Fix. #3	1.200	33.23	456.91	0.052	228.46	1.200	0.000	0.00
Fix. #4	0.000	0.00	0.00	0.000	0.00	0.000	0.000	0.00



16362-1-24 - VA - 80 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	167.0	1.8300	1.83	5.285	5.285	51.55
2	I	3.68	3.68	16.985	16.470	162.0	1.8297	5.51	5.127	5.127	50.06
3	I	3.68	7.36	16.470	15.955	156.9	1.8294	9.19	4.970	4.970	48.57
4	I	3.68	11.04	15.955	15.440	151.9	1.8291	12.86	4.812	4.812	47.08
5	I	3.68	14.71	15.440	14.925	146.8	1.8288	16.54	4.654	4.654	45.59
6	I	3.68	18.39	14.925	14.410	141.7	1.8284	20.22	4.496	4.496	44.11
7	J	2.93	22.07	14.790	14.380	194.1	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>2119</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)	58.397	31.467
Cross-Section Area (in^2)	13.541	8.620
Width-Thickness Ratio	70.00	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)	35.991	34.389
Allow. Shear Stress (ksi)	18.150	17.040



16362-1-24 - VA - 80 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)	
1	1.00	0.450	12.47	65.91	66.07	1.100	0.000	0.00	0	0.484	0.00	0.00	
2	1.00	0.450	12.47	63.94	64.09	1.100	0.000	0.00	0	0.503	0.00	0.00	
3	1.00	0.450	12.47	61.97	62.12	1.100	0.000	0.00	0	0.524	0.00	0.00	
4	1.00	0.450	12.47	60.00	60.15	1.100	0.000	0.00	0	0.546	0.00	0.00	
5	1.00	0.450	12.47	58.03	58.17	1.100	0.000	0.00	0	0.571	0.00	0.00	
6	1.00	0.450	12.47	56.07	56.20	1.100	0.000	0.00	0	0.597	0.00	0.00	
7	1.00	0.450	12.47	44.41	44.51	1.100	0.000	0.00	0	0.601	0.00	0.00	
8	1.00	0.450	12.47	50.84	50.97	1.100	0.000	0.00	0	0.626	0.00	0.00	
9	1.00	0.450	12.47	49.10	49.22	1.100	0.000	0.00	0	0.655	0.00	0.00	
10	1.00	0.450	12.47	47.36	47.47	1.100	0.000	0.00	0	0.686	0.00	0.00	
11	1.00	0.450	12.47	45.62	45.73	1.100	0.000	0.00	0	0.721	0.00	0.00	
12	1.00	0.450	12.47	43.87	43.98	1.100	0.000	0.00	0	0.758	0.00	0.00	
13	1.00	0.450	12.47	42.13	42.23	1.100	0.000	0.00	0	0.799	0.00	0.00	
14	1.00	0.450	12.47	40.39	40.49	1.100	0.000	0.00	0	0.844	0.00	0.00	
15	1.00	0.450	12.47	38.65	38.74	1.100	0.000	0.00	0	0.894	0.00	0.00	
16	1.00	0.450	12.47	36.90	36.99	1.100	0.000	0.00	0	0.949	0.00	0.00	
17	1.00	0.450	12.47	35.16	35.25	1.100	0.000	0.00	1	1.011	0.00	0.00	
18	1.00	0.468	12.97	34.76	33.50	1.100	0.000	0.00	1	1.080	0.00	0.00	
19	1.00	0.502	13.9	35.31	31.75	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.540	14.96	35.91	30.01	1.100	0.000	0.00	1	1.100	0.00	0.00	

Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.206	33.40	1252.50	626.25	1.206	0.000	0.00	0	1.206	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	0	1.134	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #9	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #10	1.00	1.200	33.23	289.10	144.55	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #11	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #12	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #13	1.00	1.200	33.23	365.53	182.77	1.200	0.000	0.00	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



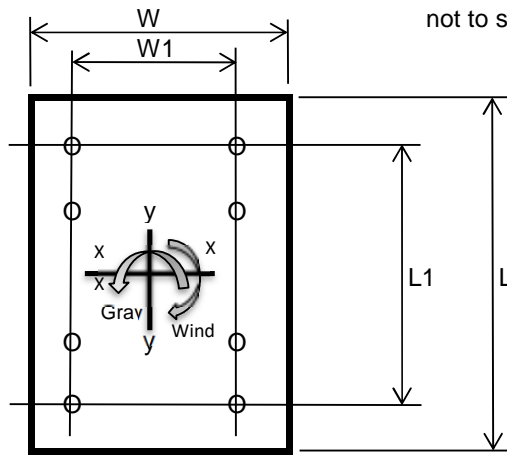
Flange Analysis - Arm #1

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	2748	4188	-	lbs
Shear (Wind)	5024	2976	-	lbs
Torsion (Arm Rise)	18425	10916	-	ft-lbs
Moment (Gravity)	85085	136444	-	ft-lbs
Moment (Wind)	177334	102766	-	ft-lbs
Nat. Wind Moment	-	-	-	ft-lbs
Galloping Moment	-	-	-	ft-lbs
Truck Gust Mom.	-	-	-	ft-lbs

General Inputs		
Diameter of tube	17.50	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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	22.14	25.14	ksi
Bolt Shear Stress - fv	2.27	1.52	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	0.58	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	13.77	22.08	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	29.19	16.92	ksi
Combined applied stress for interaction (SRSS)	32.27	27.82	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-1-24 - VA - 80 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	13.000	12.790	36.6	0.7480	0.75	1.612	1.612	15.90
2	I	1.50	1.50	12.790	12.580	36.0	0.7479	2.25	1.586	1.586	15.65
3	I	1.50	3.00	12.580	12.370	35.4	0.7479	3.75	1.559	1.559	15.40
4	I	1.50	4.50	12.370	12.160	34.7	0.7479	5.25	1.533	1.533	15.16
5	I	1.50	6.00	12.160	11.950	34.1	0.7478	6.75	1.507	1.507	14.91
6	I	1.50	7.50	11.950	11.740	33.5	0.7478	8.25	1.481	1.481	14.66
7	I	1.50	9.00	11.740	11.530	32.9	0.7477	9.75	1.454	1.454	14.41
8	I	1.50	10.50	11.530	11.320	32.3	0.7477	11.25	1.428	1.428	14.17
9	I	1.50	12.00	11.320	11.110	31.7	0.7477	12.75	1.402	1.402	13.92
10	I	1.50	13.50	11.110	10.900	31.1	0.7476	14.25	1.376	1.376	13.67
11	I	1.50	15.00	10.900	10.690	30.5	0.7476	15.75	1.349	1.349	13.42
12	I	1.50	16.50	10.690	10.480	29.9	0.7475	17.25	1.323	1.323	13.18
13	I	1.50	18.00	10.480	10.270	29.3	0.7475	18.75	1.297	1.297	12.93
14	I	1.50	19.50	10.270	10.060	28.7	0.7474	20.25	1.271	1.271	12.68
15	I	1.50	21.00	10.060	9.850	28.1	0.7474	21.75	1.244	1.244	12.43
16	I	1.50	22.50	9.850	9.640	27.5	0.7473	23.25	1.218	1.218	12.19
17	I	1.50	24.00	9.640	9.430	26.9	0.7472	24.75	1.192	1.192	11.94
18	I	1.50	25.50	9.430	9.220	26.3	0.7472	26.25	1.166	1.166	11.69
19	I	1.50	27.00	9.220	9.010	25.7	0.7471	27.75	1.139	1.139	11.45
20	I	1.50	28.50	9.010	8.800	25.1	0.7471	29.25	1.113	1.113	11.20
		<u>30.00</u>				<u>616</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)	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



16362-1-24 - VA - 80 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	12.47	20.10	20.15	1.100	0.000	0.00	0	0.705	0.00	0.00	
2	1.00	0.450	12.47	19.77	19.82	1.100	0.000	0.00	0	0.721	0.00	0.00	
3	1.00	0.450	12.47	19.45	19.49	1.100	0.000	0.00	0	0.737	0.00	0.00	
4	1.00	0.450	12.47	19.12	19.16	1.100	0.000	0.00	0	0.753	0.00	0.00	
5	1.00	0.450	12.47	18.79	18.84	1.100	0.000	0.00	0	0.770	0.00	0.00	
6	1.00	0.450	12.47	18.46	18.51	1.100	0.000	0.00	0	0.788	0.00	0.00	
7	1.00	0.450	12.47	18.14	18.18	1.100	0.000	0.00	0	0.806	0.00	0.00	
8	1.00	0.450	12.47	17.81	17.85	1.100	0.000	0.00	0	0.826	0.00	0.00	
9	1.00	0.450	12.47	17.48	17.52	1.100	0.000	0.00	0	0.846	0.00	0.00	
10	1.00	0.450	12.47	17.15	17.20	1.100	0.000	0.00	0	0.867	0.00	0.00	
11	1.00	0.450	12.47	16.83	16.87	1.100	0.000	0.00	1	0.889	0.00	0.00	
12	1.00	0.450	12.47	16.50	16.54	1.100	0.000	0.00	1	0.912	0.00	0.00	
13	1.00	0.450	12.47	16.17	16.21	1.100	0.000	0.00	1	0.936	0.00	0.00	
14	1.00	0.450	12.47	15.84	15.88	1.100	0.000	0.00	1	0.961	0.00	0.00	
15	1.00	0.450	12.47	15.52	15.55	1.100	0.000	0.00	1	0.988	0.00	0.00	
16	1.00	0.450	12.47	15.19	15.23	1.100	0.000	0.00	1	1.015	0.00	0.00	
17	1.00	0.453	12.54	14.95	14.90	1.100	0.000	0.00	1	1.045	0.00	0.00	
18	1.00	0.466	12.91	15.05	14.57	1.100	0.000	0.00	1	1.075	0.00	0.00	
19	1.00	0.480	13.30	15.15	14.24	1.100	0.000	0.00	1	1.100	0.00	0.00	
20	1.00	0.495	13.70	15.25	13.91	1.100	0.000	0.00	1	1.100	0.00	0.00	
Fix. #1	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #2	1.00	1.199	33.21	996.30	498.15	1.199	0.000	0.00	0	1.199	0.00	0.00	0.00
Fix. #3	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	0	1.200	0.00	0.00	0.00
Fix. #4	1.00	1.134	31.40	235.50	117.75	1.134	0.000	0.00	1	1.134	0.00	0.00	0.00
Fix. #5	1.00	1.200	33.23	456.91	228.46	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #6	1.00	1.200	33.23	33.23	16.62	1.200	0.000	0.00	1	1.200	0.00	0.00	0.00
Fix. #7	1.00	1.132	31.34	329.07	164.54	1.132	0.000	0.00	1	1.132	0.00	0.00	0.00
Fix. #8	1.00	1.200	33.23	365.53	182.77	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



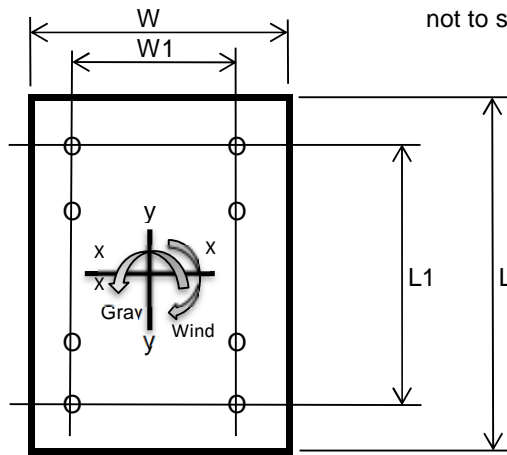
Flange Analysis - Arm #2

Applied Loads	Gp II	GpIII	GpIV	
Shear (Gravity)	983	1653	-	lbs
Shear (Wind)	2826	1582	-	lbs
Torsion (Arm Rise)	4443	2488	-	ft-lbs
Moment (Gravity)	15222	26492	-	ft-lbs
Moment (Wind)	44359	24535	-	ft-lbs
Nat. Wind Moment	-	-	-	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)	2.25
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 ²
Bolt Shear Stress Area	1.29	1.29	in ²
Mom. Inertia Bolt Grouping About X (Gravity Mom.)	794.39	794.39	in ⁴
Mom. Inertia Bolt Grouping About Y (Wind Mom.)	1428.89	1428.89	in ⁴
Bolt Tensile Stress - ft	4.93	5.07	ksi
Bolt Shear Stress - fv	0.7	0.46	ksi
Combined Bolt Stress			
Allowable Tensile Stress = Ft =	44.22	44.22	ksi
Allowable Shear Stress = Fv =	22.11	22.11	ksi
$[(fv/Fv)^2 + (ft/Ft)^2]^{.5} \leq 1$	0.12	0.12	CSR
Therefore	OK	OK	
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	OK	

Plate Analysis			
Stress from gravity loads = $2P \cdot e / (W \cdot t^2 / 6)$	2.76	4.80	ksi
Stress from wind loads = $4P \cdot e / (L \cdot t^2 / 6)$	8.18	4.53	ksi
Combined applied stress for interaction (SRSS)	8.63	6.60	ksi
Allow. Plate Stress = $0.66 \cdot Fy \cdot \text{Group Load Incr.}$	43.89	43.89	ksi
Since Allow Stress > Applied Stress Therefore	OK	OK	



16362-1-24 - VA - 80 MPH - MP-3 Standard Loads - Type C - 70'/30' Arms

Fatigue Allowable - Shaft to Baseplate Weld & 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	19.00	in
Ttp - Thickness of baseplate	2.00	in
Dbc - Bolt circle diameter	26.00	in
Cbc - Bolt circle ratio	1.368421	
Dop - Baseplate center hole diameter	14.25	in
Cop - Center hole to shaft diameter ratio	0.75	
Kf - Fatigue stress concentration factor for finite life	2.58	
Ki - Fatigue stress concentration factor for infinite life	6.07	
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	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	1.76	
Ki - Fatigue stress concentration factor for infinite life	3.33	
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	0.1793	in
Dt - Arm base diameter	13.00	in
Ttp - Thickness of baseplate	2.25	in
Dbc - Bolt circle diameter	31.82	in
Cbc - Bolt circle ratio	2.447677	
Dop - Baseplate center hole diameter	6	in
Cop - Center hole to arm diameter ratio	0.461538	
Kf - Fatigue stress concentration factor for finite life	1.79	
Ki - Fatigue stress concentration factor for infinite life	3.16	
Fatigue Allowable	7	ksi

Note: Maximum diagonal distance between bolts used as bolt circle



16362-1-24 - VA - 80 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)	18.57	in
Shaft Thickness	0.375	in
Total Area	26.1281	in ²
Ix	988	in ⁴
Iy	1065	in ⁴
Controlling Moment - Natural Wind Gust	0	ft-lbs

CHECK

Allowable - Stress at Root	16.0	ksi
Actual Stress at Root	0.00	ksi
CSR	0.00	
Allowable - Stress at Toe	7.0	ksi
Actual Stress at Toe	0.00	ksi
CSR	0.00	
Therefore	OK	



16362-1-24 - VA - 80 MPH - MP-3 Standard Loads - Type C - 70'/30' Arms

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	2748		2748	85085		85086		406	17485		0.49
Gp II	2748	5024	5727	85085	177334	196690	18425	846	40418	1894	0.86
Gp III	4188	2976	5138	136444	102766	170816	10916	759	35102	1122	0.74
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	1711		1711	36293		36293		397	13841		0.41
Gp II	1711	3372	3782	36293	83839	91358	12368	878	34840	2359	0.79
Gp III	2743	1967	3375	60422	47862	77082	7213	784	29396	1376	0.66
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	983		983	15222		15222		273	7896		0.23
Gp II	983	2826	2992	15222	44359	46898	4443	830	24326	1153	0.53
Gp III	1653	1582	2288	26492	24535	36109	2488	634	18729	646	0.40
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		-



16362-1-24 - VA - 80 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	5244		85085	15222	86436		239		10157		0.29
Gp II	5244	5918	107580	125953	165643	182772	239	540	19465	10739	0.63
Gp III	7796	3627	67946	167665	180909	105622	355	331	21259	6206	0.53
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	3826		85085	15222	86436		202		13585		0.39
Gp II	3826	5049	30497	87589	92746	182772	202	533	14577	14363	0.69
Gp III	5937	3002	34604	138128	142397	105622	313	317	22380	8300	0.60
Gp IV Natural			0	0	0				0		-
Gp IV Truck			0		0				0		-
Gp IV Gallop			0		0				0		-
CA	0.9967										



16362-1-24 - VA - 80 MPH - MP-3 Standard Loads - Type C - 70/30' Arms

Anchor Bolt & Base Plate Analysis

INPUTS

Shear Force	5918 lbs
Bending Moment	180909 ft-lbs
Torsion Moment	182772 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	19.00 in

ANALYSIS - ANCHOR BOLTS

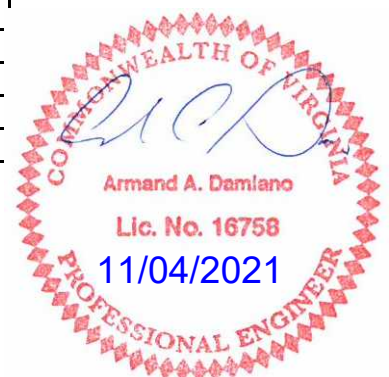
Bolt Tensile Stress Area	2.5 in ²
Bolt Shear Stress Area	2.3 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	16.661 ksi
Bolt Direct Shear Stress	0.322 ksi
Bolt Torsion Shear Stress	9.17 ksi
Combined Bolt Stress	
$F_v = .3 F_y$ * Allowable Increase Factor	21.945 ksi
$F_t = .5 F_y$ * Allowable Increase Factor	36.575 ksi
$f_t =$	16.661 ksi
$f_v =$	9.492 ksi
$[(f_v/F_v)^2 + (f_t/F_t)^2]^{.5} \leq 1$	0.63 CSR
Therefore	OK

ANALYSIS - BASEPLATE (Case I)

Length of "Failure Line" On Base Plate	9.941 in
Dist. Shaft Face To Bolt Center	3.5 in
Design Moment	146 in-kip
Section Modulus of Failure Plane	6.62 in ³
Applied Plate Stress	22.06 ksi
Allowable Plate Stress = $.66 F_y$ * Allow. Incr.	31.6 ksi
Therefore	OK

ANALYSIS - BASEPLATE (Case II)

Length of "Failure Line" On Base Plate	9.475 in
Dist From Shaft To Nut Face	1.938 in
Design Moment	81 in-kip
Section Modulus of Failure Plane	6.31 in ³
Applied Plate Stress	12.84 ksi
Allowable Plate Stress = $.66 F_y$ * Allow. Incr.	31.6 ksi
Therefore	OK



16362-1-24 - VA - 80 MPH - MP-3 Standard Loads - Type C - 70/30' Arms

Anchor Bolt & Base Plate Analysis

ANALYSIS - ANCHOR BOLTS - FATIGUE

Bending Moment	0 ft-lbs
Bolt Tensile Stress Area	2.5 in ²
Mom. Inertia Bolt Grouping	1693.98 in ⁴
c Dist. (Section 5.17.7)	13.00 in
Bolt Tensile Stress	0 ksi
Bolt Stress	
Ft = .Stress Allowable	7.00 ksi
Fatigue Stress Ratio	0
Therefore	OK

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 _b = Net Bearing Area	4.528 in ²
D _w = 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	41653 lbs
Computed Factor-of Safety	1.49 OK

CONCRETE PULL OUT CAPACITY

Maximum Applied Tensile Load Per Bolt	41653 lbs
Total Tensile Load	333224 lbs
Concrete Failure Surface Area	4310.27 in ²
Concrete Shear Strength	472166 psi
Computed Factor-of Safety	1.41 OK

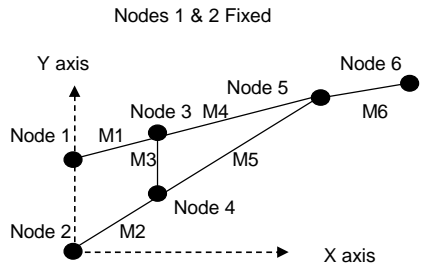
LOAD TRANSFER TO REINFORCEMENT CAGE

Maximum Applied Tensile Load Per Bolt	41653 lbs
Total Tensile Load	333224 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.



16362-2 - 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)
80									
Node #1	0	27	0	0	-8.15	-13.5	0	0	0
Node #2	0	0	0	0	-10.01	-16.5	0	0	0
Node #3	48	50.5	0	0	-15.82	-26.2	0	0	0
Node #4	48	44.8	0	0	-17.92	-29.7	0	0	0
Node #5	96	61	0	0	-22.63	-37.3	0	0	0
Node #6	144	69	0	0	-64.42	-67.7	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	53.44	0.88	1.075	-16.29	1.1	1	-26.85	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	-32.98	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	-0.82	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	-24.68	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	-25.45	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	-24.45	0.666	0.666	1.332	11000000	29000000
Fixture Node 6				2		-57.00	1	1	-55.38					

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	143.5	lbs
M1x	3614.7	in-lbs
M1y	-10108.8	in-lbs
M1z	-1505.3	in-lbs
P2x	589.5	lbs
P2y	493.7	lbs
P2z	47.4	lbs
M2x	2475.9	in-lbs
M2y	-5904.0	in-lbs
M2z	-1343.3	in-lbs

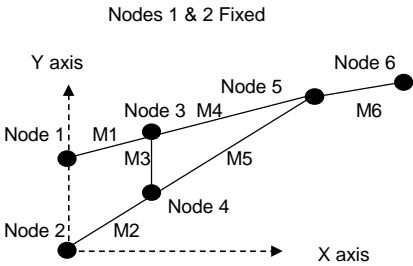
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-641	272	19211	-1005	0.56
#2	708	108	10973	-1861	0.44
#3	961	1528	17175	-384	0.57
#4	-715	84	7622	-80	0.21
#5	737	113	8501	-200	0.32
#6	10	173	8057	-1	0.25

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16362-2 - 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)
80									
Node #1	0	27	0	0	-11.27	-6.8	0	0	0
Node #2	0	0	0	0	-13.85	-8.3	0	0	0
Node #3	48	50.5	0	0	-21.96	-13.1	0	0	0
Node #4	48	44.8	0	0	-24.85	-14.9	0	0	0
Node #5	96	61	0	0	-31.3	-18.7	0	0	0
Node #6	144	69	0	0	-91.26	-33.9	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	-22.53	1.1	1	-13.42	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	-16.49	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	-0.41	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	-12.34	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	-12.72	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	-12.22	0.666	0.666	1.332	11000000	29000000
Fixture Node 6				2		-81.00	1	1	-27.69					

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	71.9	lbs
M1x	1810.6	in-lbs
M1y	-5063.5	in-lbs
M1z	-2130.1	in-lbs
P2x	830.5	lbs
P2y	695.0	lbs
P2z	23.8	lbs
M2x	1240.2	in-lbs
M2y	-2957.3	in-lbs
M2z	-1900.4	in-lbs

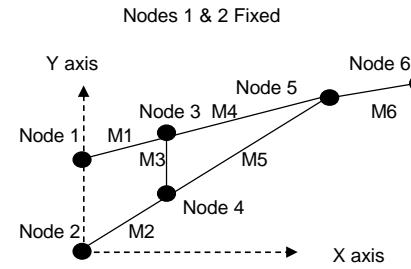
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-904	214	10258	-504	0.28
#2	998	132	6345	-932	0.33
#3	1352	2049	22675	-193	0.76
#4	-1009	42	5362	-40	0.13
#5	1039	57	5376	-100	0.25
#6	14	179	8347	-1	0.26

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16362-2 - 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)
80									
Node #1	0	27	0	0	-9.94	-16.4	0	0	0
Node #2	0	0	0	0	-11.04	-18.2	0	0	0
Node #3	60	52.47	0	0	-19.56	-32.5	0	0	0
Node #4	60	40.5	0	0	-21.08	-35	0	0	0
Node #5	120	61	0	0	-28.13	-46.4	0	0	0
Node #6	180	69	0	0	-66.23	-70.6	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	65.18	1.08	1.075	-19.87	1.1	1	-32.74	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	-36.36	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	-1.73	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	-30.44	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	-31.85	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	-30.41	0.666	0.666	1.332	11000000	29000000
Fixture Node 6				2		-57.00	1	1	-55.38					

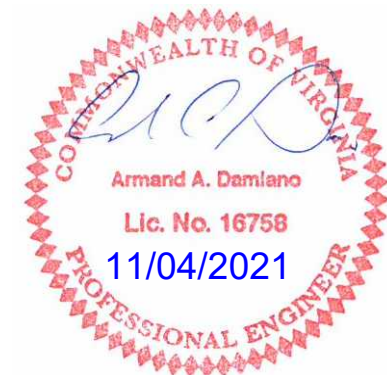
AASHTO Gp	2
Mntg Hght =	28.5
Datum =	0

RESULTS		
ITEM	GLOBAL AXIS REACTIONS	
P1x	-709.4	lbs
P1y	-312.8	lbs
P1z	143.7	lbs
M1x	3903.7	in-lbs
M1y	-13011.0	in-lbs
M1z	-719.5	in-lbs
P2x	709.4	lbs
P2y	468.8	lbs
P2z	75.4	lbs
M2x	3482.7	in-lbs
M2y	-9315.0	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	240	24109	-1250	0.71
#2	786	112	17286	-1950	0.66
#3	934	441	9995	-476	0.37
#4	-699	115	9784	104	0.28
#5	719	124	10715	-470	0.42
#6	9	180	10405	-1	0.32

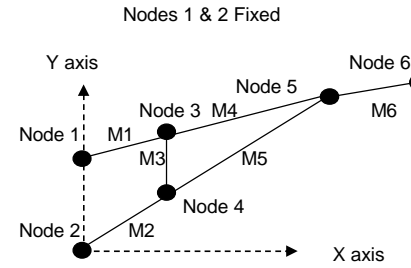
ALLOWABLES	
Gp II Increase	1.4
Fy =	36000 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Fa Member 1	21600 psi
Fa Member 2	4399 psi
Fa Member 3	11129 psi
Fa Member 4	21600 psi
Fa Member 5	5734 psi
Fa Member 6	6291 psi

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16362-2 - 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)
80									
Node #1	0	27	0	0	-13.75	-8.2	0	0	0
Node #2	0	0	0	0	-15.27	-9.1	0	0	0
Node #3	60	52.47	0	0	-27.21	-16.3	0	0	0
Node #4	60	40.5	0	0	-29.32	-17.5	0	0	0
Node #5	120	61	0	0	-38.91	-23.2	0	0	0
Node #6	180	69	0	0	-93.77	-35.3	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	2.375	0.154	65.18	1.08	1.075	-27.48	1.1	1	-16.37	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	-18.18	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	-0.86	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	-15.22	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	-15.93	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	-15.20	0.666	0.666	1.332	11000000	29000000
Fixture Node 6				2		-81.00	1	1	-27.69					

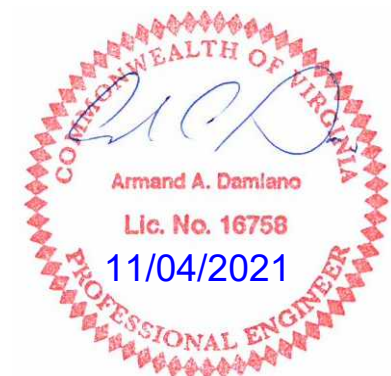
AASHTO Gp	3
Mntg Hght =	28.5
Datum =	0

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	71.9	lbs
M1x	1952.8	in-lbs
M1y	-6507.5	in-lbs
M1z	-1027.6	in-lbs
P2x	998.7	lbs
P2y	659.3	lbs
P2z	37.7	lbs
M2x	1742.1	in-lbs
M2y	-4658.5	in-lbs
M2z	-996.5	in-lbs

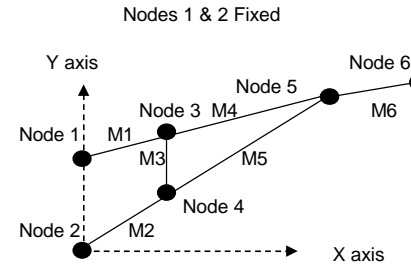
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1021	130	12180	-625	0.34
#2	1106	71	8804	-975	0.45
#3	1314	417	9530	-238	0.38
#4	-984	88	4984	52	0.12
#5	1013	87	5437	-235	0.29
#6	12	185	10731	-1	0.33

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16362-2 - 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)
80									
Node #1	0	27	0	0	-10.52	-12.7	0	0	0
Node #2	0	0	0	0	-11.4	-13.7	0	0	0
Node #3	48	41.7	0	0	-31.56	-38.4	0	0	0
Node #4	48	25.6	0	0	-33.36	-40.6	0	0	0
Node #5	144	61	0	0	-57.15	-68.5	0	0	0
Node #6	216	69	0	0	-72.19	-73.6	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	0.218	50.20	0.83	1.478	-21.04	1.1	1	-25.22	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	-27.33	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	-2.32	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	-49.19	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	-51.40	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	-36.39	0.868	0.868	1.736	11000000	29000000
Fixture Node 6				2		-57.00	1	1	-55.38					

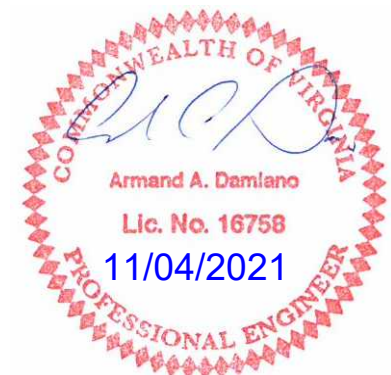
AASHTO Gp	2
Mntg Hght =	28.5
Datum =	0

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	162.3	lbs
M1x	3845.0	in-lbs
M1y	-16779.3	in-lbs
M1z	-991.2	in-lbs
P2x	1070.4	lbs
P2y	557.9	lbs
P2z	85.2	lbs
M2x	4014.1	in-lbs
M2y	-12774.3	in-lbs
M2z	-969.9	in-lbs

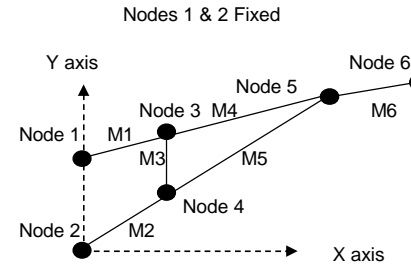
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-763	205	23529	-777	0.69
#2	814	102	18054	-1551	0.63
#3	611	363	10921	-405	0.4
#4	-756	109	13430	-6	0.38
#5	780	97	13133	-563	0.67
#6	6	140	10187	1	0.31

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16362-2 - 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)
80									
Node #1	0	27	0	0	-10.59	-6.4	0	0	0
Node #2	0	0	0	0	-11.47	-6.9	0	0	0
Node #3	48	41.7	0	0	-32.15	-19.2	0	0	0
Node #4	48	25.6	0	0	-33.96	-20.3	0	0	0
Node #5	144	61	0	0	-57.49	-34.3	0	0	0
Node #6	216	69	0	0	-96.28	-36.8	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	50.20	0.83	1.075	-21.17	1.1	1	-12.61	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	-13.66	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	-1.16	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	-24.59	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	-25.70	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	-18.20	0.666	0.666	1.332	11000000	29000000
Fixture Node 6				2		-81.00	1	1	-27.69					

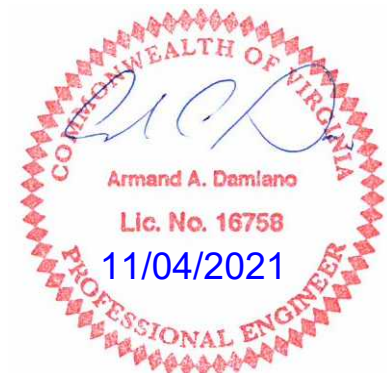
AASHTO Gp	3
Mntg Hght =	28.5
Datum =	0

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	82.8	lbs
M1x	1923.6	in-lbs
M1y	-8435.1	in-lbs
M1z	-1476.2	in-lbs
P2x	1302.0	lbs
P2y	668.4	lbs
P2z	41.1	lbs
M2x	1965.7	in-lbs
M2y	-6348.9	in-lbs
M2z	-1430.1	in-lbs

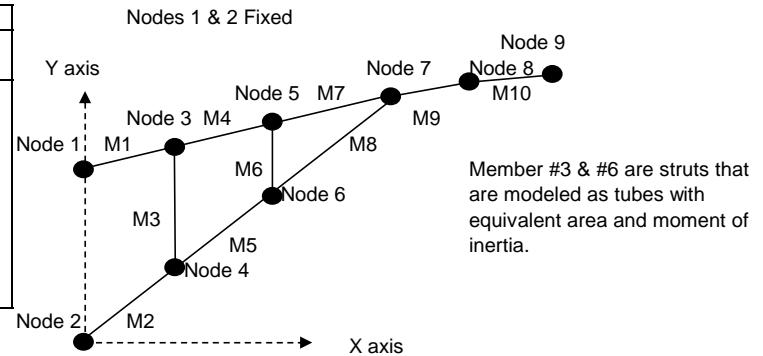
RESULTS					
AASHTO STRESSES, LOCAL AXIS					
Member	Axial (psi)	Shear (psi)	Bending (in-lbs)	Torsion (in-lbs)	CSR
#1	-1278	158	15609	-529	0.43
#2	1357	89	11914	-1051	0.49
#3	732	356	10876	-268	0.41
#4	-1275	96	8703	-4	0.22
#5	1315	88	8624	-372	0.69
#6	10	191	13243	-1	0.4

V09.19.15



16' Luminaire Arm

Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)						
	80	X	Y	Z	Fx	Fy grav.	Fz wind	Mx	My	Mz
	(in)	(in)	(in)	(lbs)	(lbs)	(lbs)	(in-lbs)	(in-lbs)	(in-lbs)	(in-lbs)
Node #1	0	27	0	0	-7.78	-12.9	0	0	0	0
Node #2	0	0	0	0	-8.3	-13.7	0	0	0	0
Node #3	48	43.94	0	0	-17.67	-29.3	0	0	0	0
Node #4	48	25.5	0	0	-18.61	-30.79	0	0	0	0
Node #5	96	63.05	0	0	-16.54	-27.33	0	0	0	0
Node #6	96	51.04	0	0	-17.1	-28.26	0	0	0	0
Node #7	144	61	0	0	-18.55	-30.56	0	0	0	0
Node #8	168	65	0	0	-14.94	-26.1	0	0	0	0
Node #9	192	69	0	0	-60.72	-61.6	0	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	-25.63	0.671	0.671	1.342	11000000	29000000
Member #2	2.38	0.154	54.35	0.90	1.077	-16.6	1.1	-27.37	0.671	0.671	1.342	11000000	29000000
Member #3	1.75	0.1525	18.44	0.22	0.766	-4.01	1.1	-6.83	0.247	0.247	0.494	11000000	29000000
Member #4	2.38	0.154	51.66	0.85	1.077	-15.78	1.1	-26.01	0.671	0.671	1.342	11000000	29000000
Member #5	2.38	0.154	54.37	0.90	1.077	-16.61	1.1	-27.38	0.671	0.671	1.342	11000000	29000000
Member #6	1.75	0.1525	12.01	0.15	0.766	-2.61	1.1	-4.45	0.247	0.247	0.494	11000000	29000000
Member #7	2.38	0.154	48.04	0.79	1.077	-14.68	1.1	-24.19	0.671	0.671	1.342	11000000	29000000
Member #8	2.38	0.154	49.02	0.81	1.077	-14.98	1.1	-24.68	0.671	0.671	1.342	11000000	29000000
Member #9	2.38	0.154	24.33	0.40	1.077	-7.44	1.1	-12.25	0.671	0.671	1.342	11000000	29000000
Member #10	2.38	0.154	24.33	0.40	1.077	-7.44	1.1	-12.25	0.671	0.671	1.342	11000000	29000000
Camera Node 8				1		-15	1	-27.69					
Fixture Node 9				2		-57	1	-55.38					

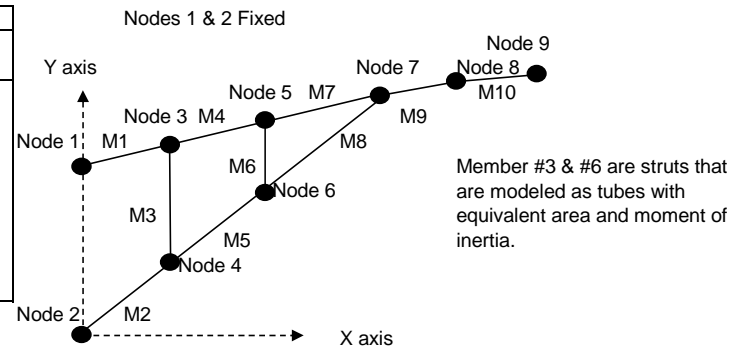
ALLOWABLES		
Fy =	36000	psi
Fa = .60 Fy	21600	psi
Fa Comp.=	7847	psi
Fb = .66 Fy	23760	psi
Fv = .33 Fy	11880	psi
Gp II Increase	1.4	

RESULTS							
ITEM	LOCAL AXIS		AASHTO STRESSES		GLOBAL AXIS		
P1x	-435.2	lbs	Axial	405	psi	-425.2	lbs
P1y	44.3	lbs	Shear	202	psi	-103.0	lbs
P1z	99.0	lbs	Bending	6347	in-lbs	99.0	lbs
M1x	-818.9	in-lbs	Torsion	684	in-lbs	364.0	in-lbs
M1y	-3414.0	in-lbs	CSR	0.21		-3491.9	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	93	psi	215.0	lbs
P2z	48.8	lbs	Bending	5213	in-lbs	48.8	lbs
M2x	-1140.8	in-lbs	Torsion	953	in-lbs	370.5	in-lbs
M2y	-2937.1	in-lbs	CSR	0.21		-3129.0	in-lbs
M2z	115.6	in-lbs				115.6	in-lbs



24' Luminaire Arm

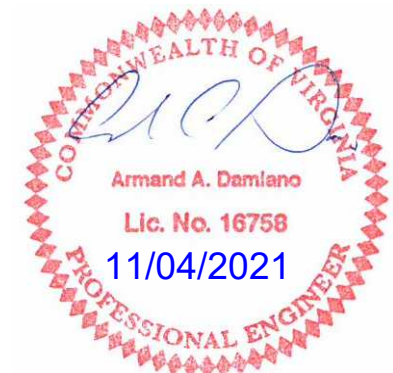
Wind Vel	COORDINATES			NODAL APPLIED LOADS (GLOBAL AXIS)					
	X (in)	Y (in)	Z (in)	Fx (lbs)	Fy grav. (lbs)	Fz wind (lbs)	Mx (in-lbs)	My (in-lbs)	Mz (in-lbs)
80									
Node #1	0	27	0	0	-16.4	-15.4	0	0	0
Node #2	0	0	0	0	-16.88	-15.9	0	0	0
Node #3	50	34.29	0	0	-35.64	-34.6	0	0	0
Node #4	50	14.34	0	0	-36.55	-35.44	0	0	0
Node #5	100	41.58	0	0	-51.11	-48.75	0	0	0
Node #6	100	28.06	0	0	-52.45	-50.01	0	0	0
Node #7	200	56.12	0	0	-79.63	-74.76	0	0	0
Node #8	240	62.56	0	0	-33.79	-38.54	0	0	0
Node #9	280	69	0	0	-70.15	-67.8	0	0	0
K Node #1	36	240	0						
K Node #2	360	360	0						
K Node #3	300	0	0						

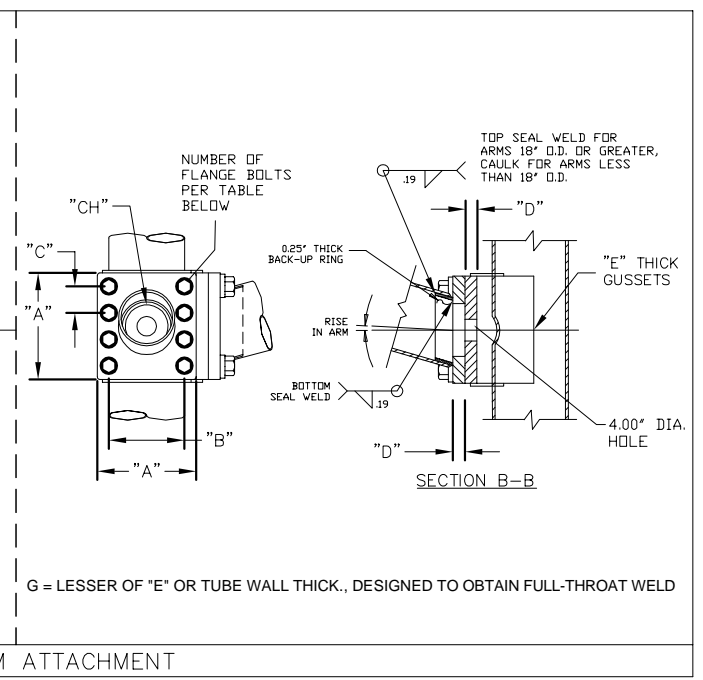
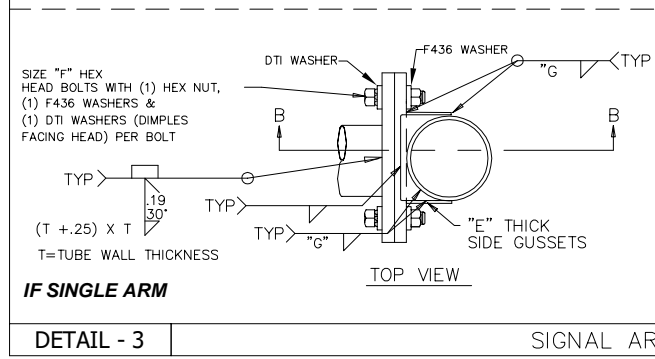
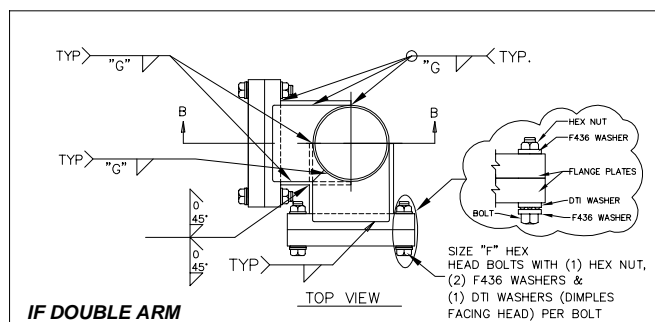
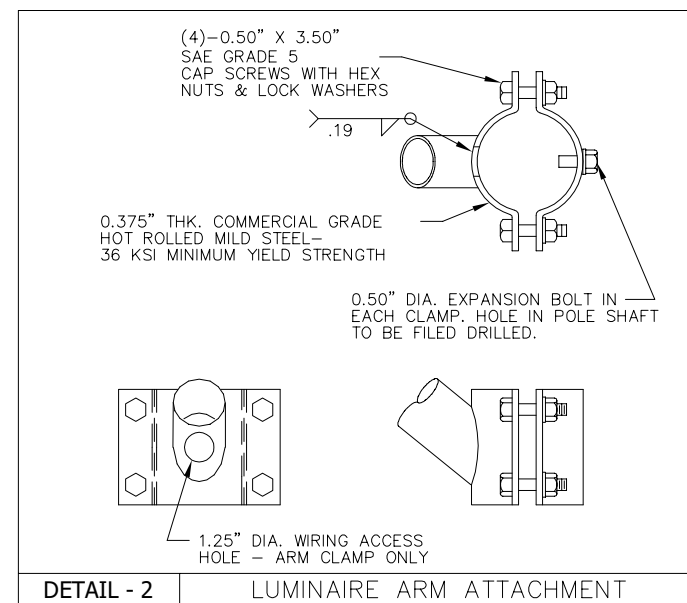
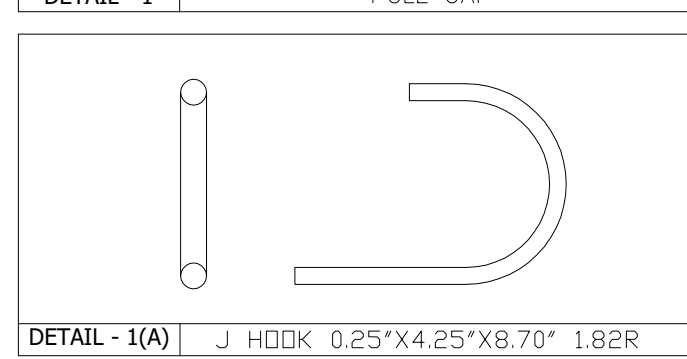
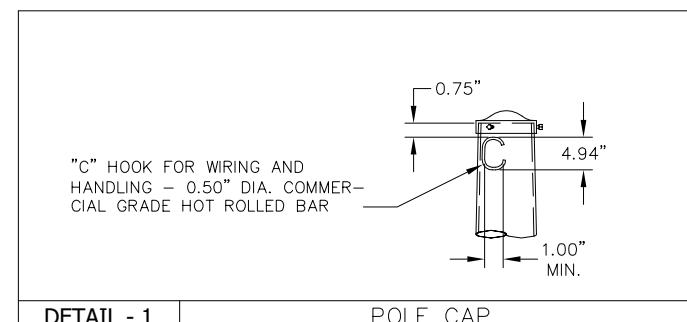
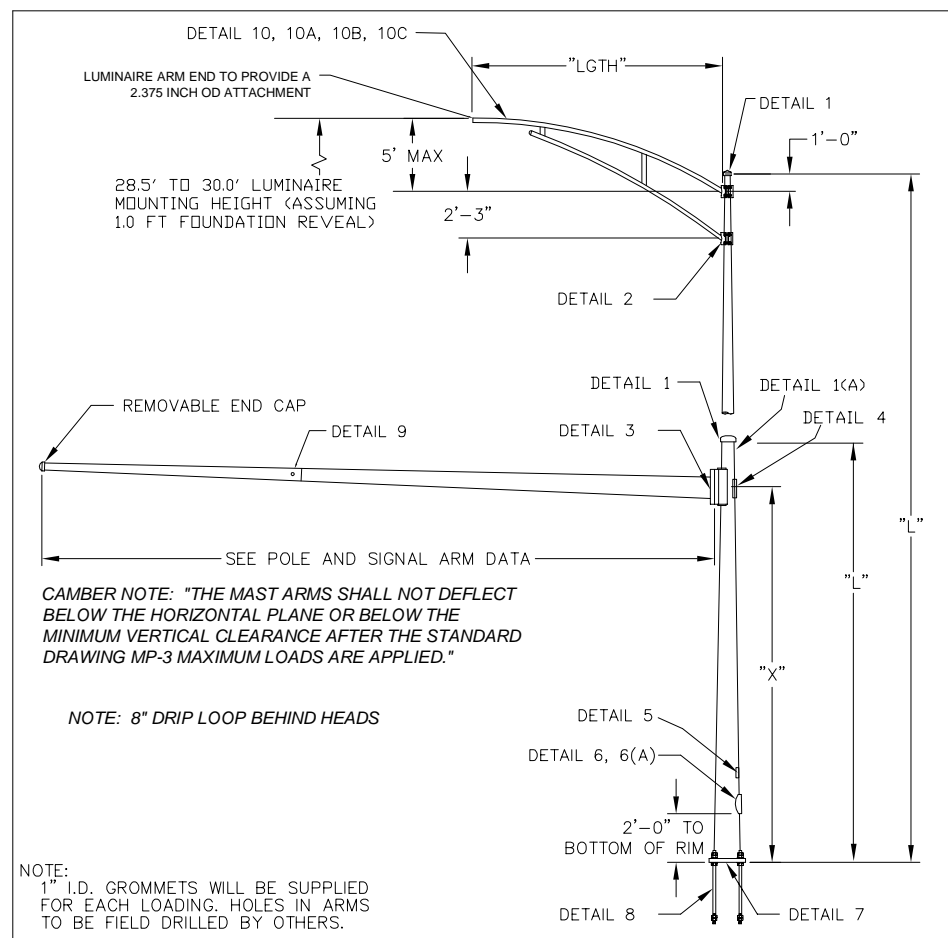


	OD (in)	Wall (in)	Lgth (in)	PArea (sq.ft.)	Area (in^2)	Wght (lbs)	Cd	Wind (lbs)	Iy (in^4)	Iz (in^4)	Jx (in^4)	G (psi)	E (psi)
Member #1	2.88	0.28	50.53	1.01	2.288	-32.79	1.1	-30.78	1.955	1.955	3.91	11000000	29000000
Member #2	2.88	0.28	52.02	1.04	2.288	-33.75	1.1	-31.69	1.955	1.955	3.91	11000000	29000000
Member #3	1.8	0.2	19.95	0.25	1.006	-5.7	1.1	-7.6	0.327	0.327	0.654	11000000	29000000
Member #4	2.88	0.28	50.53	1.01	2.288	-32.79	1.1	-30.78	1.955	1.955	3.91	11000000	29000000
Member #5	2.88	0.28	51.85	1.04	2.288	-33.64	1.1	-31.59	1.955	1.955	3.91	11000000	29000000
Member #6	1.8	0.2	13.52	0.17	1.006	-3.86	1.1	-5.15	0.327	0.327	0.654	11000000	29000000
Member #7	2.88	0.28	101.05	2.02	2.288	-65.57	1.1	-61.56	1.955	1.955	3.91	11000000	29000000
Member #8	2.88	0.28	103.86	2.08	2.288	-67.39	1.1	-63.27	1.955	1.955	3.91	11000000	29000000
Member #9	2.88	0.28	40.52	0.81	2.288	-26.29	1.1	-24.69	1.955	1.955	3.91	11000000	29000000
Member #10	2.88	0.28	40.52	0.81	2.288	-26.29	1.1	-24.69	1.955	1.955	3.91	11000000	29000000
Camera Node 8				1		-15	1	-27.69					
Fixture Node 9				2		-57	1	-55.38					

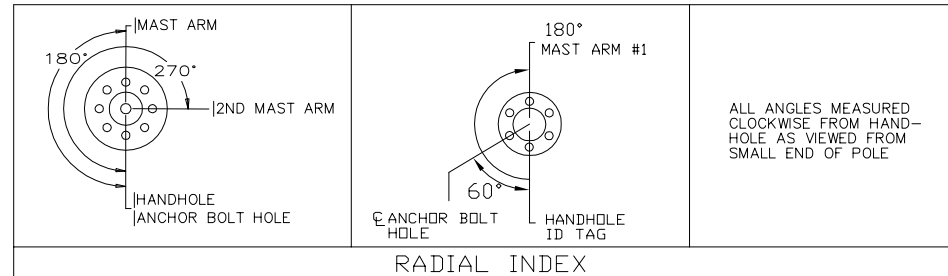
ALLOWABLES	
Fy =	36000 psi
Fa = .60 Fy	21600 psi
Fa Comp.=	11751 psi
Fb = .66 Fy	23760 psi
Fv = .33 Fy	11880 psi
Gp II Increase	1.4

ITEM	RESULTS						
	LOCAL AXIS		AASHTO STRESSES		GLOBAL AXIS		
P1x	-875.9	lbs	Axial	383	psi	-880.6	lbs
P1y	96.0	lbs	Shear	150	psi	-31.3	lbs
P1z	140.9	lbs	Bending	4278	in-lbs	140.9	lbs
M1x	-1366.6	in-lbs	Torsion	460	in-lbs	-596.6	in-lbs
M1y	-5237.7	in-lbs	CSR	0.15		-5380.1	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	49	psi	207.5	lbs
P2z	35.5	lbs	Bending	3498	in-lbs	35.5	lbs
M2x	-1737.1	in-lbs	Torsion	585	in-lbs	-361.2	in-lbs
M2y	-4746.6	in-lbs	CSR	0.14		-5041.5	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			
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.					

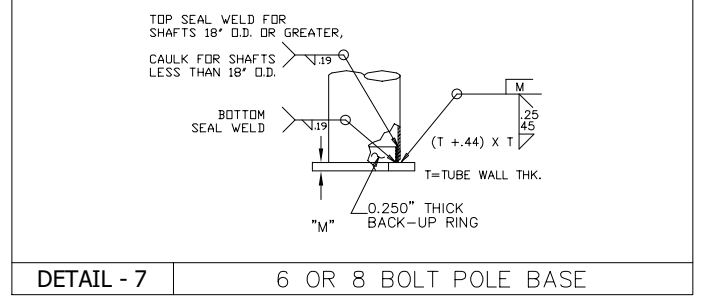


DESIGN BASED ON:
- AASHTO 6TH EDITION
- 80 MPH (APPENDIX C) WIND
- 25 YEAR RECURRENCE
- FATIGUE CATEGORY II FOR 50' ARMS OR LONGER
- NO FATIGUE REQUIREMENTS FOR ARMS 49' LONG OR SMALLER
- NO GALLOPING LOADS
- NO TRUCK GUST
- MP-3 STANDARD LOADS

NOTE: DRAWING NOT TO SCALE

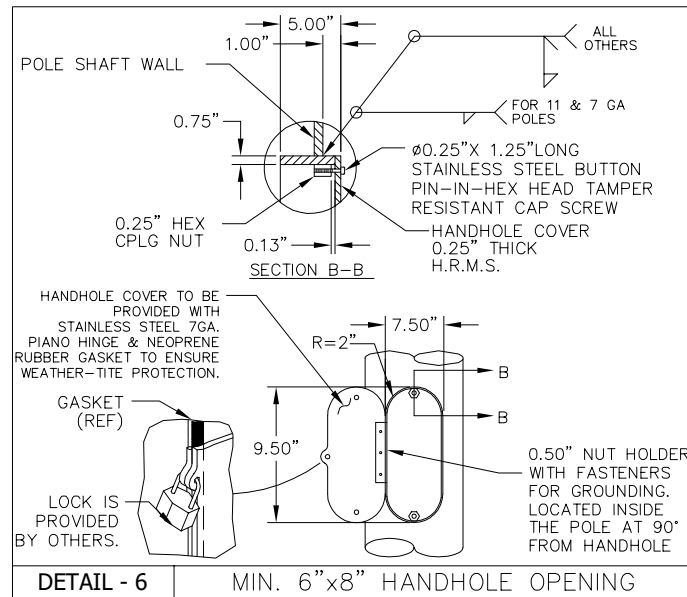
VIRGINIA DEPARTMENT OF TRANSPORTATION
C.O. STRUCTURE AND BRIDGE
REVIEW OF WORKING DRAWINGS
Working drawings have been reviewed in accordance with Section 105.10 of the Specifications with the following comments.
 Reviewed Revise and Resubmit
 Reviewed as Noted
Reviewed by: Karl Larson 11/30/2021

COMMONWEALTH OF VIRGINIA
Armand A. Damiano
Lic. No. 16758
11/04/2021
PROFESSIONAL ENGINEER

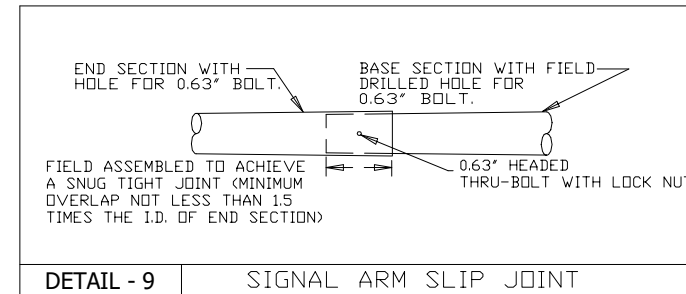
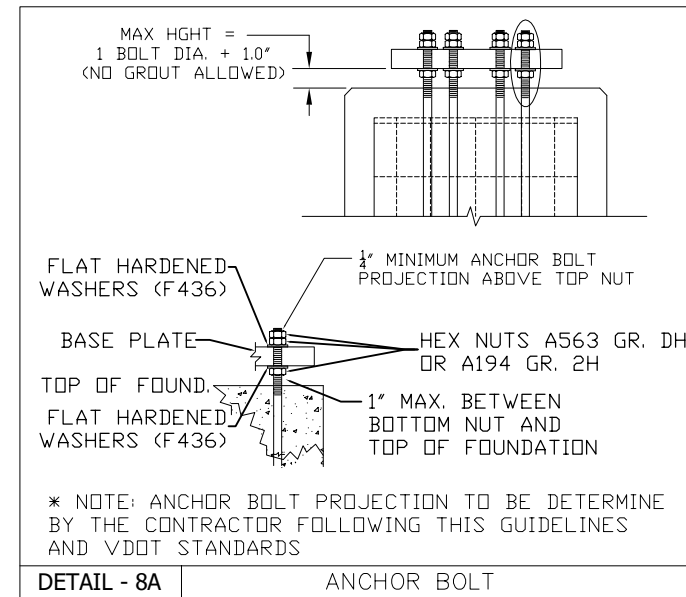
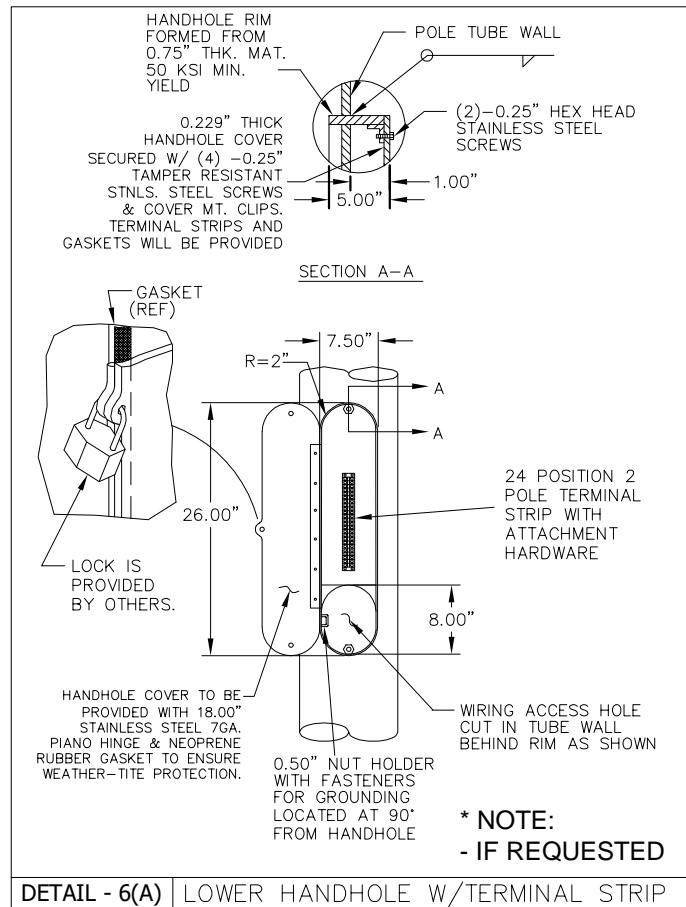
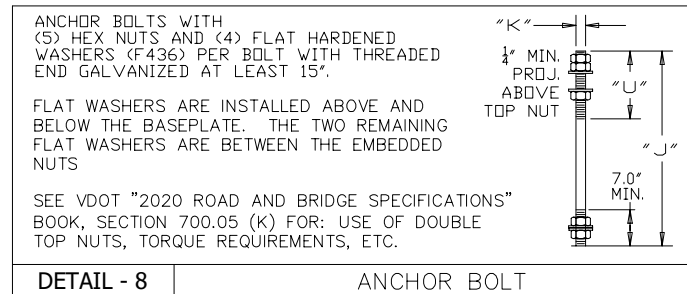


REV.	DATE	REVISION
A	08/08/19	VDDT REVIEW COMMENTS
B	10/02/19	VDDT REVIEW COMMENTS
C	11/04/21	VDDT REVIEW COMMENTS

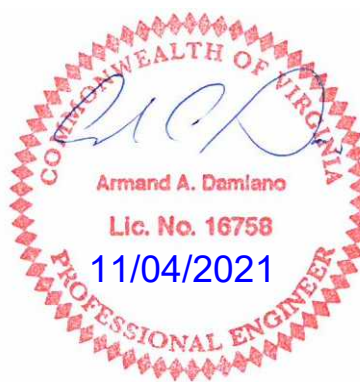
CUSTOMER: **ATS-SALES**
Valley, NE 68064 POLES
(402) 359-2201
DATE: 04/04/19
DRAWING: 16362-2(A) C



DETAIL - 6 MIN. 6"x8" HANDHOLE OPENING



VIRGINIA DEPARTMENT OF TRANSPORTATION
C.O. STRUCTURE AND BRIDGE
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Reviewed by: Karl Larson 11/30/2021



REV.	DATE	REVISION
A:	08/08/19:	VDOT REVIEW COMMENTS
B:	10/02/19:	VDOT REVIEW COMMENTS
C:	11/04/21:	VDOT REVIEW COMMENTS

CUSTOMER: **ATS-SALES**
valmont
Valley, NE 68064 POLES
(402) 359-2201

DATE: 04/04/19
DRAWING: 16362-2(B) C

MAST ARM POLE DETAILS
80 MPH - MP-3 STANDARDS
VIRGINIA

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	-	16.00	13.27	19.5	0.250	18.0	30.0	24.0	11.50	2.00	2.25	6 OR 8	2.00	60.0	14.0	49	NA	NA	F1
B1	-	19.50	16.77	19.5	0.313	18.0	32.0	26.0	14.25	2.00	2.25	8	2.00	60.0	14.0	75 Case 1	NA	NA	F2
B2	-	20.50	17.77	19.5	0.375	18.0	32.0	26.0	15.75	2.00	2.25	8	2.00	60.0	14.0	75 Case 2	NA	NA	F3
C	-	19.00	16.27	19.5	0.375	18.0	32.0	26.0	14.25	2.00	2.25	8	2.00	60.0	14.0	70/60	NA	NA	F2
D	-	16.00	12.50	25.0	0.250	18.0	30.0	24.0	11.50	2.00	2.25	6 OR 8	2.00	60.0	14.0	49	24.0	5.0	F1
E1	-	19.50	16.00	25.0	0.313	18.0	32.0	26.0	14.25	2.00	2.25	8	2.00	60.0	14.0	75 Case 1	24.0	5.0	F2
E2	-	20.50	17.00	25.0	0.375	18.0	32.0	26.0	15.75	2.00	2.25	8	2.00	60.0	14.0	75 Case 2	24.0	5.0	F3
F	-	19.00	15.50	25.0	0.375	18.0	32.0	26.0	14.25	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:11/04/21:	VDDT REVIEW COMMENTS	
CUSTOMER:		 Valley, NE 68064 POLES (402) 359-2201
MAST ARM POLE DETAILS 80 MPH - MP-3 STANDARDS VIRGINIA		
DAT	04/04/19	REV
DRAWING:	16362-2(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	13.00	8.80	0.179	30.00	6.00	-	F2
-	40.0 OPTION A	12.00	6.40	0.179	40.00	6.00	-	F1
-	40.0 OPTION B	13.00	7.40	0.179	40.00	6.00	-	F2
-	49.0	13.00	6.14	0.239	49.00	6.00	-	F1
-		-	-	-	-	-	-	F2
-	50.0	13.00	6.00	0.239	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	0.250	28.69	6.00	-	F2
-		-	13.00	7.54	0.179	39.00	-	F3
-	70.0	17.50	14.00	0.250	25.00	6.00	-	F2
-		-	14.79	8.09	0.188	47.92	-	F3
-	75.0 - Case 1	18.00	14.08	0.250	28.00	6.00	-	F2
-		-	14.87	7.88	0.188	49.93	-	F3
-	75.0 - Case 2	19.00	14.80	0.313	30.00	6.00	-	F2
-		-	15.66	8.94	0.219	48.02	-	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"

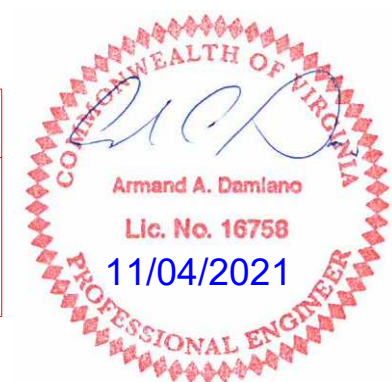
NOTES:
 - ARMS BETWEEN STANDARD LENGTHS MAY BE SUBSTITUTED WITH THE NEXT LONGER ARM AND TRIMMED TO THE CORRECT LENGTH IF THE FLANGE SIZE CORRESPONDS TO WHAT IS REQUIRED BY THE SHAFT.
 - ACTUAL LENGTH OF FLANGE BOLTS MAY BE ADJUSTED TO ACCOMMODATE CUSTOMIZED WASHERS ASSEMBLY.

VIRGINIA DEPARTMENT OF TRANSPORTATION
 C.O. STRUCTURE AND BRIDGE
 REVIEW OF WORKING DRAWINGS

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



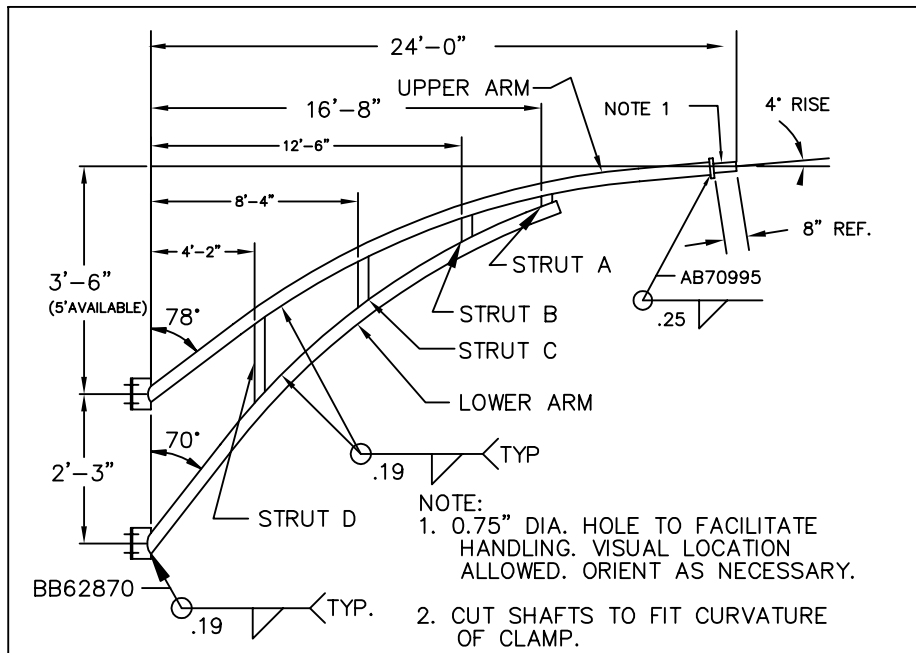
REV.	DATE	REVISION
A	08/08/19	VDDT REVIEW COMMENTS
B	10/02/19	VDDT REVIEW COMMENTS
C	11/04/21	VDDT REVIEW COMMENTS

CUSTOMER: ATS-SALES

valmont
 Valley, NE 68064 POLES
 (402) 359-2201

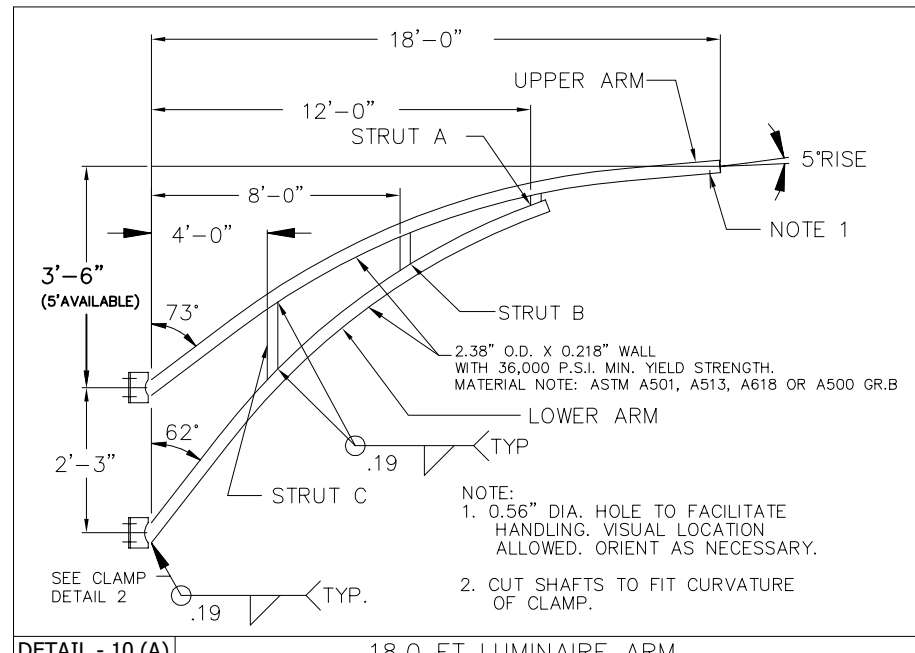
DAT 04/04/19 REV
 DRAWING: 16362-2(D) C

MAST ARM POLE DETAILS
 80 MPH - MP-3 STANDARDS
 VIRGINIA



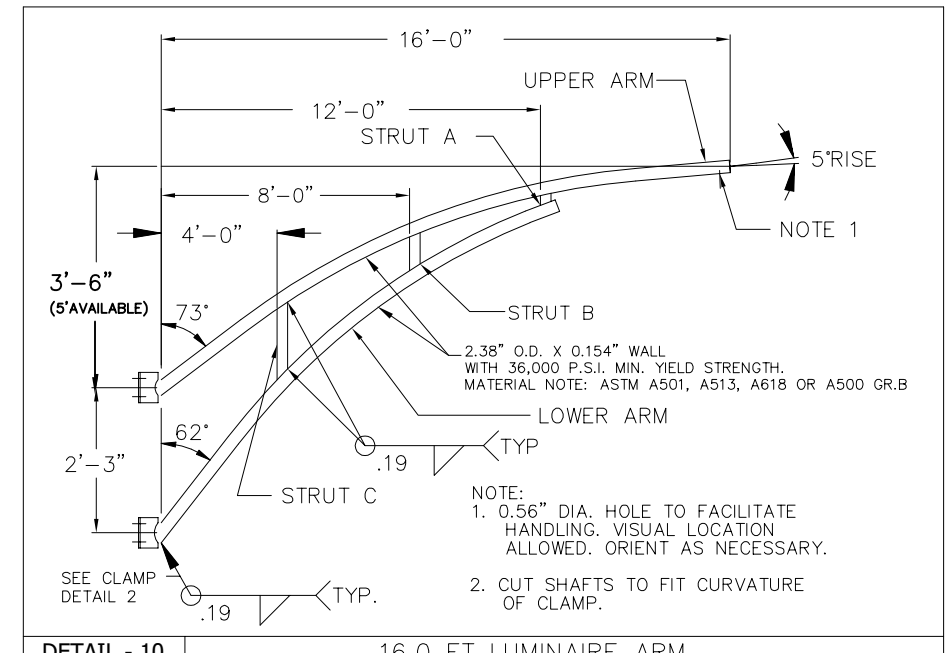
DETAIL - 10 24.0 FT LUMINAIRE ARM

STRUT DATA					ARM DATA			
STRUT	THK.	"X"	"Y"	LENGTH	ARM	O.D.	WALL	LENGTH
A	0.50"	0.20"	0.43"	0'-2.69"	UPPER	2.88"	0.38"	24'- 7.42"
B	0.50"	0.28"	0.46"	0'-7.11"	LOWER	2.88"	0.38"	17'- 8.38"
C	0.50"	0.36"	0.56"	1'-0.00"	TOTAL S109 MATERIAL= 42'- 3.80"			
D	0.50"	0.44"	0.67"	1'-5.51"	TOTAL S-70 MATERIAL = 3'-3.31"			



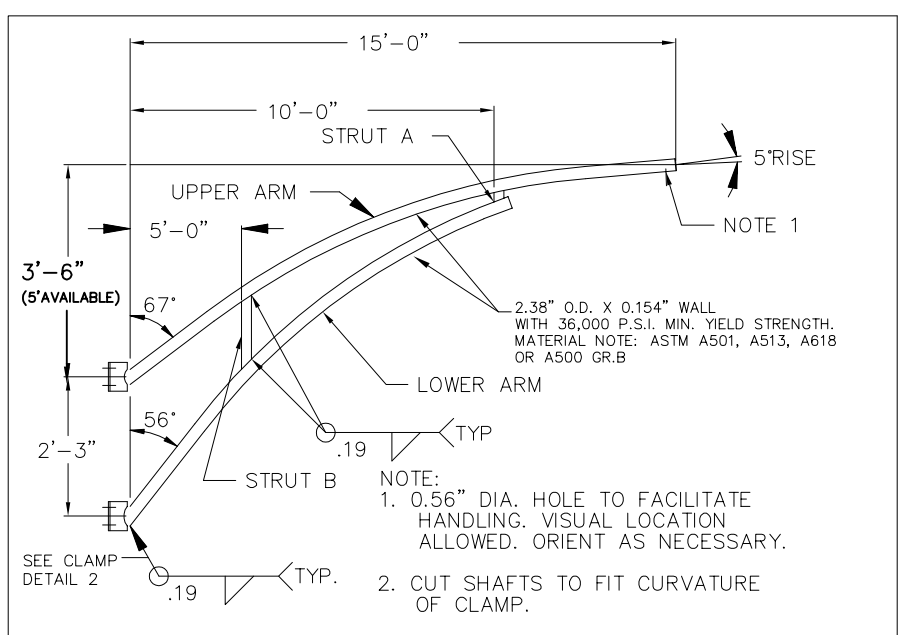
DETAIL - 10 (A) 18.0 FT LUMINAIRE ARM

STRUT DATA				ARM DATA			
STRUT	THK	WIDTH	LENGTH	ARM	O.D.	WALL	LENGTH
A	0.38"	2.00"	4.09"	UPPER	2.38"	0.218"	18'- 4.81"
B	0.38"	2.00"	9.13"	LOWER	2.38"	0.218"	13'- 7.25"
C	0.38"	2.00"	1'- 3.56"	TOTAL A36 MATERIAL= 2'- 4.78"			



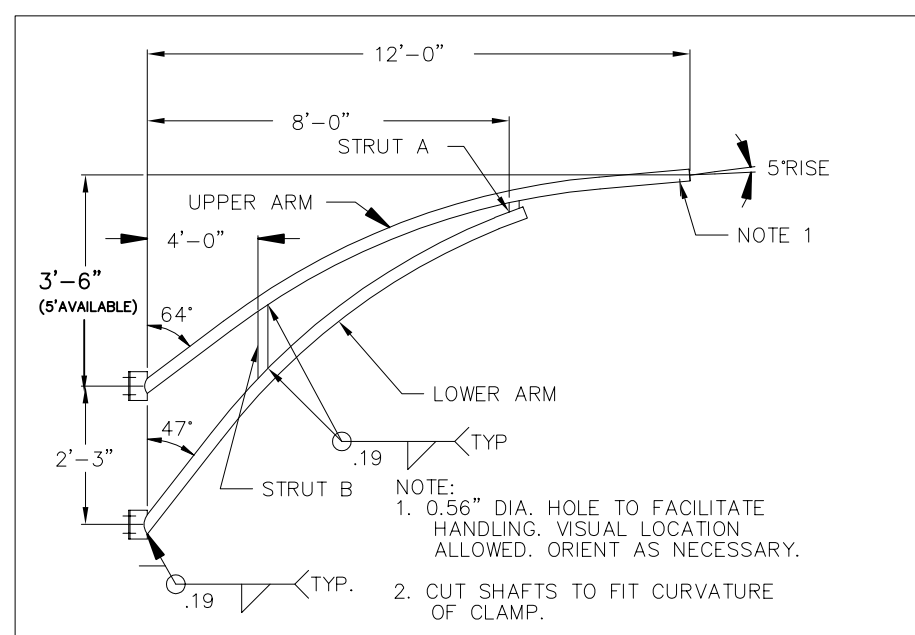
DETAIL - 10 16.0 FT LUMINAIRE ARM

STRUT DATA				ARM DATA			
STRUT	THK	WIDTH	LENGTH	ARM	O.D.	WALL	LENGTH
A	0.38"	2.00"	4.09"	UPPER	2.38"	0.154"	16'- 4.81"
B	0.38"	2.00"	9.13"	LOWER	2.38"	0.154"	13'- 7.25"
C	0.38"	2.00"	1'- 3.56"	TOTAL A36 MATERIAL= 2'- 4.78"			



DETAIL - 10 (B) 15.0 FT LUMINAIRE ARM

STRUT DATA				ARM DATA			
STRUT	THK	WIDTH	LENGTH	ARM	O.D.	WALL	LENGTH
A	0.38"	2.00"	2.69"	UPPER	2.38"	0.154"	15'- 6.63"
B	0.38"	2.00"	11.13"	LOWER	2.38"	0.154"	11'- 7.13"
TOTAL A36 MATERIAL= 1'- 1.81"				TOTAL S109 MATERIAL= 27'- 1.75"			



DETAIL - 10 (C) 12.0 FT LUMINAIRE ARM

STRUT DATA				ARM DATA			
STRUT	THK	WIDTH	LENGTH	ARM	O.D.	WALL	LENGTH
A	0.38"	2.00"	2.38"	UPPER	2.38"	0.154"	12'- 8.00"
B	0.38"	2.00"	9.44"	LOWER	2.38"	0.154"	9'- 11.81"
TOTAL A36 MATERIAL= 0'- 11.82"				TOTAL S109 MATERIAL= 22'- 7.81"			

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
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CUSTOMER: MAST ARM POLE DETAILS
80 MPH - MP-3 STANDARDS
VIRGINIA

DATE: 04/19
DRAWING: 16362-2(E) C

ATS-SALES
valmont
Valley, NE 68064 POLES
(402) 359-2201

**ORDER ENTRY TABLE TO BE COMPLETED AT TIME OF RELEASE FOR: MP-3 80 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

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	ATS-SALES	
B	10/02/19	VDDT REVIEW COMMENTS		
C	11/04/21	VDDT REVIEW COMMENTS		
CUSTOMER:			 Valley, NE 68064 POLES (402) 359-2201	
MAST ARM POLE DETAILS 80 MPH - MP-3 STANDARDS VIRGINIA				
DATE:			04/04/19	REV.
DRAWING:			16362-2(F)	C