MAXIMUM REACH ENTERPRISES
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16 April 2012

TOP HEAD LUG & TAIL LUG DESIGN FOR TOWER 2

In January of this year, I was contacted by Crane Service Inc., a Crane and Rigging Company, to design top head lugs for four vertical vessels that were in an old abandoned El Paso gas plant in Southern Utah. The lugs were needed in order to down end the vessels. See the file "Tower Height Estimates.pdf" for a photo of the old plant and the four vertical vessels. This design example is for Tower 2 as it was the heaviest. Note that Tower 2 is the second from the right hand side of the photo.

I agreed to design the lifting lugs and sent an email asking for the following information:

1. An outline drawing of each vessel showing the location of the CG would be good.
2. Height of each vessel from the basering to the top tangent line.
3. O. D. of each vessel just below the top tangent line.
4. Thickness of the shell just below the top tangent line. Could be obtained by drilling holes in the shell, using a "material identification device", or doing Ultrasonic Testing.
5. Documented weight of each vessel, either just the shell or dressed out with P&L/insulation/piping.
6. Type of head of each vessel. The General Welding document shows a 2:1 elliptical head for #3 vessel shown.
7. Type of shell material of each vessel just below the top tangent line. General Welding shows A-212 B for the # 3 vessel.
8. Close up photos of the top of each vessel and the basering & skirt of each vessel would be good. The photos should identify each vessel.

Comments:

1. CSI will be responsible for the crane study for each vessel.
2. CSI will be responsible for locating the top head lugs so they will not interfere with any nozzles or piping.
3. CSI will be responsible for the rigging hook up for each vessel.
4. CSI will be responsible for the tailing hook up for each vessel. A sample tailing hook up is attached. I recommend tailing down the vessels with a sling in a choker hitch, rather than connecting slings to the basering.
5. The vessels can be down ended dressed as they are with this method.

CSI replied that general arrangement drawings were not available, but they would hire an NDT company to do Ultrasonic testing to determine the shell thickness and would measure the vessel to provide the other measurements I required. See file "UT Report On Six Vessels.pdf", sheet 3 for the information for Tower 2. Be sure to look under the yellow sticky notes to see the hidden information, ie, the vessel circumference, the height, etc. CSI also sent a separate email showing that the head length, measured from top tangent line over the head and down to the tangent line on the other side = 9.83'. This measurement was used to determine if the head was indeed a 2:1 semi-elliptical.

CSI also decided that they did not feel qualified to down end the three heavy vessels using a tail sling and asked me to design tail lugs for them. They also requested that the tail lugs be positioned above the bottom tangent line as they did not want to weld to the skirt. With this scope of work in mind, I then sent them a manhour estimate for all attachments:

SCOPE OF WORK: Manhour estimate

Design top head lugs	8 mh * 4 vessels	= 32
Design tail lugs	4 mh * 3 vessels	= 12
Administrative	4 mh	= 4
Total	mh	48
Cost @ $90/mh * 48 =		not to exceed $4,320.00

DRAWING INDEX:

A drawing index is always developed as the design of the lift attachments proceeds. It is usually sent to the field or client on a monthly basis, so they will know what drawings will be coming to them. But in this case with few designs, I filled it out per CSI's down ending schedule and sent it to them at the start of the first lug design.

MAXIMUM REACH ENTERPRISES DRAWING INDEX

CUSTOMER: **Crane Service Inc.**
PROJECT: ANETH GAS PLANT

NUMBER	DRAWN BY	DESCRIPTION	REV.
CSI – 1601	KEG	Top Head Lug For Dehydration Vessel	1.00
1602	KEG	Top Head Lug For Tower 3	1.00
1603	KEG	Top Head Lug For Tower 2	1.00
1604	KEG	Top Head Lug For Tower 1	1.00
1605	KEG	Tail Lug For Tower 3	1.00
1606	KEG	Tail Lug For Tower 2	1.00
1607	KEG	Tail Lug For Tower 1	1.00

WEIGHT DETERMINATION:

With the above field measurements, I was able make what I felt was a conservative estimate of the weight of the vessel and the location of the CG. The steps and assumptions to do this were:

Vessel circumference = 24.5', Therefore the O.D. = C/Pi = 24.5/3.14 = 7.8' = 93.58"

Assumptions:
1. Use 1.68" thickness for the shell
2. Use 1.79" thickness for the head
3. From the shell weight table, sheet 6, used 96" O.D. and 1-5/8" thickness = 1,687 lbs./ft.
4. From the head weight table, sheet 7, used 96" O.D. and 1-7/8" thickness = 5,517 lbs/head

Therefore, the vessel weight was:

Weight of the shell	= 76.83'*1,687 lbs./ft/ = 129,612 lbs.	
Weight of the two heads	= 2*5,517 lbs. = 11,034	
Subtotal	140,646	
Add 25% for trays, piping, nozzles, basering, etc.	= 140.646*0.25 = 35,162	
TOTAL	175,808	
NOTE: When Tower 2 was lifted off the foundation, it weighed	160,000 ===➔Good	

As the location of the CG was unknown, I assumed that 60% of the weight was carried by the lifting lugs at the initial pick position (IPP), and 66% was carried by the tail slings.

Therefore:	The IPP load	= 175,808*0.6 = 105,485 lbs.
	The load/lug at IPP	= 105,485/2 = 52,743
	The load/lug at set	= 175.808/2 = 87.904
	The tail load	= 175.81k*47.33'/71.83' = 115.84 k

NOTES:

1. When Tower 2 was down ended and in the horizontal, the load to the tail crane was 92.00 k===➔Good
2. See the Rigging Summary Sheet (RSS) on sheet 4 for the dimensions used to calculate the tail load. The RSS is sheet number 1 in most design calculations, and is the control document. If any information changes in the design, then the Rigging Engineer will update the RSS. It will not be sheet number 1 in this example due to the need to present the background of the lift first. It will be sheet number 4.
3. The location of the CG shown on the RSS was an educated estimate because for most vertical vessels, it is located about 40% of the distance from the bottom of the basering toward the lifting lugs.
4. The 7' shown on the RSS is the sum of the skirt height (6'-8") plus an estimate of 4" above the bottom tangent line where the tail lug will be located.

TOP HEAD LUG DESIGN

<u>Calculating The Eccentricity Of The Lug:</u>

Sheet 5 shows the layout and formulas for calculating the 18" of eccentricity for the top head lug. Note that the 18" is not to scale. The distance is actually 17" but I increased it to 18" just to be conservative.

The maximum width of the top head lugs = 0.01745*O.R.*30° = 0.01745*93.58"*30°/2= 24.49"
This is based on the theory that any lug with a width of 30° or over must be designed using "curved plate design" which is a lot more complicated than using flat plate design.

<u>Using The Plate Lug Program On My Website:</u>

After the eccentricity had been determined, two runs were made using the plate lug program, one with the vessel in the horizontal (IPP) to determine maximum lug plate bending and minimum weld size and one with the vessel in the vertical (SET) to determine the end area required and bearing stress at the lug hole. See sheets 10 thru 13 respectively. See sheet 29 to see how I arrived at the dimensions for the top head lugs.

<u>Top Head Lug Drawing:</u>

Sheet 14 shows the resulting top head lug drawing, "Approved For Fabrication".

The photos at the end of the top head lug design show the fabricated/installed top head lug and the rigging hook up.

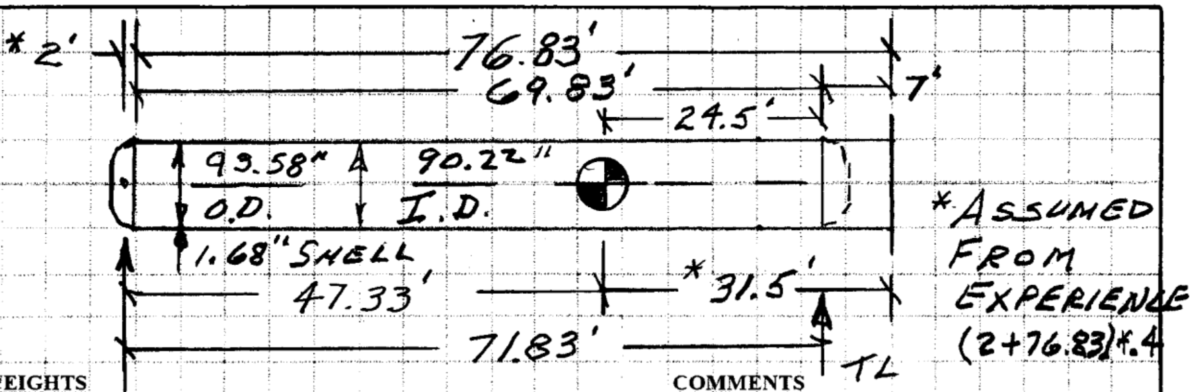
MAXIMUM REACH

DATE 3 FEB 2012
CONT. NO. CSI
BY KE GOODMAN CHK'D
SHEET NO. 4 OF

CALCULATIONS and SKETCHES

RIGGING SUMMARY SHEET FOR: TOWER 2

SKETCH



RIGGING WEIGHTS

COMMENTS

REF. DRAWINGS

- SHEET 3
- UT THICKNESS REPORT ON SIX VESSELS.PDF
- BRETT KRAGE EMAIL 30 JAN 2012, 3:35PM (HEAD LENGTH = 9.83')

FABRICATED WT. WITHOUT INTERNALS 140.65K

WT. OF INTERNALS ERECTED W/EQUIP 35.16K

WT. OF EQUIP. TO BE ERECTED 175.81 K

WT. OF RIGGING EQUIPMENT

TOTAL ERECTION LOAD

RIGGING

LIFTING ATTACHMENT & ELEVATION THL @ TOP TANGENT LINE

INITIAL PICK WEIGHT LL = 105.49k

TAILING METHOD TAIL LUG @ BOTTOM TANGENT LINE

TAIL WEIGHT TL = 115.84K

EQUIPMENT TO BE USED AND RATED CAPACITYS (BY CSI)

1 - SPREADER BAR

2 - SLINGS, TENSION = 175.81*1.15/2 = 101.1 K
MIN. SIZE: 2.75"ϕ, IPS, SWL = 113.0 K
2.50"ϕ, EIPS, SWL = 108.7 K

2 - 55 Te SHACKLES, CROSBY G2130

SHELL STRESS N/A

BASE RING REINFORCING? NO

PRINTED IN U.S.A.

MAXIMUM REACH

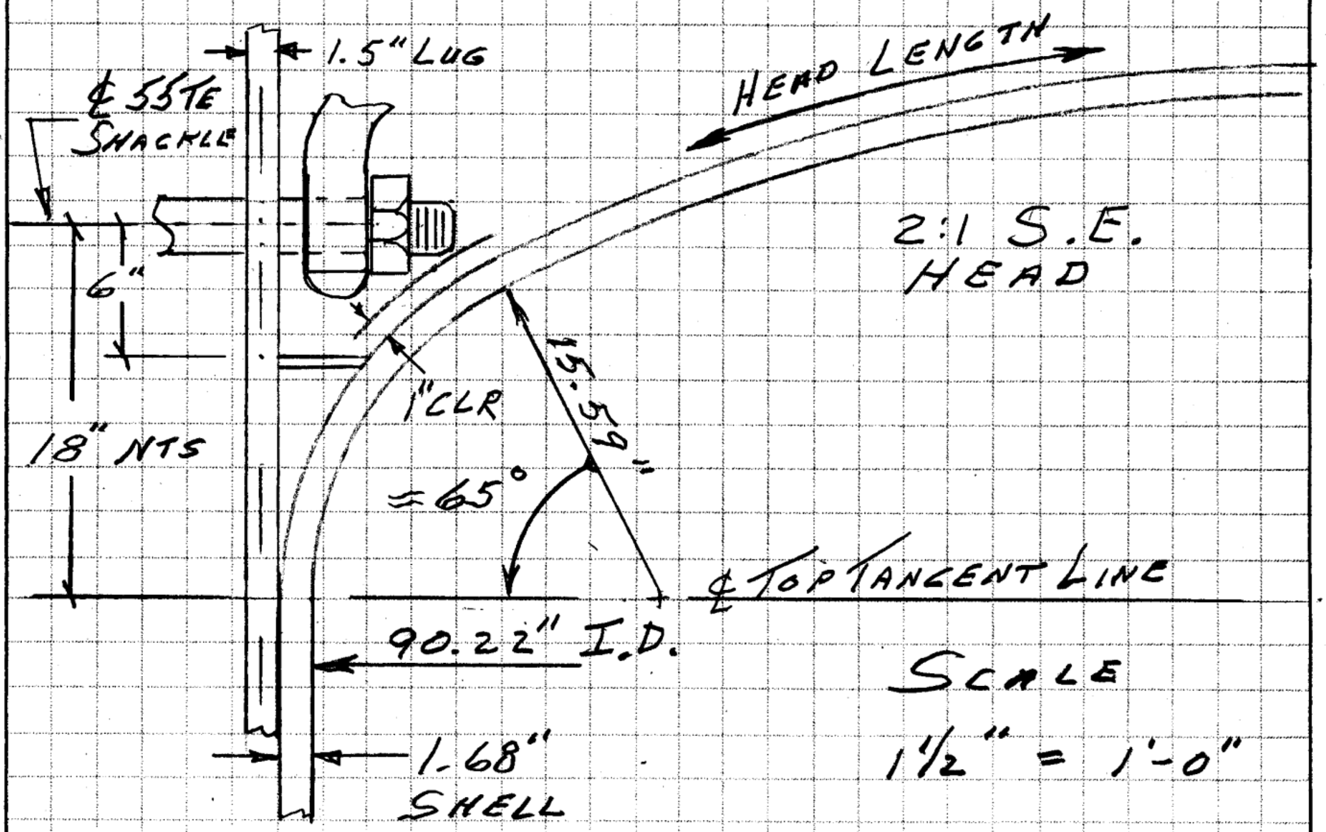
CALCULATIONS and SKETCHES

DATE	
CONT. NO.	
BY	CHK'D
SHEET NO.	5

TOWER 2

TOP HEAD LUG DESIGN

	REF. SH.
DISH RADIUS = 0.9045 * 90.22" = 81.60"	8
KNUCKLE R = 0.17275 * 90.22" = 15.59"	8



HEAD LENGTH = (17.38" * 65° + 83.39" * 26.53°) 0.01745 * 2	8
= 116.97" = 9.75'	
FIELD MEASUREMENT = 9.83'	

3.0 CARBON STEEL VESSEL WEIGHT PER LINEAR FT. OF O.D. SHELL

6

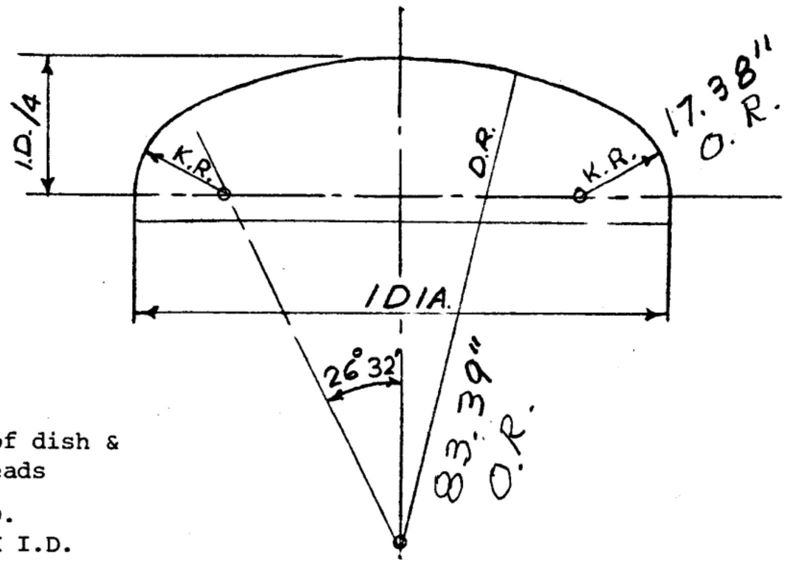
O.D. \ t	1/8"	3/16"	1/4"	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"	1 1/16"	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 5/8"	1 3/4"	1 7/8"	2"
14"	21	30	40	49	58	67	75	84	93	102	110	113	127	135	143	151	159	175	191	206	221	236	250	264
16"	24	35	45	56	66	77	~~87~~	97	107	117	126	136	146	156	165	175	184	203	221	239	257	274	291	308
18"	26	39	51	63	75	86	98	110	121	132	143	154	165	177	187	196	209	230	252	272	293	313	333	352
20"	30	43	57	70	83	96	109	122	134	147	160	172	185	197	209	221	234	258	282	305	329	351	374	396
24"	35	52	69	84	100	116	131	147	162	178	193	208	223	239	253	268	283	313	342	371	400	428	456	484
30"	44	65	86	106	126	145	165	185	204	223	242	262	281	301	319	338	358	395	433	470	507	544	580	616
36"	53	78	103	127	151	175	198	223	245	269	292	315	339	363	385	408	432	478	524	569	615	659	704	748
42"	62	91	120	149	177	204	232	260	287	315	342	369	397	425	451	479	506	560	615	668	722	775	828	880
48"	71	104	137	170	202	234	265	298	329	361	391	423	455	488	517	549	581	643	705	767	829	890	951	1012
54"	80	118	154	191	228	263	299	336	370	406	441	477	513	550	583	619	655	725	796	866	937	1006	1075	1144
60"	89	131	172	213	253	293	332	374	412	452	491	531	571	612	649	689	729	808	887	966	1044	1121	1199	1276
66"	98	144	189	234	279	322	366	411	453	498	541	584	629	674	715	759	803	890	978	1065	1151	1237	1323	1408
72"	106	157	206	256	304	352	399	449	495	543	590	638	687	736	781	830	878	973	1068	1164	1258	1352	1446	1549
78"	115	170	223	277	330	382	433	487	537	589	640	692	745	792	847	900	952	1055	1159	1263	1366	1468	1570	1672
84"	124	183	240	298	355	411	466	525	578	635	690	746	803	861	913	970	1026	1138	1250	1362	1473	1583	1694	1804
90"	133	196	258	320	381	441	500	562	620	681	739	800	861	923	979	1040	1100	1220	1341	1461	1580	1699	1818	1936
96"	142	209	275	341	406	470	533	600	661	726	789	853	919	985	1045	1110	1175	1303	1431	1560	1687	1814	1942	2068
102"	151	222	292	363	431	500	567	637	703	772	839	907	977	1047	1111	1180	1249	1385	1522	1659	1795	1930	2065	2200
108"	160	235	309	384	457	529	600	675	745	813	888	961	1035	1110	1177	1250	1324	1468	1613	1758	1902	2045	2189	2332
114"	169	249	326	405	482	559	634	713	786	863	938	1015	1093	1172	1243	1321	1398	1550	1704	1857	2009	2161	2313	2464
120"	177	262	344	427	508	588	667	750	828	909	988	1069	1151	1234	1309	1391	1472	1633	1794	1956	2116	2276	2437	2596
126"	186	275	361	448	534	617	700	787	868	954	1037	1122	1209	1294	1375	1460	1545	1715	1885	2055	2222	2390	2558	2726
132"	195	288	378	470	559	647	734	826	911	1000	1087	1176	1267	1358	1441	1531	1621	1798	1976	2154	2331	2507	2684	2860
138"	204	301	396	490	584	676	767	862	951	1045	1136	1230	1325	1418	1507	1600	1694	1880	2066	2253	2436	2621	2806	2990
144"	213	314	412	512	610	706	801	901	994	1092	1187	1284	1383	1483	1573	1672	1769	1963	2157	2352	2546	2738	2932	3124
150"	222	327	430	533	635	736	834	938	1035	1138	1236	1339	1441	1543	1639	1741	1843	2046	2248	2451	2653	2854	3056	3257
156"	231	340	447	555	661	765	868	976	1076	1183	1286	1392	1499	1605	1705	1811	1917	2128	2339	2550	2760	2970	3180	3389
162"	239	353	465	576	686	795	901	1014	1118	1229	1335	1446	1557	1667	1771	1881	1991	2211	2430	2649	2867	3085	3303	3521
168"	248	366	482	598	712	824	935	1051	1159	1275	1385	1500	1615	1729	1837	1951	2066	2293	2521	2748	2975	3201	3427	3653
174"	257	380	499	619	737	854	968	1089	1201	1320	1435	1554	1673	1792	1903	2022	2140	2376	2611	2847	3082	3316	3551	3785
180"	266	393	516	640	763	883	1002	1127	1243	1366	1484	1608	1731	1854	1969	2092	2214	2458	2702	2946	3189	3432	3675	3917
186"	275	406	534	662	788	913	1035	1164	1284	1412	1534	1662	1789	1916	2035	2162	2288	2541	2793	3045	3296	3547	3799	4049
192"	284	419	551	683	814	942	1069	1202	1326	1458	1584	1715	1847	1978	2101	2232	2363	2623	2884	3144	3404	3663	3922	4181
198"	293	432	568	704	839	972	1102	1240	1367	1503	1633	1769	1905	2040	2167	2302	2437	2706	2974	3243	3511	3778	4046	4313
204"	302	445	585	726	865	1001	1136	1277	1409	1549	1683	1823	1963	2102	2235	2372	2511	2788	3065	3342	3618	3894	4170	4445
210"	310	458	602	747	890	1031	1169	1315	1450	1595	1733	1877	2021	2164	2299	2442	2585	2871	3156	3441	3725	4009	4294	4577
216"	319	471	620	769	916	1060	1203	1353	1492	1640	1782	1931	2079	2226	2365	2513	2660	2953	3247	3540	3833	4125	4417	4709
222"	328	484	637	790	941	1090	1236	1390	1534	1686	1832	1985	2137	2288	2431	2583	2734	3036	3337	3639	3940	4240	4541	4841
228"	337	497	654	811	967	1119	1270	1428	1575	1732	1882	2038	2195	2351	2497	2653	2808	3118	3428	3738	4047	4356	4665	4973
234"	346	511	671	833	992	1149	1303	1466	1617	1778	1932	2092	2253	2413	2563	2723	2883	3201	3519	3837	4155	4472	4789	5105
240"	355	524	689	854	1018	1179	1337	1503	1658	1823	1981	2146	2311	2475	2629	2793	2957	3283	3610	3936	4262	4587	4913	5237
Weight lb./sq.ft.	5.65	8.34	10.97	13.61	16.22	18.79	21.32	23.98	26.46	29.10	31.63	34.27	36.91	39.54	42.02	44.65	47.28	52.53	57.78	63.04	68.29	73.54	78.80	84.05
Incl. % Over Weight	10.75	9.00	7.50	6.75	6.00	5.25	4.50	4.50	3.75	3.75	3.38	3.38	3.38	3.38	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

Note: 1. All weights are in lb.

4.0 CARBON STEEL VESSEL WEIGHT 2:1 S.E. HEADS

I.D. \ t	1/8"	3/16"	1/4"	5/16"	3/8"	7/16"	1/2"	9/16"	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"	1 1/16"	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 5/8"	1 3/4"	1 7/8"	2"
14"	7.7	12	16	20	24	28	32	37	41	46	50	55	60	64	69	74	79	89	100	111	122	133	145	157
16"	10	15	20	26	31	36	42	47	53	59	65	71	77	83	89	95	101	114	128	141	155	169	184	199
18"	13	19	26	32	39	46	53	60	67	74	81	89	96	103	111	119	126	142	159	175	192	210	228	[illegible]
20"	16	24	32	40	48	56	65	73	82	91	99	108	117	126	135	145	154	174	193	213	233	254	276	297
24"	22	34	45	57	68	80	92	104	116	129	141	154	166	179	192	205	218	245	272	300	328	356	386	415
30"	35	53	71	88	106	125	143	161	180	199	218	237	256	276	295	315	335	375	416	457	499	542	585	629
36"	50	75	101	127	152	178	205	231	258	285	311	339	365	393	421	448	476	533	590	648	707	766	826	887
42"	68	103	138	172	207	242	277	313	349	386	421	458	494	532	568	605	643	719	795	872	950	1029	1109	1189
48"	89	134	180	224	270	315	361	407	454	501	547	596	642	691	737	786	834	932	1030	1129	1229	1330	1433	1536
54"	113	169	227	283	341	398	456	514	573	633	691	751	809	870	929	989	1050	1173	1295	1419	1544	1671	1798	1926
60"	139	209	280	349	420	491	562	634	706	779	850	924	996	1071	1143	1217	1291	1442	1591	1743	1895	2050	2205	2361
66"	168	252	339	422	507	593	679	765	852	941	1026	1116	1202	1292	1379	1468	1557	1738	1917	2099	2282	2467	2653	2840
72"	200	300	403	502	603	705	807	910	1013	1118	1219	1325	1427	1534	1637	1742	1848	2062	2274	2489	2705	2923	3143	3364
78"	234	352	473	589	708	827	946	1066	1187	1310	1429	1552	1672	1797	1917	2040	2163	2414	2661	2912	3164	3418	3674	3931
84"	272	408	548	682	820	958	1097	1235	1375	1517	1655	1798	1936	2080	2219	2361	2504	2793	3078	3368	3659	3952	4247	4543
90"	312	468	629	783	941	1099	1258	1417	1577	1740	1897	2061	2219	2384	2543	2706	2869	3200	3526	3857	4190	4525	4861	5193
96"	355	533	715	890	1070	1250	1430	1611	1792	1978	2156	2342	2522	2709	2890	3074	3259	3635	4004	4380	4757	5136	5517	5899
102"	400	601	807	1005	1207	1410	1613	1817	2022	2231	2432	2642	2844	3055	3258	3466	3675	4097	4513	4935	5359	5786	6214	6644
108"	449	674	904	1126	1353	1580	1808	2036	2265	2499	2724	2959	3186	3422	3649	3882	4115	4587	5052	5524	5998	6474	6952	7433
114"	500	751	1007	1254	1507	1760	2013	2267	2522	2782	3033	3295	3546	3809	4062	4320	4580	5104	5622	6146	6672	7201	7732	8266
120"	554	832	1116	1389	1669	1949	2230	2511	2793	3081	3359	3648	3927	4217	4497	4783	5069	5650	6221	6801	7383	7967	8554	9143
126"	611	917	1230	1531	1839	2148	2457	2767	3078	3395	3701	4019	4326	4646	4954	5269	5584	6223	6852	7489	8129	8772	9417	10064
132"	670	1006	1350	1680	2018	2357	2696	3036	3376	3724	4059	4408	4745	5095	5433	5778	6124	6823	7512	8211	8912	9615	10321	11030
138"	733	1100	1475	1836	2205	2575	2946	3317	3689	4069	4435	4816	5183	5566	5934	6311	6688	7452	8204	8965	9730	10497	11267	12040
144"	798	1197	1606	1999	2401	2803	3207	3610	4015	4428	4826	5241	5641	6057	6458	6867	7277	8108	8925	9753	10584	11418	12254	13094
150"	865	1299	1742	2169	2604	3041	3478	3916	4355	4803	5235	5684	6117	6568	7003	7447	7891	8791	9677	10574	11474	12377	13283	14192
156"	934	1405	1884	2345	2816	3288	3761	4235	4709	5193	5660	6146	6614	7101	7571	8050	8530	9503	10459	11428	12400	13375	14353	15335
162"	1009	1515	2031	2529	3037	3546	4055	4566	5077	5599	6101	6625	7129	7654	8150	8677	9194	10242	11272	12316	13362	14412	15465	16521
168"	1085	1629	2184	2719	3265	3812	4360	4909	5458	6019	6560	7122	7664	8228	8772	9327	9883	11008	12115	13236	14360	15488	16615	17753
174"	1164	1747	2343	2916	3502	4089	4676	5264	5854	6455	7034	4638	8219	8823	9406	10001	10597	11803	12989	14190	15394	16602	17813	19028
180"	1246	1870	2507	3121	3747	4375	5003	5633	6263	6906	7526	8171	8792	9439	10062	10698	11335	12625	13893	15177	16464	17755	19049	20347
186"	1330	1996	2677	3332	4001	4671	5341	6013	6686	7372	8034	8722	9385	10075	10740	11419	12099	13474	14827	16197	17570	18946	20327	21711
192"	1417	2127	2852	3550	4262	4976	5691	6406	7123	7854	8558	9291	9997	10732	11440	12163	12887	14352	15792	17250	18711	20177	21646	23116
198"	1507	2262	3033	3775	4532	5291	6051	6812	7573	8351	9099	9879	10629	11410	12163	12931	13700	15257	16787	18336	19889	21446	23006	24571
204"	1600	2401	3219	4007	4811	5616	6422	7229	8038	8863	9657	10484	11280	12109	12907	13722	14538	16189	17813	19456	21102	22753	24408	26067
210"	1695	2544	3411	4245	5097	5951	6805	7660	8516	9390	10231	11107	11951	12828	13674	14537	15401	17150	18869	20608	22352	24100	25852	27605
216"	1793	2692	3608	4491	5392	6295	7198	8102	9008	9932	10822	11748	12640	13569	14463	15375	16289	18133	19955	21794	23637	25485	27337	29192
222"	1894	2843	3811	4744	5696	6649	7603	8558	9514	10490	11429	12408	13349	14330	15273	16237	17202	19153	21072	23013	24959	26909	28863	30821
228"	1998	2999	4020	5003	6007	7012	8018	9025	10034	11063	12053	13085	14078	15111	16106	17122	18140	20197	22219	24265	26316	28371	30431	32495
234"	2104	3158	4234	5270	6327	7385	8445	9505	10567	11651	12694	13780	14826	15914	16961	18031	19102	21268	23397	25551	27709	29872	32040	34212
240"	2214	3322	4454	5543	6655	7768	8882	9998	11115	12254	13351	14493	15593	16737	17839	18963	20089	22367	24605	26869	29138	31412	33691	35974
Weight lb/sq.ft	5.10	7.65	10.3	12.8	15.3	17.9	20.4	23.0	25.5	28.1	30.6	33.2	35.7	38.3	40.8	43.4	45.9	51.1	56.1	61.2	66.3	71.4	76.5	81.6

Note: 1. All weights are in lb.

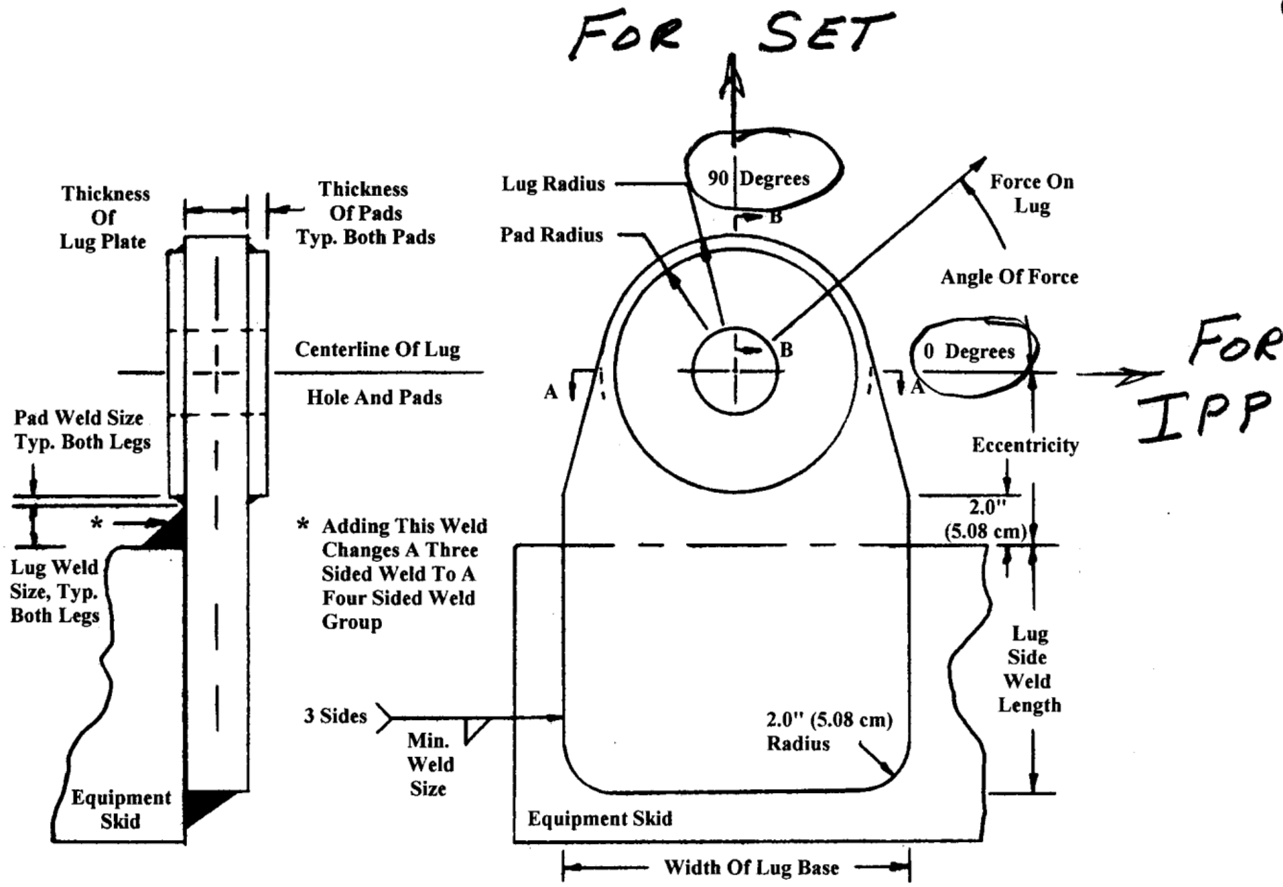


Corresponding radius of dish & corner for 2:1 S.E. heads

Dish: .9045 X I.D.
Knuckle: .17275 X I.D.

I.D.	DISH (IN.)	KNUCKLE RADIUS (IN)
12	10 7/8	2 1/16
14	12 11/16	2 7/16
16	14 1/2	2 3/4
18	16 1/4	3 1/8
20	18 1/16	3 7/16
22	19 7/8	3 13/16
24	21 11/16	4 1/8
28	25 5/16	4 13/16
30	27 1/8	4 3/16
32	28 15/16	5 1/2
36	32 9/16	6 1/4
40	36 3/16	6 15/16
42	38	7 1/4
48	43 7/16	8 5/16
54	48 13/16	9 5/16
60	54 1/4	10 3/8
66	59 11/16	11 3/8
72	65 1/8	12 7/16

I.D.	DISH (IN.)	KNUCKLE RADIUS (IN)
78	70 9/16	13 1/2
84	76	14 1/2
90	81 3/8	15 9/16
96	86 13/16	16 9/16
102	92 1/4	17 5/8
108	97 11/16	18 11/16
114	103 1/8	19 11/16
120	108 9/16	20 3/4
126	113 15/16	21 3/4
132	119 3/8	22 13/16
138	124 13/16	23 13/16
144	130 1/4	24 7/8
150	135 11/16	25 15/16
156	141 1/8	26 15/16
162	146 1/2	28
168	151 15/16	29
174	157 3/8	30 1/16
180	162 13/16	31 1/16



NOTES:
1. Section A-A: Area Across Pin Hole
2. Section B-B: Area Past Pin Hole
3. Sections Not Shown

PLATE LIFTING LUG

FOR REF. ONLY

PROGRAM TO DESIGN A PLATE TYPE LIFTING LUG v.02

COMPANY: CSI **PROJECT:** Aneth Gas Plant 10

ITEM NUMBER: Tower 2 @ IPP

Crosby G2130x55		Select a metric shackle from the lookup table based on the force on the lug or click the SHACKLE button to enter your own shackle and lug data.	
4.13	in	Shackle Inside Width at Pin	
5.69	in	Shackle Eye Diameter	
2.80	in	Shackle Pin Diameter	
2.93	in	Lug Pin Hole Diameter	Recommend hole be 0.13" or > than shackle pin dia.
5.00	in	Lug Radius	
1.50	in	Lug Plate Thickness	
20.00	in	Lug Plate Width at Base	Minimum value of 2*radius of lug
14.00	in	Lug Side weld length	Recommend using min. 0.7 * lug plate width
.50	in	Lug Pad Thickness	Input zero if pads are not required
4.50	in	Lug Pad Radius	Input zero if pads are not required
18.00	in	Lug Eccentricity	
52.74	kips	Force on the Lug	
0.00	deg	Angle of the Force on the Lug	Measured from the horizontal
36.00	ksi	Yield Stress of the Lug Material	Fy
14.85	kips/in	Allowable Force on the Weld	Use 10.91 for LH60 or 14.85 for LH70
1.80		Impact factor, IF	Recommend that a minimum 1.8 impact factor be used

OUTPUT:

Checking combined stress of the lug plate

30.00	in^2	Area of Lug Plate at Base
100.00	in^3	Section modulus of the lug plate at the base
17.09	ksi	Bending stress of the lug plate fb, actual
0.00	ksi	Tension stress of the lug plate ft, actual
21.60	ksi	Allowable bending and tension stress, Fb & Ft
0.79		Combined stress of the lug plate. Must be less than 1.0 GOOD

Checking the lug weld size for a THREE sided weld, with the weld treated as a line

11

48.00	in	Area of the weld
3.27	kips/in	Horizontal component of twist
3.25	kips/in	Vertical component of twist
0.00	kips/in	Tension force on the weld
1.10	kips/in	Shearing force on the weld
5.44	kips/in	Resultant Force on the weld
0.66	in	Minimum weld size — GOOD USE 1"

Checking the lug weld size for a FOUR sided weld, with the weld treated as a line

68.00	in	Area of the weld
2.01	kips/in	Horizontal component of twist
1.41	kips/in	Vertical component of twist
0.00	kips/in	Tension force on the weld
0.78	kips/in	Shearing force on the weld
2.97	kips/in	Resultant Force on the weld
0.36	in	Minimum weld size

Checking bearing at the pin hole

22.60	ksi	Bearing stress of the lug without pads — MAX. @ SET
13.56	ksi	Bearing stress with pads attached — GOOD
32.40	ksi	Allowable bearing stress
10.55	kips	Load per pad
0.07	in	Pad weld size, min. — USE 1/4"

Checking end area of the lug across the pin hole

5.86	in^2	End area required across the pin hole
4.59	in	Maximum effective lug radius. Used to calculate the max. allowable end area
11.72	in^2	Maximum effective end area — GOOD

Checking end area of the lug past the pin hole

3.91	in^2	Area required past the pin hole — MAX. @ SET
8.34	in^2	Actual end area
7.72	in^2	Maximum allowable end area — GOOD

PROGRAM TO DESIGN A PLATE TYPE LIFTING LUG v.02

COMPANY: CSI **PROJECT:** Aneth Gas Plant 12

ITEM NUMBER: Tower 2 @ SET

Crosby G2130x55		Select a metric shackle from the lookup table based on the force on the lug or click the SHACKLE button to enter your own shackle and lug data.	
4.13	in	Shackle Inside Width at Pin	
5.69	in	Shackle Eye Diameter	
2.80	in	Shackle Pin Diameter	
2.93	in	Lug Pin Hole Diameter	Recommend hole be 0.13" or > than shackle pin dia.
5.00	in	Lug Radius	
1.50	in	Lug Plate Thickness	
20.00	in	Lug Plate Width at Base	Minimum value of 2*radius of lug
14.00	in	Lug Side weld length	Recommend using min. 0.7 * lug plate width
.50	in	Lug Pad Thickness	Input zero if pads are not required
4.50	in	Lug Pad Radius	Input zero if pads are not required
18.00	in	Lug Eccentricity	
87.90	kips	Force on the Lug	
90.00	deg	Angle of the Force on the Lug	Measured from the horizontal
36.00	ksi	Yield Stress of the Lug Material	Fy
14.85	kips/in	Allowable Force on the Weld	Use 10.91 for LH60 or 14.85 for LH70
1.80		Impact factor, IF	Recommend that a minimum 1.8 impact factor be used

OUTPUT:

Checking combined stress of the lug plate

30.00	in^2	Area of Lug Plate at Base
100.00	in^3	Section modulus of the lug plate at the base
0.00	ksi	Bending stress of the lug plate fb, actual
5.27	ksi	Tension stress of the lug plate ft, actual
21.60	ksi	Allowable bending and tension stress, Fb & Ft
0.24		Combined stress of the lug plate. Must be less than 1.0 MAX. @ IPP

Checking the lug weld size for a THREE sided weld, with the weld treated as a line

48.00	in	Area of the weld
0.00	kips/in	Horizontal component of twist
0.00	kips/in	Vertical component of twist
1.83	kips/in	Tension force on the weld
0.00	kips/in	Shearing force on the weld
1.83	kips/in	Resultant Force on the weld
0.22	in	Minimum weld size — MAX. @ IPP

Checking the lug weld size for a FOUR sided weld, with the weld treated as a line

~~68.00~~	~~in~~	~~Area of the weld~~
~~0.00~~	~~kips/in~~	~~Horizontal component of twist~~
~~0.00~~	~~kips/in~~	~~Vertical component of twist~~
~~1.29~~	~~kips/in~~	~~Tension force on the weld~~
~~0.00~~	~~kips/in~~	~~Shearing force on the weld~~
~~1.29~~	~~kips/in~~	~~Resultant Force on the weld~~
~~0.16~~	~~in~~	~~Minimum weld size~~

Checking bearing at the pin hole

37.67	ksi	Bearing stress of the lug without pads
22.60	ksi	Bearing stress with pads attached — GOOD
32.40	ksi	Allowable bearing stress
17.58	kips	Load per pad
0.12	in	Pad weld size, min. — USE 1/4" WELD

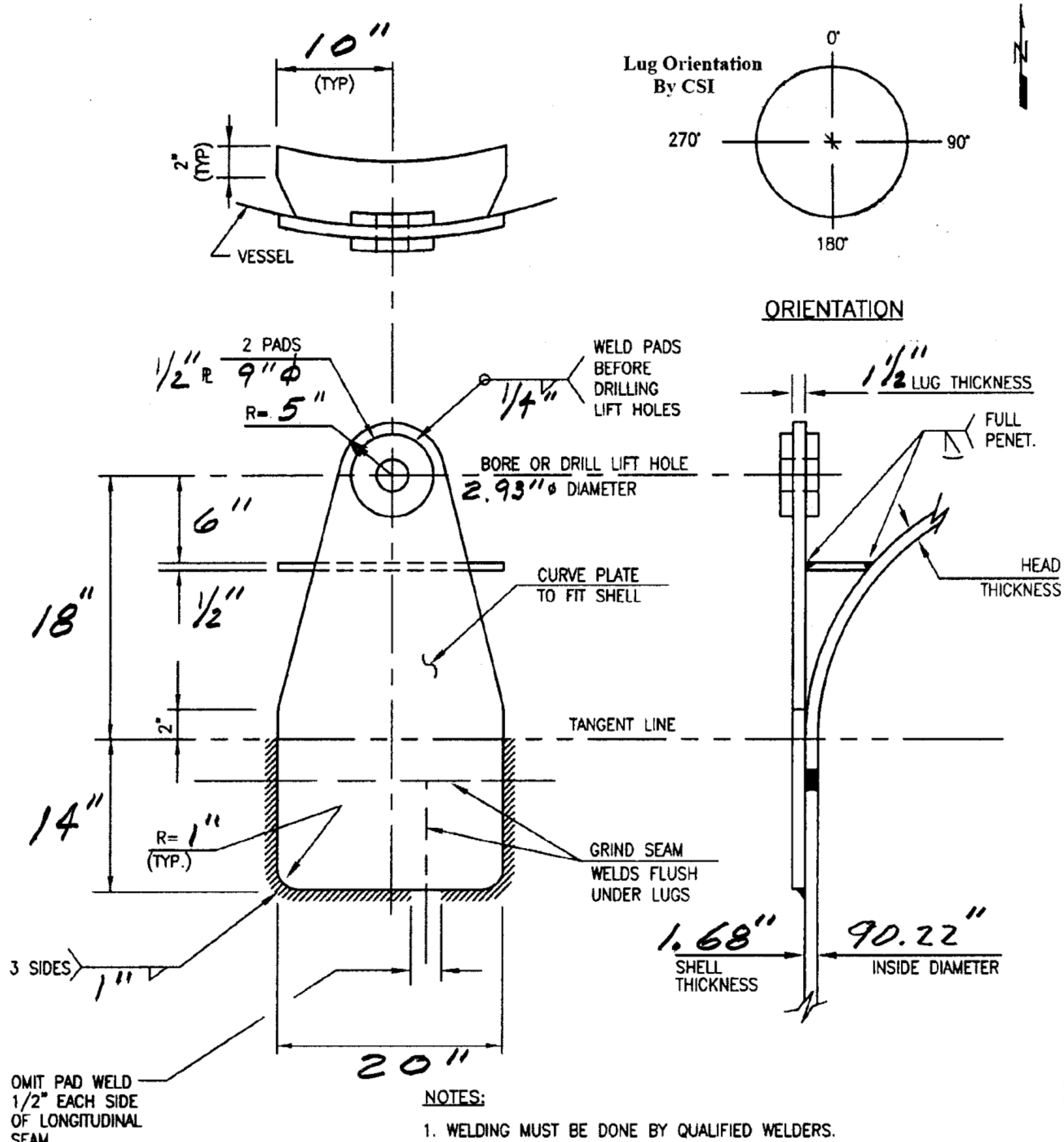
Checking end area of the lug across the pin hole

9.77	in^2	End area required across the pin hole
4.59	in	Maximum effective lug radius. Used to calculate the max. allowable end area
11.72	in^2	Maximum effective end area — GOOD

Checking end area of the lug past the pin hole

6.51	in^2	Area required past the pin hole
8.34	in^2	Actual end area
7.72	in^2	Maximum allowable end area — GOOD

Calculated by www.maximumreach.com 4/13/2012



NOTES:

1. WELDING MUST BE DONE BY QUALIFIED WELDERS.
2. MATERIAL TO BE THE SAME AS VESSEL WHERE ATTACHED. Use A36 Plate
3. MATERIAL TO BE MINIMUM YIELD STRENGTH OF 36,000 psi
4. PROVIDE TWO LUGS 180° APART PER ORIENTATION.
5. Use LH70 Rod

ESTIMATE ERECTION WT. = 175.81 K
ESTIMATE INITIAL PICK WT. = 105.49 K

1	3 FEB 2012	Approved For Fabrication KEG

CRANE SERVICE INC	DR.	TOP HEAD LUG FOR **TOWER 2**	
	CH.		
	SUPER.		
	SUPER. ENGR. KEGOODMAN	**Aneth Gas Plant**	
	SCALE: NONE	DRAWING NUMBER: **CSI - 1603**	REV. **1**

CAD FILE NAME: THL1.DWG


90.22"
INSIDE DIAMETER OF TANK
#12
2.93"
DIA. HOLE

TAIL LUG DESIGN

Reference: Top Head Lug Design, RSS on sheet 4 where:

The tail load ≈ 116 kips

Off set length = 93.58”/2 + 5” btm lug to hole = 51.8” = 4.34’

Other vessel dimensions required for running the up ending program

<u>Steps:</u>

		Ref. Sheet
1.	Run the up ending program to determine the lift angle for max. forces for combined stress	17
1.	Run the pad eye program to determine the lug end area & bearing stress with the vessel In the horizontal	18
3.	Run the L shaped tail lug program to determine the combined stress on the lug plate & weld	19
4.	Run the safe working load program for the tail sling	21
5.	Clearance between the bail of the 85 Te shackle & the lug plate = 14.85” -5.5” = 9.35”. Plenty of clearance for a doubled 2.5” EIPS sling	21
6.	Make a lug drawing “Approved For Fabrication”	22

The photos at the end of the tail lug design show the fabricated and installed tail lug, the tailing hook up and the down ending of tower 2.

PROGRAM FOR UPENDING FORCES v0.1

COMPANY: Crane Service Inc.l **PROJECT:** Aneth Gas Plant Tail Lug Tower 2

Note: Forces are in kips and lengths are in feet

176.00 Total weight of vessel including trays, insulation, piping, etc
71.83 Total length from lift point to tailing point
24.50 Lower length from the CG to the tailing point
4.34 Offset length from the centerline of the vessel to the tailing point

OUTPUT:

Lift Angle (deg)	Lift Load	Lift Load Tranverse	Lift Load Longitudinal	Tail Load	Tail Load Tranverse	Tail Load Longitudinal	Span
0.00	60.03	60.03	0.00	115.97	115.97	0.00	71.83
5.00	60.64	60.41	5.29	115.36	114.92	10.05	71.93
10.00	61.25	60.32	10.64	114.75	113.00	19.93	71.49
15.00	61.88	59.77	16.02	114.12	110.23	29.54	70.51
20.00	62.53	58.76	21.39	113.47	106.63	38.81	68.98
25.00	63.21	57.29	26.71	112.79	102.22	47.67	66.93
30.00	63.94	55.37	31.97	112.06	97.05	56.03	64.38
35.00	64.74	53.03	37.13	111.26	91.14	63.82	61.33
40.00	65.63	50.27	42.18	110.37	84.55	70.95	57.81
45.00	66.64	47.12	47.12	109.36	77.33	77.33	53.86
50.00	67.82	43.59	51.95	108.18	69.54	82.87	49.50
55.00	69.24	39.72	56.72	106.76	61.23	87.45	44.76
60.00	71.02	35.51	61.50	104.98	52.49	90.92	39.67
65.00	73.33	30.99	66.46	102.67	43.39	93.05	34.29
70.00	76.54	26.18	71.93	99.46	34.02	93.46	28.65
75.00	81.37	21.06	78.60	94.63	24.49	91.41	22.78
80.00	89.63	15.56	88.27	86.37	15.00	85.06	16.75
85.00	107.40	9.36	107.00	68.60	5.98	68.34	10.58
86.00	113.79	7.94	113.51	62.21	4.34	62.06	9.34
87.00	122.13	6.39	121.97	53.87	2.82	53.79	8.09
88.00	133.52	4.66	133.44	42.48	1.48	42.45	6.84
89.00	150.01	2.62	149.98	25.99	0.45	25.99	5.59
90.00	176.00	0.00	176.00	0.00	0.00	0.00	4.34

Calculated by www.maximumreach.com 2/6/2012

PROGRAM TO DESIGN A PAD EYE TYPE LIFTING LUG v.02

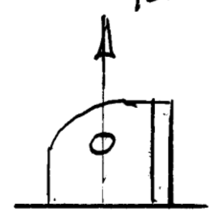
COMPANY: Crane Service Inc. **PROJECT:** Aneth Gas Plant

ITEM NUMBER: Tail Lug For Tower 2

18

Crosby G2130x85 ▼ Select a metric shackle from the lookup table based on the force on the lug or click the SHACKLE button to enter your own

5.00	in	Shackle Inside Width at Pin	
6.50	in	Shackle Eye Diameter	
3.30	in	Shackle Pin Diameter	
3.43	in	Lug Pin Hole Diameter	Recommend hole be 0.13" or > than shackle pin dia.
5.50	in	Lug Radius	
2.50	in	Lug Plate Thickness	
11.00	in	Lug Plate Width at Base	Minimum value of 2*radius of lug
0.00	in	Lug Pad Thickness	Input zero if pads are not required
0.00	in	Lug Pad Radius	Input zero if pads are not required
5.00	in	Lug Eccentricity	
116.00	kips	Force on the Lug	
90.00	deg	Angle of the Force on the Lug	Measured from the horizontal
36.00	ksi	Yield Stress of the Lug Material	Fy
14.85	kips/in	Allowable Force on the Weld	Use 10.91 for LH60 or 14.85 for LH70
1.80		Impact factor, IF	Recommend that a minimum 1.8 impact factor be used



OUTPUT:

Checking combined stress of the lug plate

27.50	in^2	Area of Lug Plate at Base
50.42	in^3	Section modulus of the lug plate at the base
0.00	ksi	Bending stress of the lug plate fb, actual
7.59	ksi	Tension stress of the lug plate ft, actual
21.60	ksi	Allowable bending and tension stress, Fb & Ft
0.35		Combined stress of the lug plate. Must be less than 1.0

N/A SEE "L" SHAPED WELD PROGRAM

Checking the lug weld size, with the weld treated as a line

22.00	in	Area of the weld
40.33	in^2	Section modulus of the weld
9.49	kips/in	Resultant Force on the weld
0.64	in	Minimum weld size

N/A SEE "L" SHAPED WELD PROGRAM

Checking bearing at the pin hole

25.31	ksi	Bearing stress of the lug without pads
0.00	ksi	Bearing stress with pads attached
32.40	ksi	Allowable bearing stress
0.00	kips	Load per pad
0.00	in	Pad weld size, min.

GOOD

Checking end area of the lug across the pin hole

12.89	in^2	End area required across the pin hole
5.37	in	Maximum effective lug radius. Used to calculate the max. allowable end area
13.72	in^2	Maximum effective end area

GOOD

Checking end area of the lug past the pin hole

8.59	in^2	Area required past the pin hole
9.46	in^2	Actual end area
9.15	in^2	Maximum allowable end area

GOOD

Calculated by www.maximumreach.com 2/6/2012

∴ DESIGN GOOD FOR LUG END AREA & BEARING

L SHAPED TAIL LUG PLATE AND WELD DESIGN

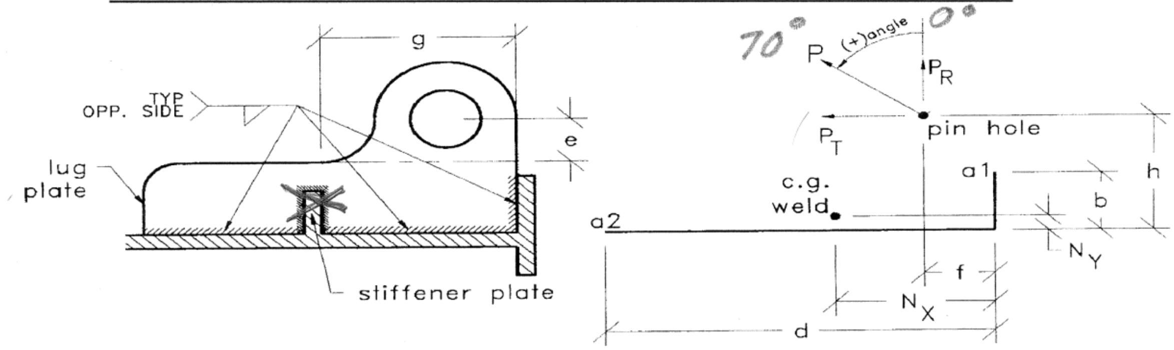
(See note 5)

Maximum Reach Enterprises
Henderson, NV

Client:	Crane Service Inc.
Project:	Aneth Gas Plant
Location:	
Item:	Tail Lug For Tower 2

Contract #:	
Date:	06-Feb-12
Rev #:	1

LUG BENDING & WELD SIZE CALCULATIONS DUE TO COMBINED STRESS



NOTES:

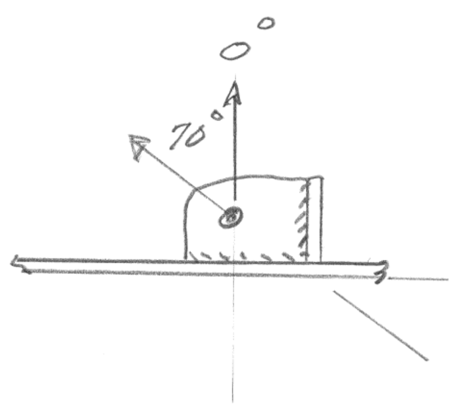
1. Fill in data in shaded fields.
2. Analysis based on Omer Blodgett's calculations for an "L" shaped weld, dated 24 Mar 99.
3. This calculation does not take in to account the weld between the stiffener plate/ring and the lug plate.
4. The calculated fillet weld size is typical for each side and both ends of the lug.
5. Lug end area must be designed by the Top Head Lug design program or one of the lug programs on www.maximumreach.com.

INPUT:

		TRIAL #1	*TRIAL #2*	
Load, P		99.46	116.00	kips
Angle		70.00	0.00	degrees
Recommend 1.8 min.	**I.F.**	1.80	1.80	
Electrode		E70	E70	
Allow. force on weld		14.85	14.85	kips/in.
Base ring ext. past skirt	**b**	10.50	10.50	in.
OAL of the weld	**d**	11.00	11.00	in.
Arm for lug bending	**e**	5.00	5.00	in.
Radius of lug	**f**	5.50	5.50	in.
Length of lug for bending	**g**	11.00	11.00	in.
CL of lug hole to shell	**h**	5.00	5.00	in.
Thickness of Lug, t		2.50	2.50	in.
Lug Material, SA-		A36	A36	
Yield Stress, Fy		36	36	ksi

REFERENCE (Allow. Force)

E60 electrode	12.73 kips/in.
E70 electrode	14.85 kips/in.



OUTPUT FOR TAIL LUG PLATE:

Forces on the tail lug plate

PR=P*cos(angle)	34.02	116.00	kips
PT=P*sin(angle)	93.46	0.00	kips

(Continued)

20

Find Properties Of Lug

Bending Allowable, Fb=0.6Fy	21.6	21.6	ksi	
Tension Allowable, Ft=0.6Fy	21.6	21.6	ksi	
A=t*g	27.50	27.50	sq. in.	
S=t*g^2/6	50.42	50.42	cu. in.	
fb=PT*e*I.F./S	16.68	0.00	ksi	< Fb
Bending Stress:	***O.K.***	***O.K.***		
ft=PR*I.F./A	2.23	7.59	ksi	< Ft
Tension Stress:	***O.K.***	***O.K.***		
fb/Fb+ft/Ft<=1	0.88	0.35		< 1.0
Combined Stress In Lug Plate:	***O.K.***	***O.K.***		

GOOD

OUTPUT FOR WELD:

Find Properties Of Weld Treated As A Line

About the X-X axis (vertical axis)			
Nx = d(t+d)/2(t+d+b)	3.09	3.09	in.
Ix = td^2+t^3/6+2d^3/3-d^2(t+d)^2/2(t+d+b)	733.02	733.02	cu. in.
About the Y-Y axis (horizontal axis)			
Ny = b(b+t)/2(t+d+b)	2.84	2.84	in.
Iy=2b^3/3+t*b^2+t^3/6-b^2(b+t)^2/2(t+d+b)	661.81	661.81	cu. in.
Total weld length Lw = 2*d + 2*b+ 2*t	48.00	48.00	in.
S= Ix + Iy	1394.82	1394.82	cu. in.

Find Various Forces On Weld

Torsion T = PT*(h-Ny)+PR*(Nx-f)	119.67	-279.13	kip-in.
At point a2			
fth = T* (d-Nx)/S	0.68	-1.58	kips/in.
ftv = T*Ny/S	0.24	-0.57	kips/in.
fh = PR/Lw	0.71	2.42	kips/in.
fv = PT/Lw	1.95	0.00	kips/in.
fr = SQRT((ftv-fv)+(fth-fh)^2)	1.70	4.04	kips/in.
At point a1			
fth=T*Nx/S	0.27	-0.62	kips/in.
ftv=T*(b-Ny)/S	0.66	-1.53	kips/in.
fh=PR/Lw	0.71	2.42	kips/in.
fv=PT/Lw	1.95	0.00	kips/in.
fr=SQRT((ftv+fv)^2+(fth+fh)^2)	2.78	2.36	kips/in.
Governing Point:	***a1***	***a2***	
	Governs	***Governs***	

Find Fillet Weld Size Required

MIN. WELD SIZE w = I.F.*fr/allowable force	0.34	0.49	in.
RECOMMENDED WELD SIZE	1	1	in.

GOOD, USE 1"

DESIGN GOOD FOR COMBINED STRESS FOR LUG PLATE & L SHAPED WELD

SAFE WORKING LOAD OF A SLING v0.2

COMPANY: Crane Service Inc. **PROJECT:** Aneth Gas Plant

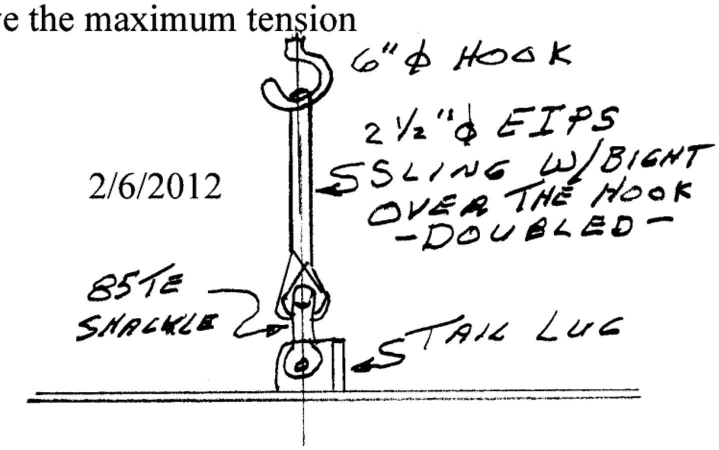
ITEM NUMBER: Tail Sling For Tower 2

116.00	Maximum Tension in the sling or total tension for all parts of the sling
EIPS 2.50 in 120.80 Kip ▾	SELECT: Wire Rope type, diameter and SWL @ 100% Efficiency
2.00	Number of parts being used, ie two parts for a doubled sling
90.00	Effeciency factor of the swaged fitting at the eye of a IWRC sling (%) 1" diameter and smaller 95.0% 1-1/8" diameter thru 1-7/8" 92.5% 2" diameter and larger 90.0%
6.00 *	Diameter of the hook or "Other type of pin" Enter zero if not applicable
0.00	Diameter of the curved plate of the spreader bar Enter zero if not applicable
0.00	Diameter of the trunnion Enter zero if not applicable
0.00	Diameter of the shackle pin or sheave Enter zero if not applicable

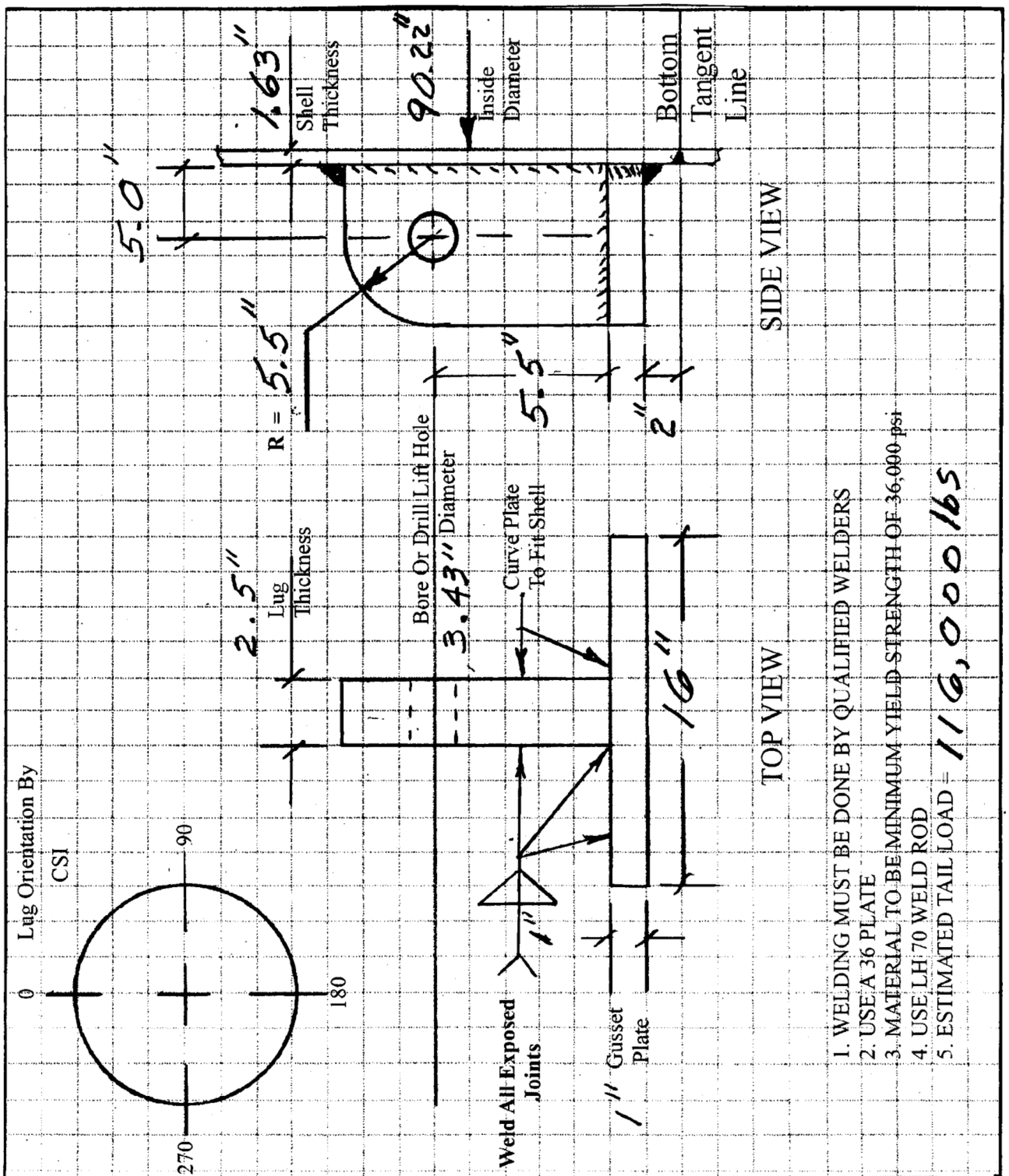
* ASSUMED. WILL PROBABLY BE LARGER.

OUTPUT:

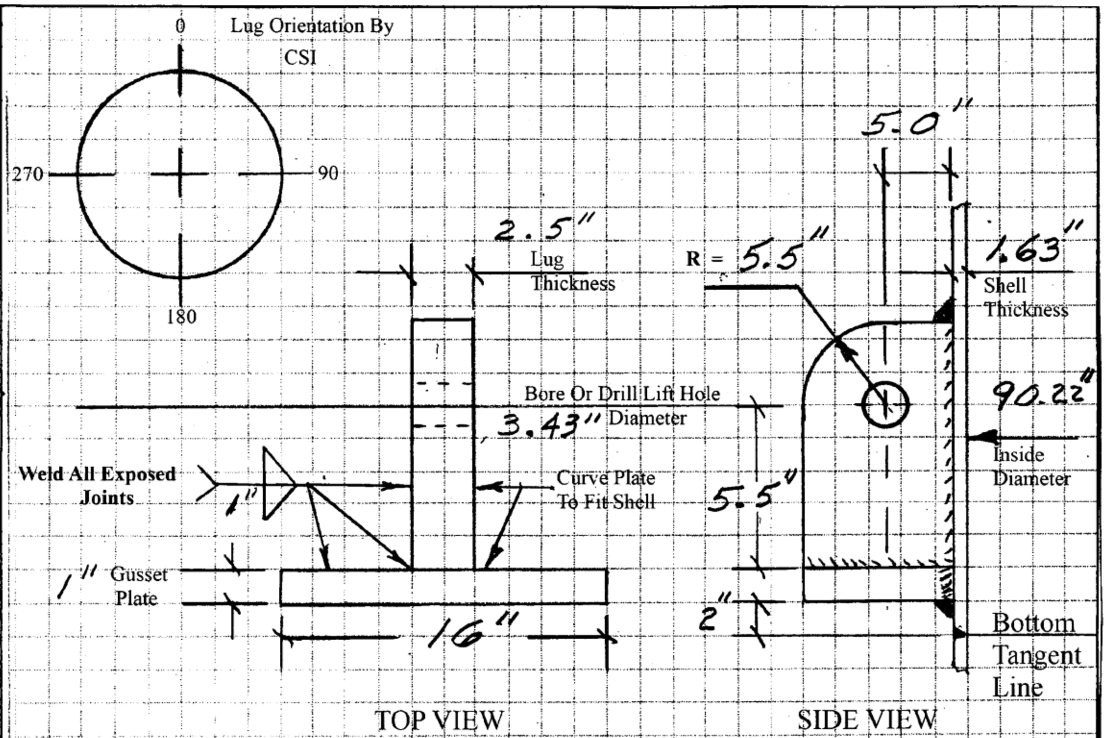
2.40	Hook or "Other type of pin"/sling ratio
0.00	Curved plate/sling ratio
0.00	Trunnion/sling ratio
0.00	Shackle Pin or sheave/sling ratio
67.73	Efficiency factor of the sling over a hook or "other type of pin" (%)
0.00	Efficiency factor of the sling around the curved plate (%)
0.00	Efficiency factor of the sling around the trunnion (%)
0.00	Efficiency factor of the sling around a shackle pin or sheave (%)
163.62	Safe Working Load of the **sling** using the smallest efficiency factor GOOD
47.62	Reserve capacity of the **sling** above the maximum tension



Calculated by www.maximumreach.com 2/6/2012



△ 7 FEB 2013 Approved For Fabrication KEG	DR. / CH. / SUPR. / SUPR. ENG. K E GOODMAN	TAIL LUG WITH L SHAPED WELD FOR TOWER 2 Aneth Gas Plant
CRANE SERVICE INC.	SCALE: NONE	DRAWING NUMBER: CSI - 1606 — REV. 1



1. WELDING MUST BE DONE BY QUALIFIED WELDERS
2. USE A 36 PLATE
3. MATERIAL TO BE MINIMUM YIELD STRENGTH OF 36,000 psi
4. USE LH 70 WELD ROD
5. ESTIMATED TAIL LOAD = 116,000 lbs

CRANE SERVICE INC.

Approved For Fabrication

DR. | CH. | SUPR. | SUPR. ENG.

SCALE: NONE

TAIL LUG WITH L SHAPED WELD FOR TOWER 2
Aneth Gas Plant

DRAWING NUMBER: CSI - 1606

REV. 1

POST REORDER NO. 120054

FORM E-306 REV. 6/88

22


CAUTION — CUIDADO


CRANE
SERVICE INC

ATTACHMENTS:

Tower Height Estimates.pdf

UT Thickness Report For Six Vessels.pdf

L Shaped Tail Lug And Weld.xls

The above pdf reference files and xls program will be sent upon request.

COMMENTS:

ANGLE OF FORCE ON LUGS:

Some of you may feel that there is a contradiction between the **angles of force** on the lugs used in the plate lug program and the tail lug program, ie, for L Shaped Lugs & Welds. My intention was to relate these angles of force to the **lift angle** of the vessel.

<u>Plate or Pad Eye Lugs:</u>

With the vessel in the horizontal at 0° lift angle, ie, in the IPP, the top head lugs are laying down and the angle of force on the lugs is vertical, ie, transverse to the longitudinal centerline of the lugs and the vessel. Therefore, I used the convention that the angle of force on the lugs in this position is 0°. When the lift angle is 90°, then the vessel is set and the angle of force on the lugs is 90°. As the lift angle increases, the angle of force on the lugs increases at the same rate. Maximum values for lug plate bending and weld size occur at 0°. Maximum values for end area and bearing stress occur at 90°.

If plate lugs or pad eye lugs are used to lift say a lubrication skid where the force to the lugs is vertical, then the above angle of force convention is still good, ie, the lugs are being used with the longitudinal centerline in the vertical so the angle of force at set is at 90°. There is not rotation of the load. This means that bending and the weld do not have to be checked at 0°. They are a maximum at 90°. But if the lift slings come off the lifting lugs at say 60°, then a run would have to be made for this angle to check the bending in the lug plate and the weld. This run would also automatically check the lug end area and bearing for 90°.

L Shaped Tail Lug And Weld

With the vessel at IPP, the force on the tail lug is vertical, so I used 0° for this angle of force. As the lift angle increases, the angle of force on the tail lug increases at the same rate. Maximum values for end area, bearing and weld size occur at 0°. The maximum value for lug plate bending occurs at somewhere around 65°, ie, in our example it occurred at 70°.

On page 18, I used the pad eye program to calculate the required end area and the bearing for the tail lug, so notice that I used 90° as the angle of force and the full 116 k of tail load. I did this because maximum values occur when the angle of force is in line with the longitudinal centerline of the lug, ie, 90° for a plate lug or a pad eye lug. I could have used the plate lug program and got the same results.

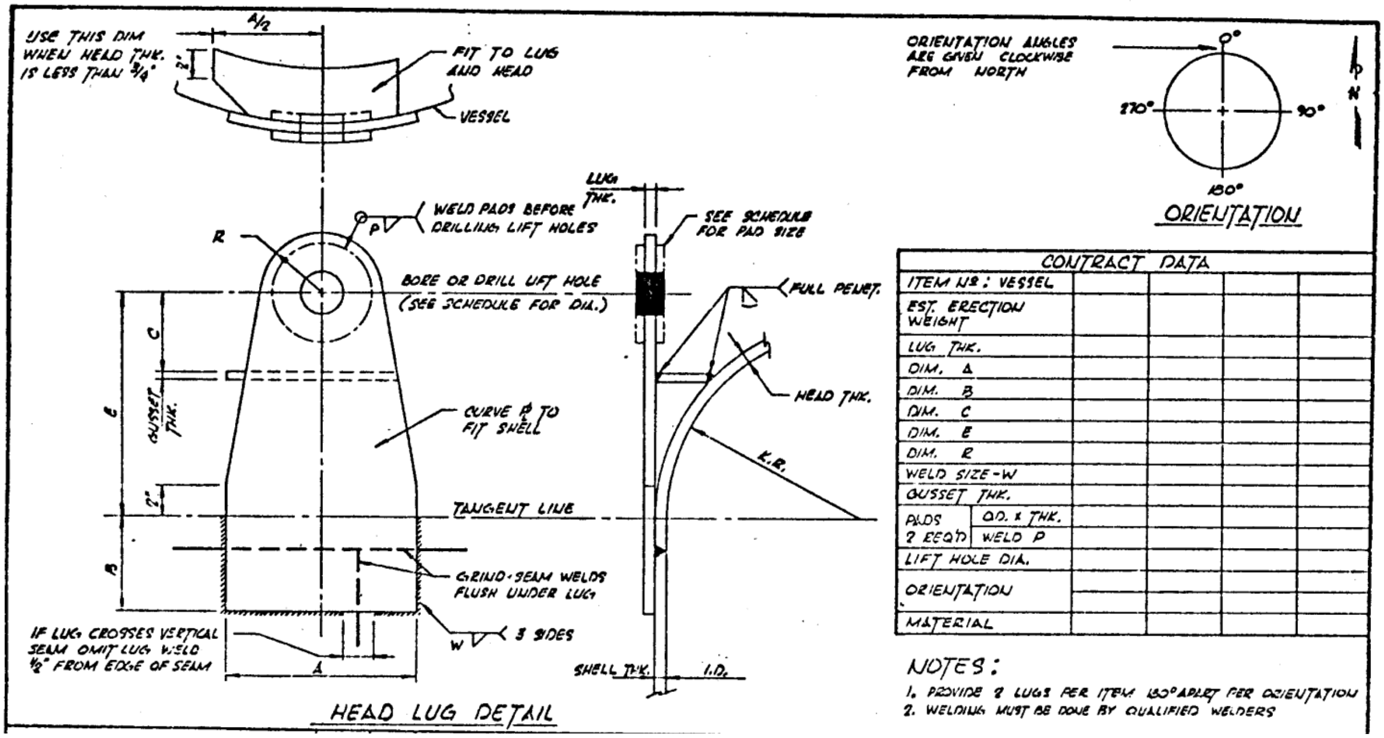
Also note on sheet 18 that the weld required was 0.64", but the weld required from the L Shaped Lug program was 0.49". That is because in the pad eye program, only the base weld length of 11" was used, and did not include the 10.5" of side weld.

TOP HEAD LUG DIMENSIONS:

I did not end up with the dimensions for the top head lug for Tower 2 simply by selecting a 55 Te shackle in the plate lug program and then using the values shown. It is not that simple. The dimensions shown in the program are for a very compact lug with a short eccentricity of 4.5". The eccentricity for most top head lugs is between 13" and 30" to provide clearance for the shackle, insulation, etc. So the dimensions shown are just a starting place, and the Rigging Engineer has to play around with the dimensions until he has a lug plate that provides the correct eccentricity, enough bending strength, weld length & size, enough end area and low bearing.

Shown below are two sheets that provide guidelines for selecting top head lugs. The user still has to tailor the shown dimensions to fit his purpose.

Note that I selected lug "3 C" from the guideline sheet, but that I still had to change some of the dimensions to get it to fit my design.



TYPE		TOTAL ERECTION WEIGHT (TONS)	SHACKLE SIZE (TONS)	LUG THICKNESS	A	B	C	E	R	W	GUSSET THICKNESS	PADS O. D.	PADS THK.	PADS P.	LIFT HOLE DIA.	LUG MATL. MIN. YIELD (PSI)
36" to 48" Inside Diameter																
1-A		0-30	35	1	12	12	7	13	3	3/8	1/2				2-1/2	30,000
1-B		31-65	50	1-1/2	14	12	8	14	4	3/4	1/2	7	3/8	1/4	3	30,000
1-C	*1	66-100	50	1-3/4	16	14	9	15	4-1/2	1	3/4	8	1/2	1/4	3	30,000
54" to 72" Inside Diameter																
2-A		0-30	35	1	12	12	7	15	3	3/8	1/2				2-1/2	30,000
2-B		31-65	50	1-1/2	16	14	8	17	4	5/8	1/2	7	3/8	1/4	3	30,000
2-C	*1	66-100	50	1-3/4	18	14	9	18	4-1/2	7/8	1/2	8	1/2	1/4	3	30,000
2-D	*2	101-150	75	2	20	16	11	20	5	1-1/4	3/4	9	3/4	3/8	3-1/2	38,000
78" to 108" Inside Diameter																
3-A		0-30	35	1	14	10	6	18	3	1/2	1/2				2-3/8	30,000
3-B		31-65	50	1	20	12	7	19	4	5/8	1/2	7	3/8	1/4	2-7/8	30,000
3-C	*1	66-100	50	1-1/4	22	14	9	21	4-1/2	3/4	3/4	8	3/4	1/2	2-7/8	30,000
3-D	*2	101-150	75	1-3/4	22	16	10	23	5	1-1/4	1	9	1	3/8	3-3/8	38,000
3-E	*3	151-200	130	2	25	18	12	25	6-1/2	1-3/8	1	12	1	1/2	4-3/8	38,000
114" to 144" Inside Diameter																
4-A		0-30	35	1	14	10	5	20	3	1/2	1/2				2-3/8	30,000
4-B		31-65	50	1	22	14	7	22	4	1/2	1/2	7	3/8	1/4	2-7/8	30,000
4-C	*1	66-100	50	1-1/4	26	14	9	25	4-1/2	3/4	3/4	8	3/4	1/4	2-7/8	30,000
4-D	*2	101-150	75	1-3/4	26	16	12	27	5	1-1/4	1	9	1	3/8	3-3/8	38,000
4-E	*3	151-200	130	2	28	18	12	27	6-1/2	1-3/8	1	12	1	1/2	4-3/8	38,000
150" to 180" Inside Diameter																
5-A		0-30	35	1	14	10	5	21	3	1/2	1/2				2-3/8	30,000
5-B		31-65	50	1	22	14	6	23	4	5/8	1/2	7	3/8	1/4	2-7/8	30,000
5-C	*1	66-100	50	1-1/4	26	14	10	28	4-1/2	3/4	3/4	8	3/4	1/4	2-7/8	30,000
5-D	*2	101-150	75	1-3/4	26	16	12	30	5	1-1/4	1	9	1	3/8	3-3/8	38,000
5-E	*3	151-200	130	2	28	18	12	30	6-1/2	1-3/8	1-3/8	12	1	1/2	4-3/8	38,000
186" to 216" Inside Diameter																
6-A		0-30	35	1	16	10	4	24	3	1/2	1/2				2-3/8	30,000
6-B		31-65	50	1	24	14	6	26	4	1/2	1/2	7	3/8	1/4	2-7/8	30,000
6-C	*1	66-100	50	1-1/4	28	14	9	31	4-1/2	3/4	3/4	8	3/4	1/4	2-7/8	30,000
6-D	*2	101-150	75	1-3/4	28	16	12	34	5	1-1/4	1	9	1	3/8	3-3/8	38,000
6-E	*3	151-200	130	2	30	18	12	34	6-1/2	1-3/8	1-3/8	12	1	1/2	4-3/8	38,000

*1 - For 75 Ton shackle increase lift hole to 3-3/8".

*2 - 130 Ton shackle increase to 4-3/8".

*3 - 150 Ton increase to 5-1/8".

THE END