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24 February 2013

DESIGN OF TAIL LUGS & BASERING REINFORCEMENT FOR VERTICAL VESSELS

Traditionally Fluor and most USA EPC contractors designed top head lugs for lifting vertical vessels and used slings to tail them, where most European contractors used trunnions to lift with and lugs to tail with. A lot of USA contractors are following the European method even though it always costs more. In most cases, they use the word SAFETY to justify this added expense.

Top head lugs are easier to design, analyze the local shell stresses, fabricate and install than trunnions. And they are safer as the slings can't jump off. If the weld size required to connect them to the top of the vessel is equal to or less than the thickness of the shell at the top tangent line, then they will not overstress the shell during lifting. So, no complicated analysis of the local shell stresses is required. In designing trunnions, on the other, the shell stresses must be analyzed very carefully. It is sort of like designing and installing trunnions on the side of an empty Pepsi can. The only real advantage of using trunnions is when the vessel is long and lifting with top head lugs would cause buckling in the vessel shell. So trunnions located down on the shell solve this problem very well.

Slings, if used correctly are cheaper to procure/install and are as safe to use as designing and using tail lugs. The reason for this is that if slings are used to tail a vessel, the skirt & basering stresses do not have to be checked. The radial forces from the sling are pretty much uniform around the skirt. On the other hand, when tail lugs are used to tail a vessel, the skirt and basering stresses **always** have to be checked. Very seldom can a vessel be tailed with just a tail lug without any internal basering reinforcement. I do not recommend tailing a vessel by attaching one or two shackles to the anchor bolt holes in the basering.

Unfortunately, a lot of heavy lift contractors do not feel comfortable tailing with slings, ie, remember that Crane Service Inc. didn't want to use tail slings. See **Appendix A:** TAILING A VERTICAL VESSEL for the correct way to tail a vertical vessel with a sling.

On the other hand, another reason for using lugs and for not using tail slings is that about the biggest diameter sling that can be used is a doubled 3". Above that diameter,

the slings are too stiff to handle. A 9 part braided sling made up of say 2" component wire rope can then be used up to its capacity. Above that, tail lugs need to be used.

If a tail lug must be used, we first check the skirt and basering to see if a single lug welded to the top of the skirt and welded to the basering will cause over stressing. Tailing with a tail lug, without internal basering reinforcement, is called a one point support because the skirt and basering are being lifted in one place only, at the top. See **Appendix B:** HELP FILE FOR ONE POINT SUPPORT. This help file points out how the program works. As you read this file, look at the Upending sketch to identify the upending forces caused by lifting and tailing, ie, explaination of transverse & longitudinal forces.

If the skirt and basering are over stressed in a one point support, then we check to see if welding an internal beam inside of the skirt and to the basering will prevent over stressing. This is called a two point support because the skirt and basering are being supported in two places, ie, at the top and bottom. I also have a program for doing this check. See **Appendix C:** HELP FILE TWO AND FOUR POINT SUPPORT to see how the program works and a printout of the first part of the program.

If the skirt and basering are over stressed in a two point support system, then we install diamond bracing. This is called a four point support system and it always works. See the above help file for a print out of the second part of the program.

But note that the lug plate, end area & weld are always designed the same way regardless of the type of support of the basering. The lug can be designed by using the pad eye program on my website and by using information from the upending program. **If the skirt thickness is relatively thin and more weld length is required, then the lug plate and weld must be designed using the L-Shaped Lug Program.** See **Appendix D:** HELP FILE FOR L SHAPED TAIL LUG PLATE DESIGN.

I will stop here, as this is probably more than you ever wanted to know about tail lugs and basering reinforcement for upending vertical vessels.

The programs to check the basering stresses and design the L Shaped tail lug will be sent upon request.

END OF DESIGN COMMENTS:

Appendix A: TAILING A VERTICAL VESSEL WITH A SLING

Vertical vessels that do not have tail lugs for up ending will have to be erected using tail slings. There is some risk in this operation if the tail sling is not rigged properly around the skirt or bottom of the vessel. The correct procedure for tailing is:

1. Refer to Tailing Hookup sketch on the next page and select the recommended timber blocking size for the diameter of the vessel being used.

2. Position the blocking on the skirt of the vessel as shown and secure it with two tirfors or come-alongs.

3. Attach the tail sling to the hook on the tail crane.

4. Center the hook and the tail sling over the vessel about 2' from the base plate.

5. Wrap the tail sling around the skirt and connect it as shown with the appropriate shackle.

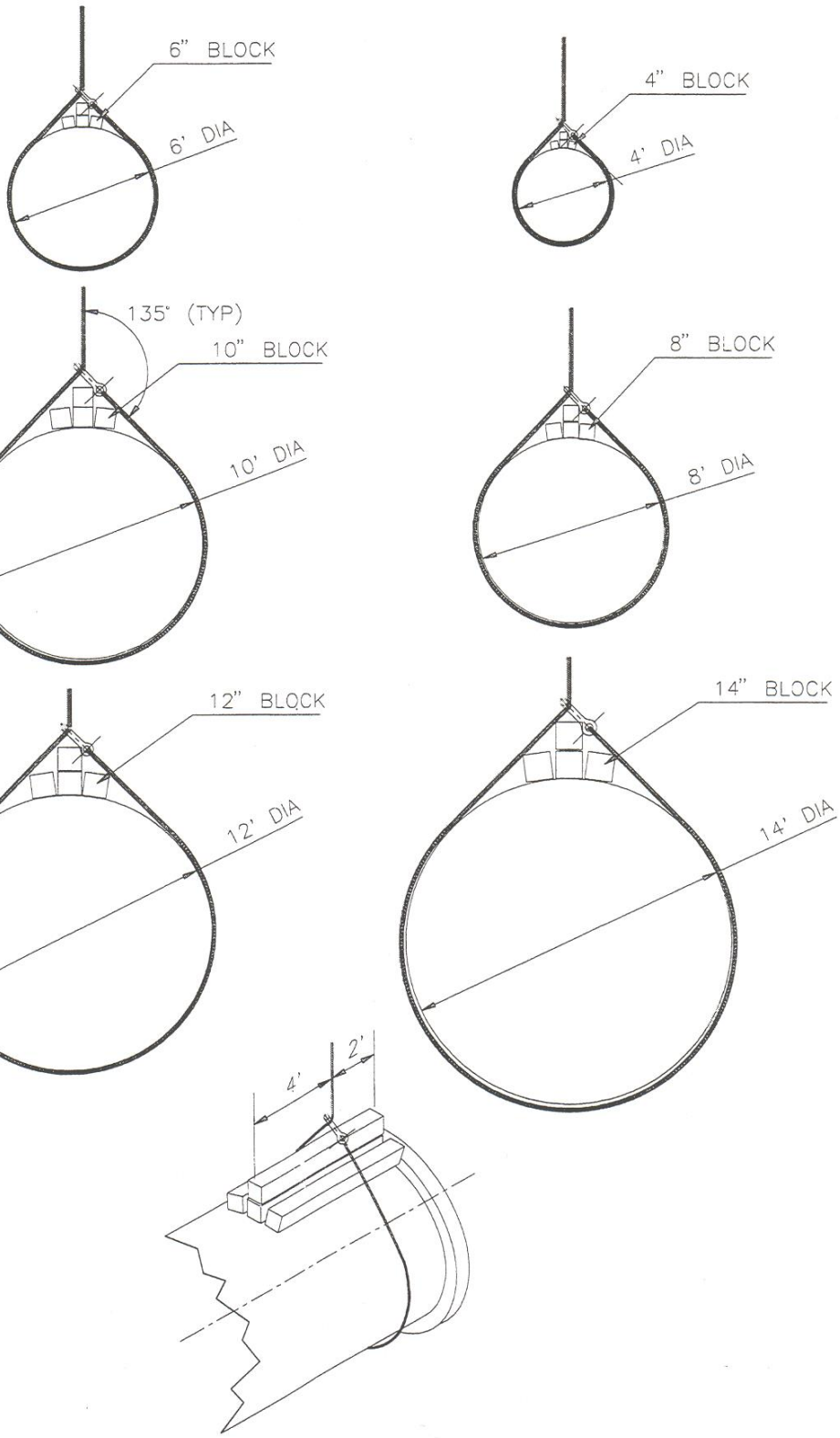
6. Before tightening up on the tail sling, rotate the sling (clockwise as viewed on the tailing hookup page) around the skirt about 6". This will move the shackle off center and force it and the sling to bite down on to the timbers as the sling is being tightened up.

7. Snug up on the tail sling. If the tail sling is not centered over the vessel, slack off on the sling and repeat step 6.

8. Hammer the shackle down as far as it will go until it rests on the timbers.

9. Slowly hoist until the tail crane has about 50% of the tail load. If the sling and the shackle are snug down against the timbers and the sling is centered over the skirt, the bottom of the vessel is ready to be lifted.

Note: If the sling and shackle are snug down against the timbers, it is nearly impossible for the sling to slip or ride up as the vessel is being up ended. In order for the sling to slip, the circumferential length would have to increase. Under load, this is impossible. The friction between the sling/wood and the skirt provides a resisting force that is greater than necessary to prevent slippage of the sling.

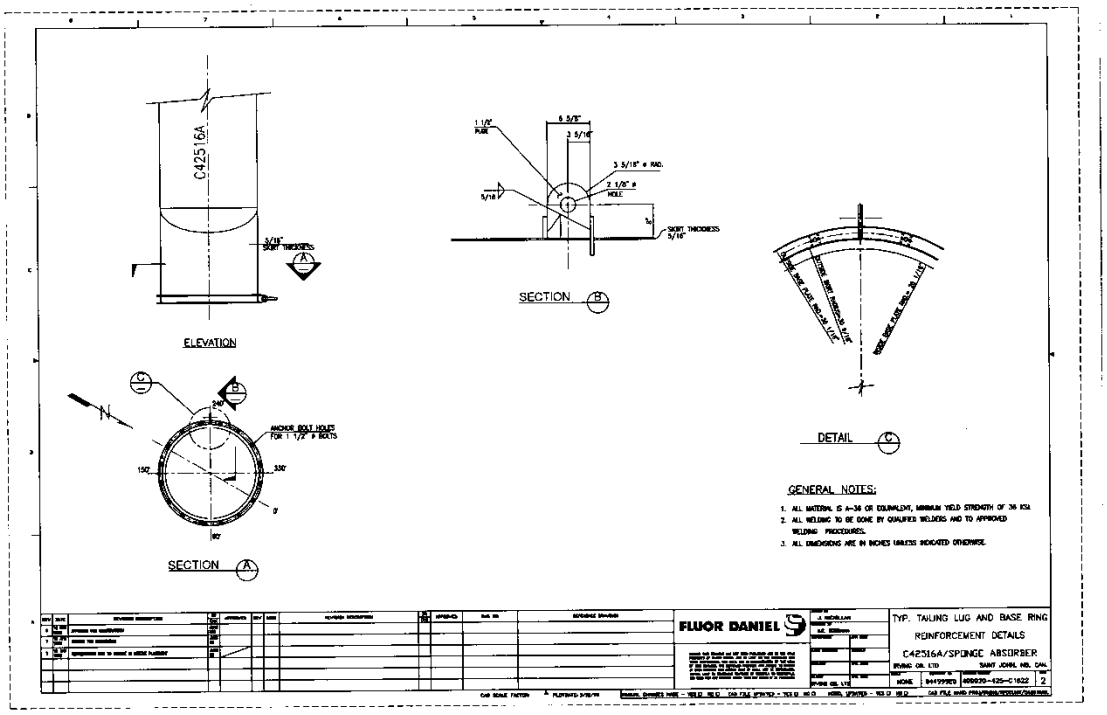


TAILING HOOK–UP
(TYP)

Appendix B: HELP FILE FOR ONE POINT SUPPORT DESIGN FOR BASERING

When vertical vessels are tailed by a tail beam or a tail lug, they tend to deform unless the base ring is correctly reinforced to take care of the bending moments. If a vessel is being tailed by a tail lug without any base ring reinforcement, it is called a **one-point support**. If the basering is overstressed, the deformed shape of the basering would look something like an oval. If an internal beam is required between the tail lug and the opposite side of the base ring, it is called a **two-point support**. If the basering is overstressed, the deformed shape would look sort of like an upside down pear. If struts are required that run from the top and bottom of the beam to each side of the base ring in a diamond shape, it is called a **four-point support.** There is very little deformation of the basering with this type of support.

The drawing below shows a vertical vessel being tailed with just a pad eye type tail lug and without any basering reinforcement. This is an example of a one point support.



The one point support program checks the basering to see if it is strong enough in bending to be tailed with just a tail lug. If it is not, then the base ring must be checked by the two or four point support program.

NOTE: Most European designers are using a modified base ring where the OD of the basering is not continuous and is at the center of the **anchor bolt holes. Not good**. Beware of the reduced cross sectional area of the base ring as the input value for the OD of the base ring must be limited to the bottom of the anchor bolt holes when calculating the section properties. See the base ring reinforcement for vessel C-1451, drawing T-2-739-857 in the HELP file for a Two and Four point support for an example.

Design Parameters: Recommended

a. Stress allowable for the skirt and base ring = .75*Fy (Max.)
b. An impact factor (IF) should be used = 1.25 (Min.)

To use the one point support program:

1. Fill out the input sheet shown below.

a. Note that the program will check an internal ring beam.
b. The next page shows examples of the three different type of chairs. Chairs are the weldments between the skirt and base that houses the anchor bolts. A type 2 chair is shown on the input sheet.

2. Enter the information from the input sheet into the program
3. Process the information
4. Check the input data to ensure that it is correct
5. Check the base ring stresses on the output data. If any are higher than the listed allowable, the base ring section will need to be increased, ie, increase the thickness, increase the O.D, decrease the I.D., etc. If this is not possible, then it must be checked for a two or four point support. If all of the base ring stresses are less than the allowable stress, check the combined stresses for the base ring and the skirt.
6. If any combined stress is greater than the allowable, the base ring section will need to be increased or checked for a two or four point support. If all of the combined stresses are below the allowable stress, then the vessel can be tailed with just a tail lug.
7. The two pages after the base ring input information are examples of output data.
8. As the tail lug must be welded to the basering between anchor bolt holes, be sure and check the orientation of the top head lugs to make sure that their location is 90° to the tail lug. This will ensure that the tail lug will not be side loaded during upending.

Note that this program only checks the stresses in the base ring and the skirt. If the tail lug will be shaped like a traditional pad eye lug, ie, the width of the lug plate is two times the lug radius, the pad eye lug design program at www.maximumreach.com can be used to determine the dimensions and the weld requirements for connecting the tail lug to the skirt/basering. If the weld required is thicker than the skirt, then the tail lug plate must be designed by the L Shaped Tail Lug Plate.xls program to determine the required weld length. The end area of the lug would still be designed by the pad eye program on the above website.

INPUT SHEET

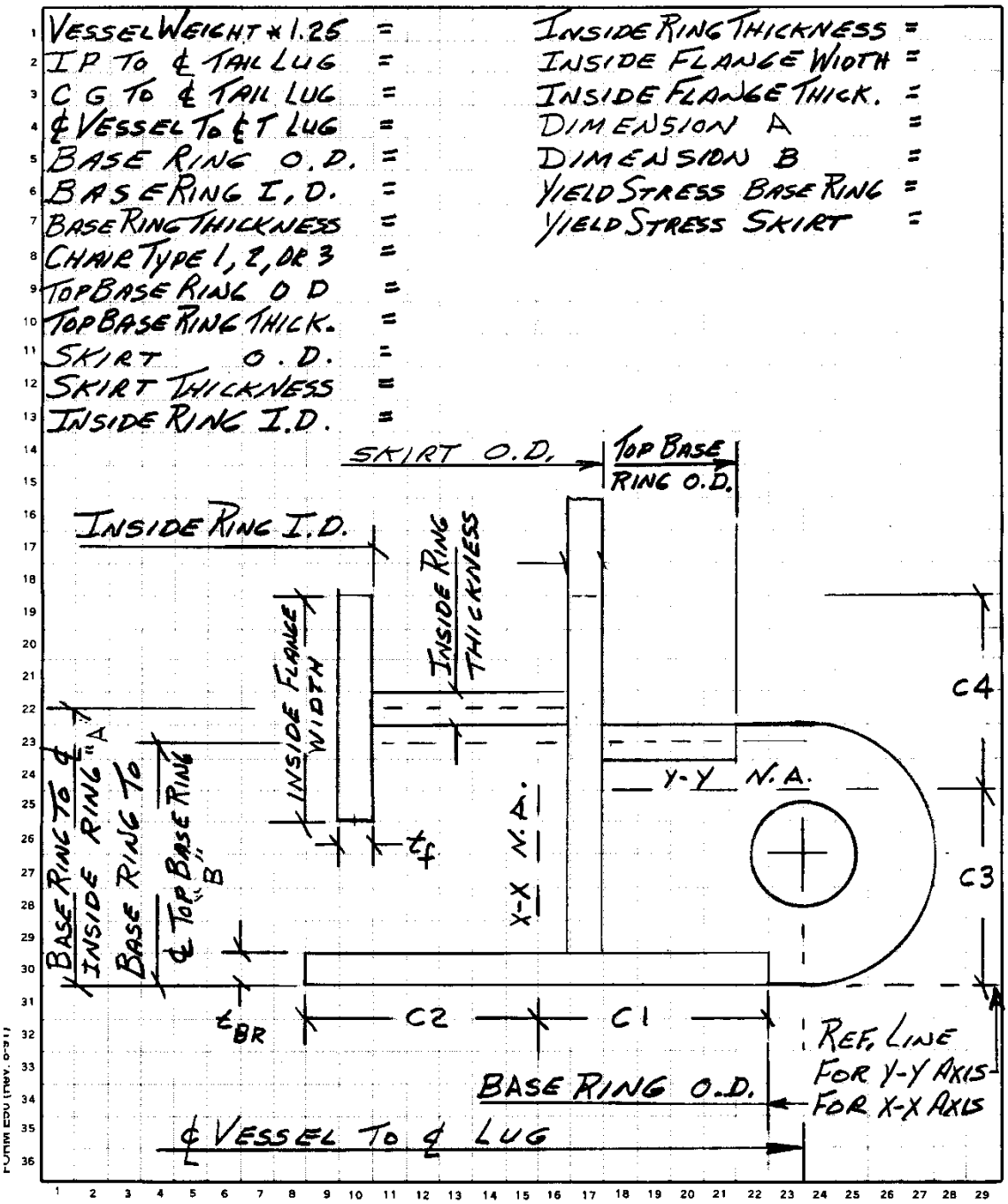
FLUOR DANIEL

DATE

CONT. NO.

NOTES:

1. **All input is in kips and inches**
2. **Ref. Construction Engineering lifting analysis, sheets 23 – 26 below**



ONE POINT SUPPORT PRINTOUT

WELCOME TO CONSTRUCTION ENGINEERING

02-21-1994
17:57:35
THIS PROGRAM IS ONE POINT SUPPORT VERSION 1.0

THIS IS A PROGRAM FOR CALCULATING THE BASE RING AND SHELL
STESSES THAT OCCUR DURING THE UP/DOWN ENDING OF A VESSEL WHEN
TAILING WITH A ***** ONE POINT SUPPORT *****TAIL LUG

********** INPUT DATA **********

CONTRACT NUMBER =428700
EQUIPMENT NUMBER =V-1701

VESSEL WEIGHT * 1.25	(KIPS)=	158.7
DIM: I P TO CL OF TAIL LUG	(IN.)=	697.4
DIM: C G TO CL OF TAIL LUG	(IN.)=	383
DIM: CL VESSEL TO CL OF TAIL LUG	(IN.)=	93.3
BASE.RING O. D.	(IN.)=	177.6
BASE RING I. D.	(IN.)=	125
BASE RING THICKNESS	(IN.)=	.47
TOP BASE RING O. D.	(IN.)=	177.6
TOP BASE RING THICKNESS	(IN.)=	.75
SKIRT O. D.	(IN.)=	174.8
SKIRT THICKNESS	(IN.)=	.71
INSIDE RING I. D.	(IN.)=	0
INSIDE RING THICKNESS	(IN.)=	0
INSIDE FLANGE WIDTH	(IN.)=	0
INSIDE FLANGE THICKNESS	(IN.)=	0
BTM BASE RING TO CL INSIDE RING	(IN.)=	0
BTM BASE RING TO CL TOP BASE RING	(IN.)=	6.7

DECREASED THE BASERING I.D.TO TAKE CARE OF THE OVERSTRESSING BETWEEN 0 AND 10 DEGREES EITHER SIDE OF THE TAIL LUG.

GOOD RUN!

########## OUTPUT ##########

BASE RING STRESSES
FOR ONE POINT LOADING

BASE RING ANGLE DEG	TAN. FORCE KIPS	MOM. FT. KIPS	Ften KSI	INSIDE Fbi KSI	INSIDE Fci KSI	OUTSIDE Fbo KSI	OUTSIDE Fco KSI	ALLOWABLE STRESS KSI
0	-5.70	1387.24	-0.24	17.28	17.04	7.05	6.81	18.00
10	-11.48	903.97	-0.48	11.26	10.78	4.59	4.11	18.00
20	-16.23	476.55	-0.68	5.94	5.25	2.42	1.74	18.00
30	-19.84	115.43	-0.83	1.44	0.61	0.59	-0.25	18.00
40	-22.25	-172.56	-0.93	-2.15	-3.08	-0.88	-1.81	18.00
50	-23.45	-384.25	-0.98	-4.79	-5.77	-1.95	-2.94	18.00
60	-23.50	-520.14	-0.99	-6.48	-7.47	-2.64	-3.63	18.00
70	-22.48	-584.09	-0.94	-7.28	-8.22	-2.97	-3.91	18.00
80	-20.55	-583.03	-0.86	-7.26	-8.13	-2.96	-3.83	18.00
90	-17.88	-526.41	-0.75	-6.56	-7.31	-2.68	-3.43	18.00
100	-14.66	-425.70	-0.62	-5.30	-5.92	-2.16	-2.78	18.00
110	-11.11	-293.69	-0.47	-3.66	-4.12	-1.49	-1.96	18.00
120	-7.47	-143.82	-0.31	-1.79	-2.11	-0.73	-1.04	18.00
130	-3.94	10.48	-0.17	0.13	-0.03	0.05	-0.11	18.00
140	-0.74	156.53	-0.03	1.95	1.92	0.80	0.76	18.00
150	1.96	282.99	0.08	3.53	3.61	1.44	1.52	18.00
160	4.00	380.39	0.17	4.74	4.91	1.93	2.10	18.00
170	5.27	441.67	0.22	5.50	5.72	2.24	2.47	18.00
180	5.70	462.41	0.24	5.76	6.00	2.35	2.59	18.00

#################### OUTPUT ##########################

COMBINED BASE RING AND SKIRT STRESSES
FOR ONE POINT LOADING

LIFT ANGLE DEG	TAIL LOAD KIPS	TAIL LOAD TRANSVERSE KIPS	TAIL LOAD LONGITUDINAL KIPS	BASE RING Fb KSI	SKIRT Fb KSI	COMBINED Fc KSI	ALLOWABLE STRESS KSI
0	71.54	71.54	0.00	17.04	-0.00	17.04	18.00
10	69.90	68.83	12.14	16.40	1.65	16.48	18.00
20	68.22	64.11	23.33	15.27	3.18	15.60	18.00
30	66.41	57.52	33.21	13.70	4.52	14.43	18.00
40	64.32	49.27	41.35	11.74	5.63	13.02	18.00
50	61.71	39.66	47.27	9.45	6.44	11.43	18.00
60	58.09	29.04	50.30	6.92	6.85	9.74	18.00
70	52.32	17.89	49.16	4.26	6.69	7.94	18.00
80	40.68	7.06	40.06	1.68	5.46	5.71	18.00
90	-0.00	0.00	-0.00	0.00	-0.00	0.00	18.00

################## BASE RING PROPERTIES ########################
FOR ABOVE INPUT

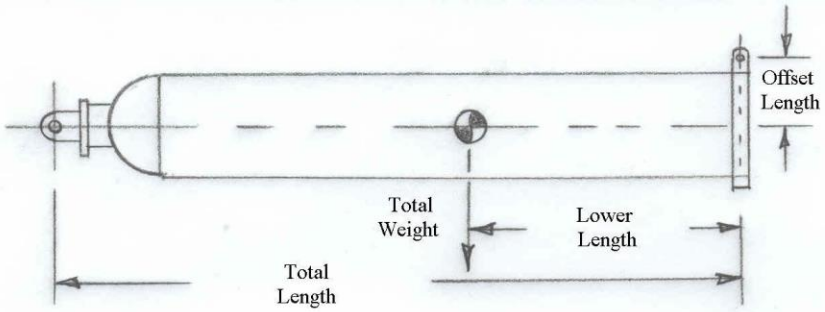
FOR X-X AXIS AND CHAIR TYPE = 2

BASE RING MEAN RADIUS	(IN.)= 81.17849
BASE RING O. D. TO N. A.	(IN.)= 7.62151
BASE RING I. D. TO N. A.	(IN.)= 18.67849
EFFECTIVE SKIRT HEIGHT (ABOVE BASE RING)	(IN.)= 14.66191
SECTION MODULUS OUTSIDE	(IN^3)= 196.7435
SECTION MODULUS INSIDE	(IN^3)= 80.27856
MOMENT OF INERTIA	(IN^4)= 1499.483
AREA OF TOTAL SECTION	(IN^2)= 23.82096

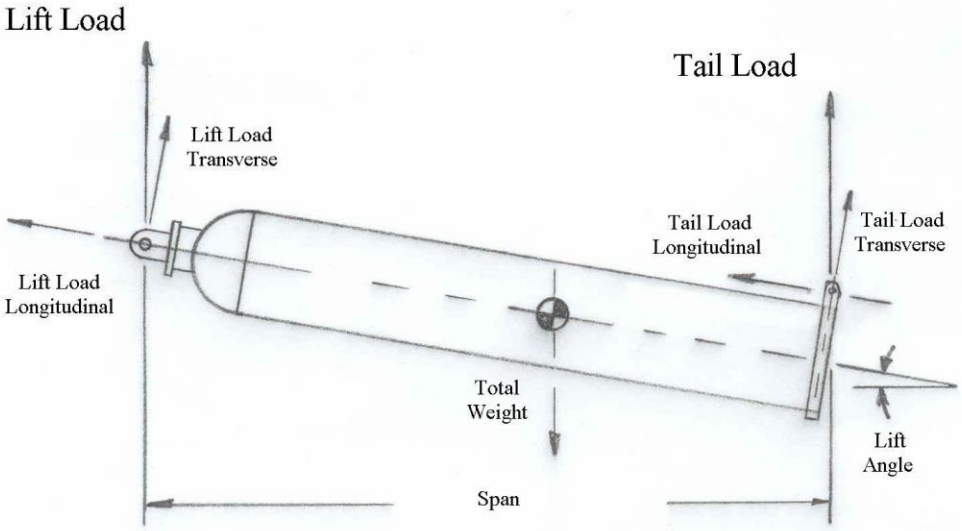
FOR Y-Y AXIS

MOMENT ARM (CL SKIRT TO CL LUG PIN HOLE)	(IN.)= 6.255002
BOTTOM OF BASE RING TO N. A.	(IN.)= 3.826354
TOP OF EFFECTIVE SKIRT HEIGHT TO N. A.	(IN.)= 11.30555
SECTION MODULUS OUTSIDE	(IN^3)= 135.7206
SECTION MODULUS INSIDE	(IN^3)= 45.93452
MOMENT OF INERTIA	(IN^4)= 519.3152

See the sketch below for an explanation of the upending forces.



INPUT SKETCH FOR UPENDING



OUTPUT SKETCH FOR UPENDING FORCES

ONE POINT SUPPORT PROGRAM LOGIC AND SUPPORT DOCUMENTS

1. The One Point Support.exe program is based on the attached sheets, 23, 24, 25 and 26.
2. Sheet 23 shows the formulae for determining the effective length of the skirt for different types of chairs. It also shows how the cross sectional area, the moment of inertia and the inner and outer section modulus is calculated around the x-x and y-y axis.
3. The program does not have an impact factor included in it. The 1.25 is just a suggested value. The user is free to use any value he wishes.
4. When the vessel is in the initial pick position (IPP), note that the base ring stresses are checked from 0 degrees to 180 degrees around the base ring per sheet 25 and 26.
   The allowable stress is equal to .75*Fy of the **base ring material**, as the skirt is not in stress at this point.

5. When the vessel is being upended, the transverse & longitudinal tail forces are calculated. The base ring stress is calculated at the top position or right under the tail lug using the appropriate transverse force and the smallest section modulus. At the same time, the skirt stress is calculated using the appropriate longitudinal force and the smallest section modulus. The combined stress is calculated using Sq (basering stress^2 + skirt stress^2). The allowable stress is equal to .75*Fy of the **skirt material.** The rational here is that the base ring stresses in the IPP must be below the allowable in order to continue with the program. As the vessel is upended, the base ring stresses start to decrease and the skirt stresses start to increase. Therefore, the skirt material will become the limiting factor.
6. The program does not take into account the area of the anchor bolt holes. The rational is that it doesn't make sense to go to this degree of detail when most design offices and fabricators are designing the base ring reinforcement using an allowable as high as 1.3*Fy and in most cases not using any impact. Also most European designers are using a modified base ring where the OD of the basering is at the center of the **anchor bolt holes. Not good**. Beware of the reduced cross sectional area of the base ring as the OD of the base ring must be limited to the bottom of the anchor bolt holes in this case.

   Because the program does not take the area of the anchor bolt holes in to account, the cross sectional area calculated by this program is slightly greater than the area calculated by the 2/4 point support program.
7. If the program shows that a change to the basering must be made in order to reduce the stresses, then the Rigging Engineer must submit this information to the Vessels Engineer in a timely manner so he can inform the vessel fabricator before the basering is actually fabricated. The changes could be increasing the basering thickness, decreasing the ID of the basering, etc. Making these changes would probably be cheaper than going to a two/four point support.

SUMMARY:

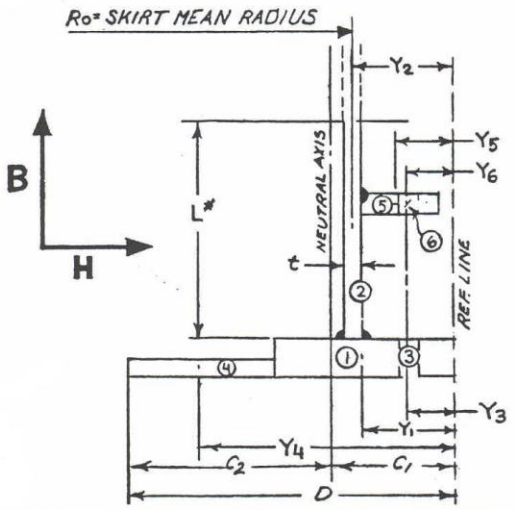
This program was written during the attachment design of the vessels for the Rayong, Thailand project. A field check of a number of vertical vessels checked by this program showed that when an allowable of .75*Fy was used in the design, along with a 1.25 IF, that there was little deformation of the base ring. Vessels that were designed up to 1.0*Fy without an IF showed as much as 1" of deformation. These vessels were designed by Fluor's joint venture partner without letting us review their design. We were lucky that the baserings fit down over the anchor bolts.

So, I feel that this program is quite conservative if the recommended yield stress and safety factor are use, and there is no need to do a finite element analysis to check the basering stresses, just go to a two or four point support if necessary.

SHEET 23

BASE PLATE SECTION PROPERTIES,-

The Program uses the following method to compute the Base Plate Properties:



ITEM	AREA, IN^2	Y, IN	Y^2, IN^2	AY	AY^2	Io, IN^4
1						
2						
3	(—)			(—)	(—)	(—)
4						
5						
6	(—)			(—)	(—)	(—)
	ΣA			ΣAY	ΣAY^2	ΣI.

Note: 1. Sections 5 & 6 should be considered only if Type II Chair is used.

2. Section 4 is the insert Plate which is added to the inside of the Base P_L.

3. For Type I & III Chairs
*L = $.78\sqrt{R_o t}$
where Ro = $\frac{\text{SK.O.D.}-t}{2}$

4. For Type II Chairs
*L = $.78\sqrt{Rot}$
+ 9"-B.P_L . Thick.

5. $Io = \frac{bh^3}{12}$ For Rectangular sections, where b = section width, parallel to Ref. Line, and where h = section length, perpendicular to Ref. Line.

$C_1 = \Sigma AY/\Sigma A$

$C_2 = D - C_1$

$I = \Sigma AY^2 + \Sigma Io - C_1 \Sigma AY$
= Moment of Inertia

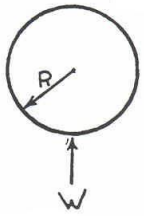
Z = The smaller of I/C_1 or I/C_2
= Section Modulus

SHEET 24

MULTI - DESIGN OF BASE PLATE FOR INITIAL PICK TAIL END LOAD

Before analyzing the loads on Base Plate, the Computer prints out the original Base Plate data and comosite net section properties. "Original" refers to the Base Plate designed by the Vessel Design Program.)

The program uses the original Base Plate properties to calculate the stresses due to one, two and four point supports.



DESIGN OF BASE PLATE FOR ONE POINT SUPPORT

BENDING MOMENT: $M^* = B_1 WR$

$B_1 = (1 + 1/2 \cos\Theta - \pi \sin\Theta + \Theta \sin\Theta)/2\pi$

W = Load on Base Ring at Initial Pick

R = Mean radius of Base Ring = O.R. - C_1

C_1 = The distance from ref. line to neutral axis (B.P sec. properties)

(Refer to B_1 Diagram on the next sheet)

TANGENTIAL FORCE: $T^* = D_1 W$

$D_1 = (\Theta \sin\Theta - 1/2 \cos\Theta - \pi \sin\Theta)/2\pi$

W = Load on Base Ring at Initial Pick

(Refer to D_1 Diagram on the following Sheet)

TOTAL STRESS: $\sigma = \frac{M}{Z} + \frac{T}{A}$

M = Bending Moment

T = Tangential Force

A = Cross Section Area of Base Ring

Z = Section Modulus: The smaller of I/C_1 or I/C_2

Where I = Moment of Inertia (Refer to section on Base Plate Section Properties)

C_1 or C_2 = The distance from Neutral Axis to the farthest edge

If the Base plate is overstressed, the Base Plate dimensions are increased, as described below, to accomodate the imposed laods.

(An overstress is indicated by double asterisks, [**, Printed next to the stress.)

*The Formula is taken from Roark's Table VIII, Case 18.

CALCULATIONS and SKETCHES

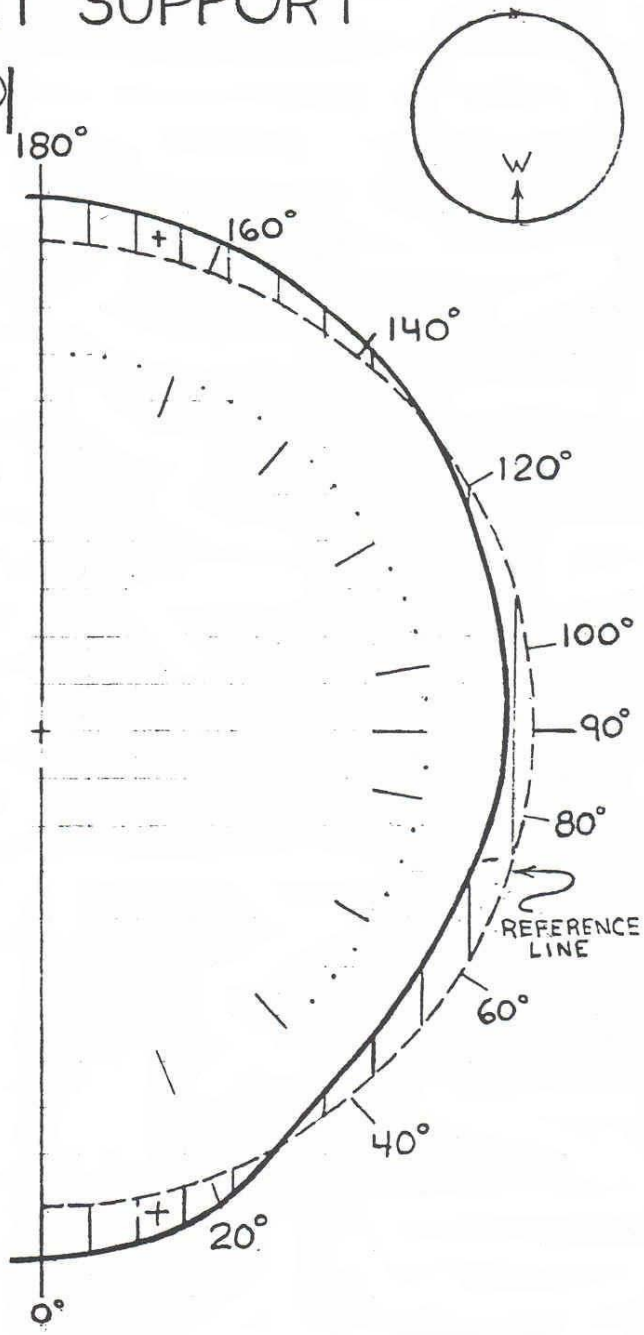
DATE 11-22-74
CONT. NO.
BY KN CHK'D
SHEET NO.

B_1 DIAGRAM

ONE POINT SUPPORT

$$B_1 = \left| \frac{(1 + 1/2\cos\theta - \pi\sin\theta + \theta\sin\theta)}{2\pi} \right|$$

θ	B_1	θ	B_1
0	.2387	90	−.0908
5	.1961	95	−.0830
10	.1555	100	−.0735
15	.1174	105	−.0627
20	.0819	110	−.0508
25	.0493	115	−.0381
30	.0197	120	−.0250
35	−.0067	125	−.0116
40	−.0299	130	+.0016
45	−.0497	135	+.0145
50	−.0663	140	.0268
55	−.0796	145	.0382
60	−.0897	150	.0486
65	−.09673	155	.0577
70	−.1008	160	.0654
75	−.1020	165	.0715
80	−.1006	170	.0762
85	−.09679	175	.0787
		180	.0796



FOR BENDING MOMENT: $M = B_1 WR$

CALCULATIONS and SKETCHES

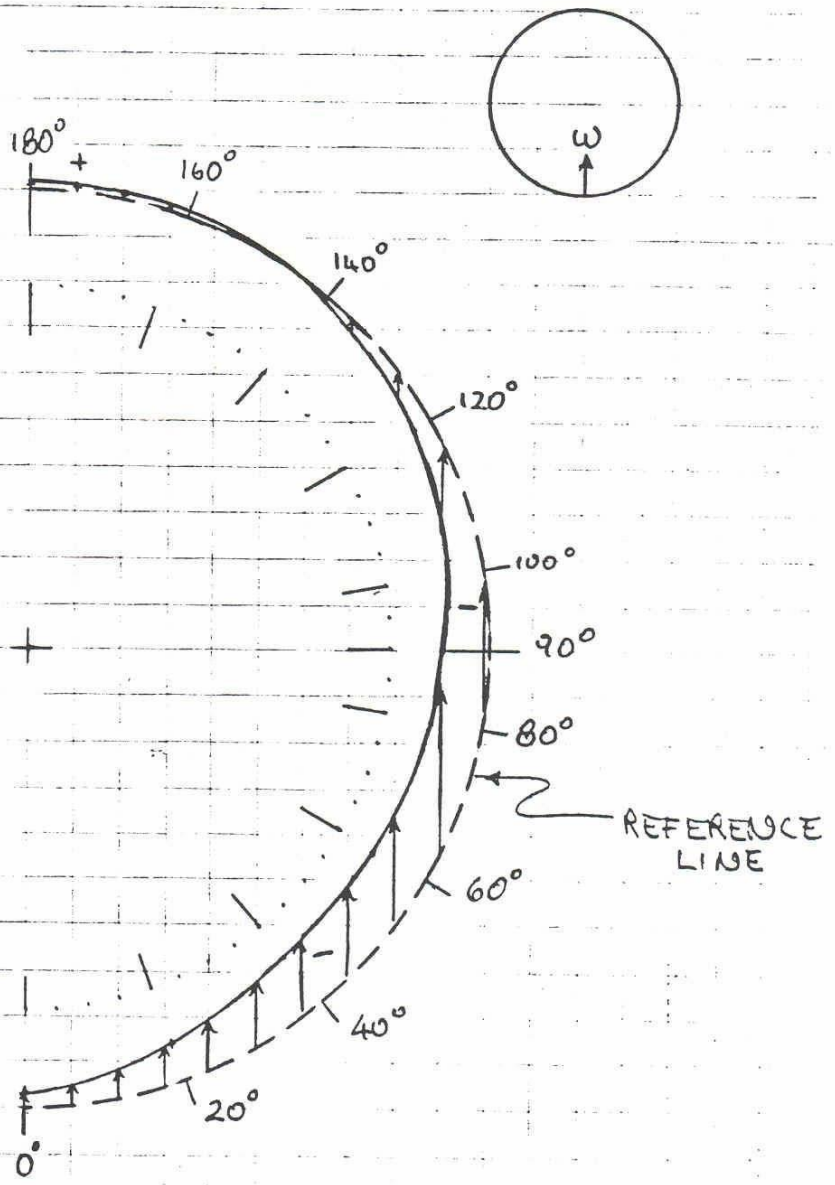
DATE
CONT. NO.
BY BVB CHK'D
SHEET NO.

D_1 DIAGRAM

ONE POINT SUPPORT

$$D_1 = \left| (\theta \sin\theta - \tfrac{1}{2}\cos\theta - \pi \sin\theta)/2\pi \right|$$

θ	D_1	θ	D_1
0	.07962	90	.24996
5	.12166	95	.22824
10	.16032	100	.20498
15	.19544	105	.18065
20	.22685	110	.15555
25	.25411	115	.12998
30	.27722	120	.10457
35	.29616	125	.07947
40	.31095	130	.05529
45	.32142	135	.03218
50	.32773	140	.01047
55	.33004	145	.00939
60	.32850	150	.02726
65	.32311	155	.04278
70	.31433	160	.05575
75	.30232	165	.06607
80	.28738	170	.07361
85	.26982	175	.07808
		180	.07962



FOR TANGENTIAL FORCE: $T = D_1 W$

END OF HELP FILE

Appendix C: HELP FILE FOR TWO AND FOUR POINT SUPPORT FOR BASERING

If the base ring is over stressed due to a one point support, then a tail beam or an internal beam will be required between the tail lug and the bottom of the base ring. This is called a two-point support. If the base ring is still overstressed, then struts are required that run from the top and bottom of the beam to each side of the base ring in a diamond shape. This is called a four-point support. The struts are usually made of pipe, L angles or small beams.

Either an external tail beam or an internal beam can be used as the base ring reinforcement to form the two or four point support system. An external tail beam with a lug on the top end is usually used when it can be utilized on four or five different vessels. On the other hand, an internal beam with a tail lug welded to the topside of the skirt/basering requires less design and fabrication and it is usually cheaper in the long run to use over a tail beam.

If the base ring has been checked for a one point support and it failed, then the designer must use the two/four point support program. The program first checks the base ring for a two point support and if it fails, then the program checks for a four point support system and indicates what it required to make it work, i.e. struts, insert plates, etc.

Design Parameters: Recommended

1.	Stress allowable for the skirt and base ring	=	.75*Fy	(Max.)
2.	An impact factor (IF) should be used	=	1.25	(Min.)

NOTE: Most European designers are using a modified base ring where the OD of the base ring is not continuous and is at the center of the **anchor bolt holes. Not good**. Beware of the reduced cross sectional area of the base ring as the input value for the OD of the base ring must be limited to the bottom of the anchor bolt holes when calculating the section properties. See the base ring reinforcement for vessel C-1451, drawing T-2-739-857 for an example of this type of basering. This drawing is located below under the section on Four Point Support:

EXAMPLES:

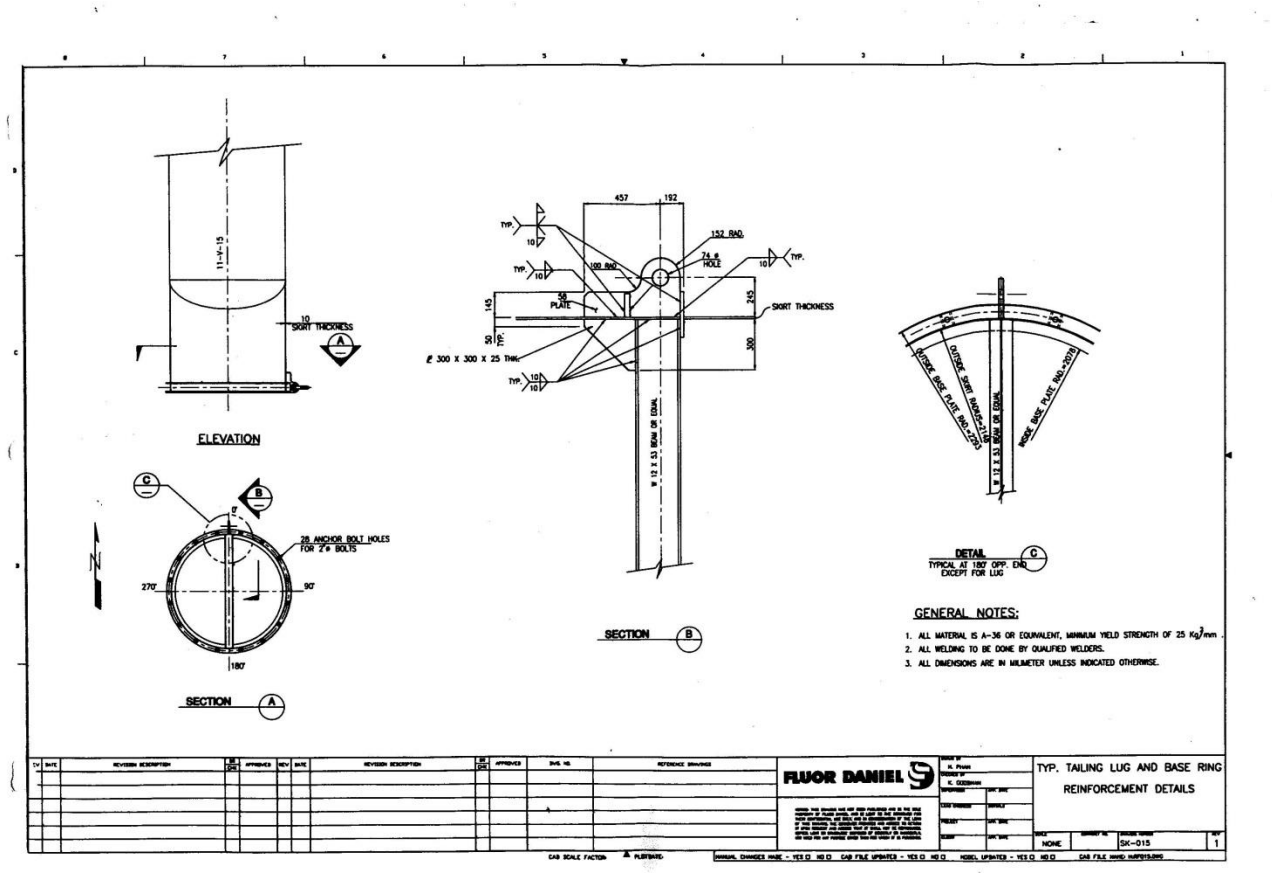
Two Point support:

The photo below shows a two point support of the basering where an internal beam (in this case a pipe) is being used. Note that the tail lug is a pad eye lug. An L-Shaped tail lug did not have to be used as the skirt was thick and the weld length for a pad eye lug was sufficient.

The next photo is just a close up of the first one. Note that this basering has type 2 chairs, ie, it has a top ring and a bottom basering. Also notice that the tail lug is located between the anchor bolt holes.

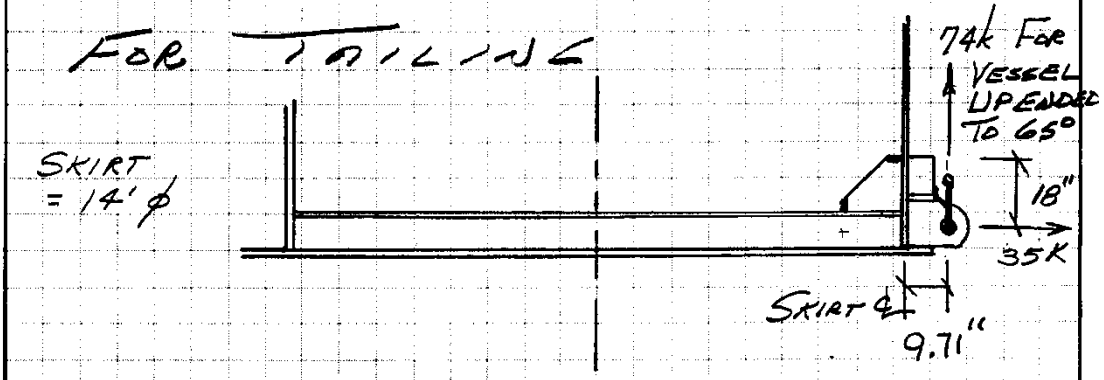
See the drawing below for an example of a base ring reinforced for a two point support where an L-Shaped tail lug was used. Note that the internal beam is welded to the base ring and the skirt and a 45° gusset plate is weld to them. The tail lug is shaped as shown for two reasons, 1) it extends up the skirt far enough to develop the weld capacity required for the upending forces because the skirt is only 10 mm thick, and 2) when the gusset plate is installed under it and is welded to the skirt and to the top of the internal beam, the bending from the upending forces are transferred thru the gusset plate to the internal beam without inducing any bending into the skirt or basering. The lug plate its self is designed by the program L- Shaped Tail Lug Plate.xls and the end area by the pad eye lug program at www.maximumreach.com .

If possible, the centerline of the lug pinhole should line up with the centerline of the internal beam.



A sample calculation below shows how to design the internal beam for either a two or a four point support. The forces used in the sample calculation sheet are shown on the following page and were calculated using the upending program.

SIZE THE W12 BEAM FOR TWO POINT SUPPORT FOR TAILING



MAX MOMENT = 9.71" * 74k * 1.8

= 1293.37 k-in

$F_T = F_b = .6 * 36 = 21.6$ KSI

$S_{REQ} = \frac{M}{f_b} = 59.88 in^3$

Try W12X53 $S = 70.6 in^3$ $A = 15.6 in^2$

$L_u = 22' > 14'$ OKAY

$f_b = \frac{1294}{70.6} = 18.33$ KSI

$f_b / F_b = .85$

$f_t = 35k * 1.8 / 15.6 in^2 = 4.04$ KSI

$f_t / F_T = .19$

COMBINED STRESS

$.19 + .85 = 1.04 \approx 1$ OK

FORM E50 (Rev. 8-91)

WELCOME TO MAXIMUM REACH ENTERPRISES
03-23-1996
17:52:16
THIS PROGRAM IS VESFORC1, VERSION 1.6 REVISION DATE 1 JAN 96

S IS A PROGRAM FOR CALCULATING THE TOP AND TAIL FORCES
THAT OCCUR DURING THE UP/DOWN ENDING OF A VESSEL WHERE THE TAIL
POINT IS ON OR ABOVE THE LONGITUDINAL CENTERLINE OF THE VESSEL

********** INPUT DATA **********
CONTRACT.NUMBER =04429400 CILACAP
EQUIPMENT.NUMBER =11 V 15 CRUDE DRUM
* TOTAL LENGTH IS FROM THE TOP LIFT POINT TO THE CL OF THE TAIL POINT
* LOWER LENGTH IS FROM THE VESSEL C. G. TO THE CL OF THE TAIL POINT
* OFFSET LENGTH IS FROM CENTER OF VESSEL TO CENTER OF THE TAIL POINT,
A POSITIVE VALUE
TOTAL.LOAD (KIPS) = 209.24
TOTAL.LENGTH (FT) = 79.07
LOWER.LENGTH (FT) = 41.9
OFFSET.LENGTH (FT) = 7.92

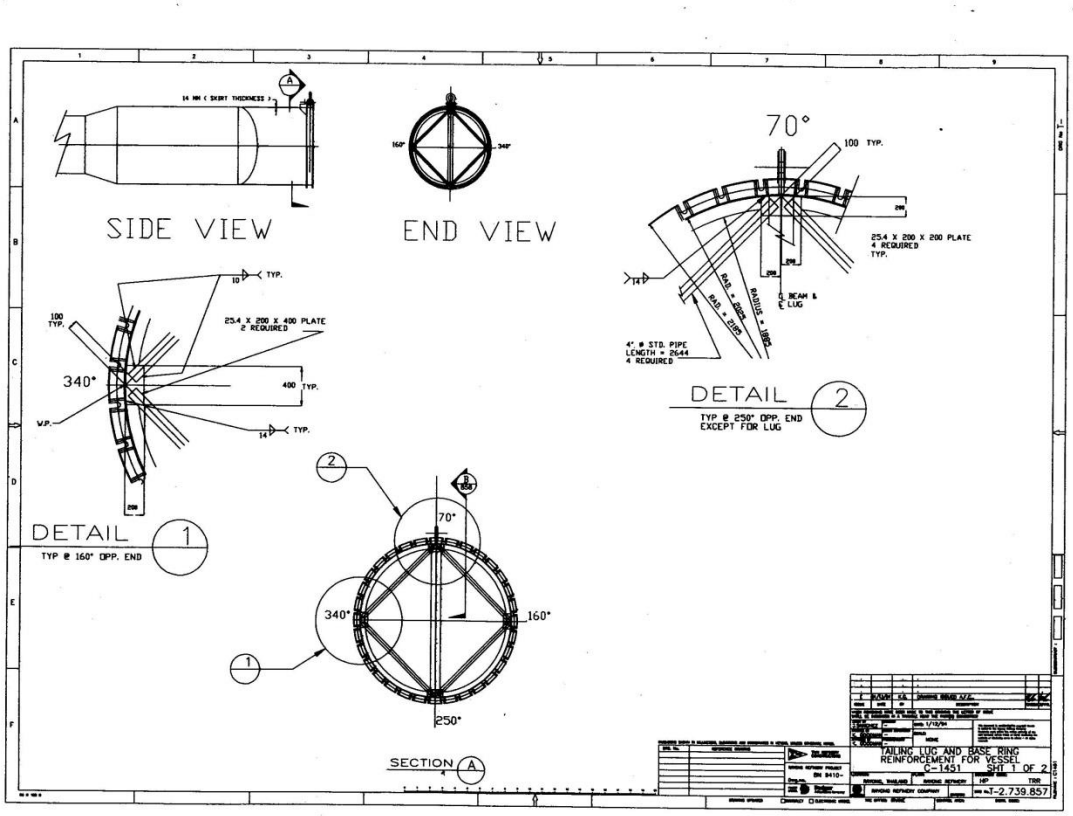
########## OUTPUT ##########

LIFT ANGLE	LIFT LOAD	LIFT LOAD TRANSVERSE	LIFT LOAD LONGITUDINAL	TAIL LOAD	TAIL LOAD TRANSVERSE	TAIL LOAD LONGITUDINAL	SPAN
(DEG)	(KIPS)	(KIPS)	(KIPS)	(KIPS)	(KIPS)	(KIPS)	(FT)
0.00	110.88	110.88	0.00	98.36	98.36	0.00	79.07
5.00	111.73	111.31	9.74	97.51	97.14	8.50	79.46
10.00	112.59	110.88	19.55	96.65	95.19	16.78	79.24
15.00	113.45	109.58	29.36	95.79	92.53	24.79	78.43
20.00	114.34	107.44	39.11	94.90	89.18	32.46	77.01
25.00	115.27	104.47	48.71	93.97	85.17	39.71	75.01
30.00	116.26	100.68	58.13	92.98	80.53	46.49	72.44
35.00	117.32	96.11	67.29	91.92	75.29	52.72	69.31
40.00	118.50	90.78	76.17	90.74	69.51	58.32	65.66
45.00	119.83	84.74	84.74	89.41	63.22	63.22	61.51
50.00	121.37	78.01	92.97	87.87	56.48	67.31	56.89
55.00	123.19	70.66	100.91	86.05	49.36	70.49	51.84
60.00	125.42	62.71	108.62	83.82	41.91	72.59	46.39
65.00	128.27	54.21	116.25	80.97	34.22	73.38	40.59
70.00	132.11	45.18	124.14	77.13	26.38	72.48	34.49
75.00	137.64	35.62	132.95	71.60	18.53	69.16	28.11
80.00	146.51	25.44	144.29	62.73	10.89	61.78	21.53
85.00	163.38	14.24	162.76	45.86	4.00	45.68	14.78
86.00	168.80	11.78	168.39	40.44	2.82	40.34	13.42
87.00	175.45	9.18	175.21	33.79	1.77	33.74	12.05
88.00	183.81	6.41	183.70	25.43	0.89	25.41	10.67
89.00	194.64	3.40	194.61	14.60	0.25	14.59	9.30
90.00	209.24	-0.00	209.24	0.00	0.00	0.00	7.92

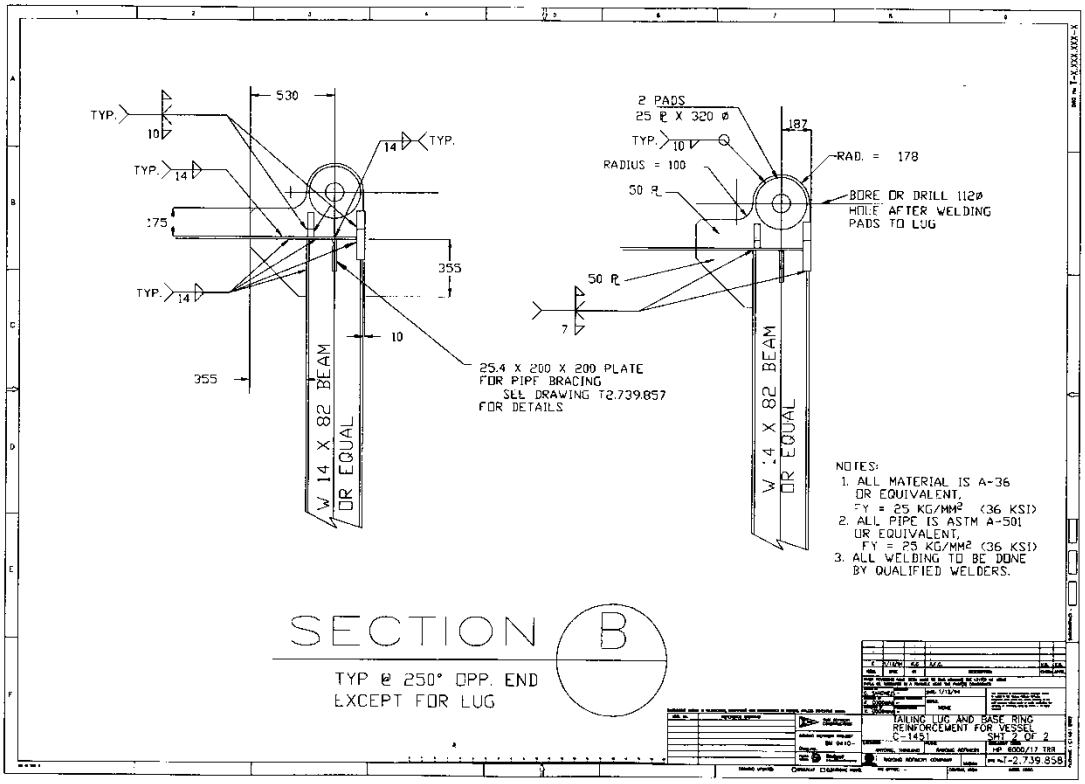
NOTES:
1. SPAN IS THE HORIZONTAL DISTANCE BETWEEN THE LIFT POINT AND THE TAIL POINT
2. NO IMPACT IS INCLUDED IN ABOVE VALUES

Four Point Support:

See the two drawings below for an example of a base ring reinforced for a four-point support system. Note that it is identical to a two-point support except the four pipe struts and six gusset plates have been added. Two of the gusset plates have been welded to the skirt at 160° and 340°, while four of the gusset plates have been welded to the skirt and both sides of the web of the internal beam at 70° and 250°(see the second photo). When designing the struts, it should be remembered that the two top struts are in tension and the bottom two are in compression. Note the notched out basering where the metal outside of the anchor bolt holes is gone. **Not Good.** In figuring the section properties, the OD of the basering would be to the bottom of the anchor bolt holes.



In the photo below, note the four gusset plates welded to the skirt and both sides of the web of the internal beam for connecting the pipe bracing. Typical for the top and bottom connections.



To use the two and four point support program:

1. Open the program.
2. Follow the input prompts

The program was originally set up so that the output could be used to design the basering reinforcement so that an external tail beam can be used to tail the vessel. The program output data can also be used to design the basering reinforcement so that an internal beam can be used to tail the vessel. The output information that must be used for designing an internal beam or that does not pertain to the internal beam will now be pointed out on the 5 input/output pages. The numbering used applies to these pages.

BASE RING AND SKIRT ANALYSIS C32

CONTRACT 456004 PAGE 1
CUSTOMER SASOL II - SECUNDA, S. AFR 06-21-1985
VESSEL IDENT. 36-VL-102 14:21:43
VES. DESCRIPTION

I N P U T D A T A

LOAD FACTORS
IMPACT 25 % default

SKIRT DATA
O.D. = 202.13 IN. THICKNESS = 0.590 IN.
WELD TO BR = 0.38 IN. YIELD = 38.000 KSI

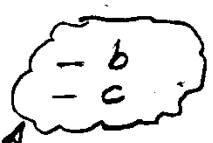
BASE RING DATA
O.D. = 210.79 IN. THICKNESS = 1.570 IN.
I.D. = 196.85 IN. YIELD = 38.000 KSI
BOLT CIRCLE= 206.06 IN. HOLE DIA. = 2.250 IN.

TYPE OF CHAIR 1

ANCHOR BOLT

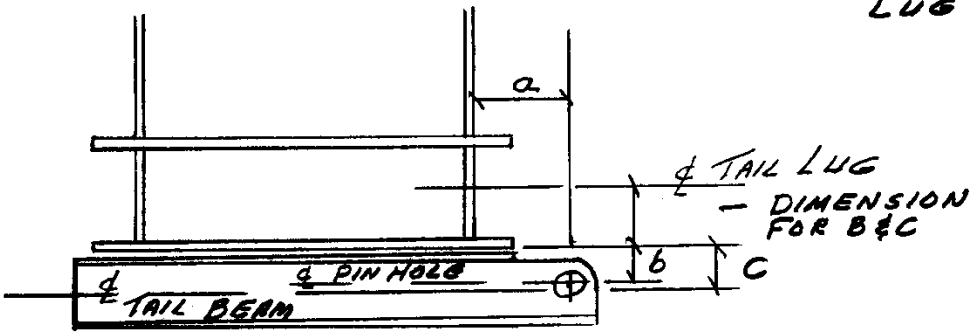
VESSEL DATA
VESSEL ERECTION WEIGHT 395.14 KIPS NO IMPACT
DIMENSION BOTTOM BASE RING TO C.G. 866.52 IN.
DIMENSION BOTTOM BASE RING TO I.P. 1620.6 IN.

TAILING BEAM DATA
TYPE SUPPORT — BEAM 2
DIM. OUTSIDE OF SKT. TO PIN HOLE a 25.33 IN.
DIMENSION TOP BM. TO PIN HOLE b 12 IN.
DIMENSION TOP BM. TO CENTER LINE c 12 IN.
DIM. INSIDE OF SKT. TO CNTR. BOLT GROUP 5.55 IN.



USE ACTUAL DIMENSION FOR TAIL LUG

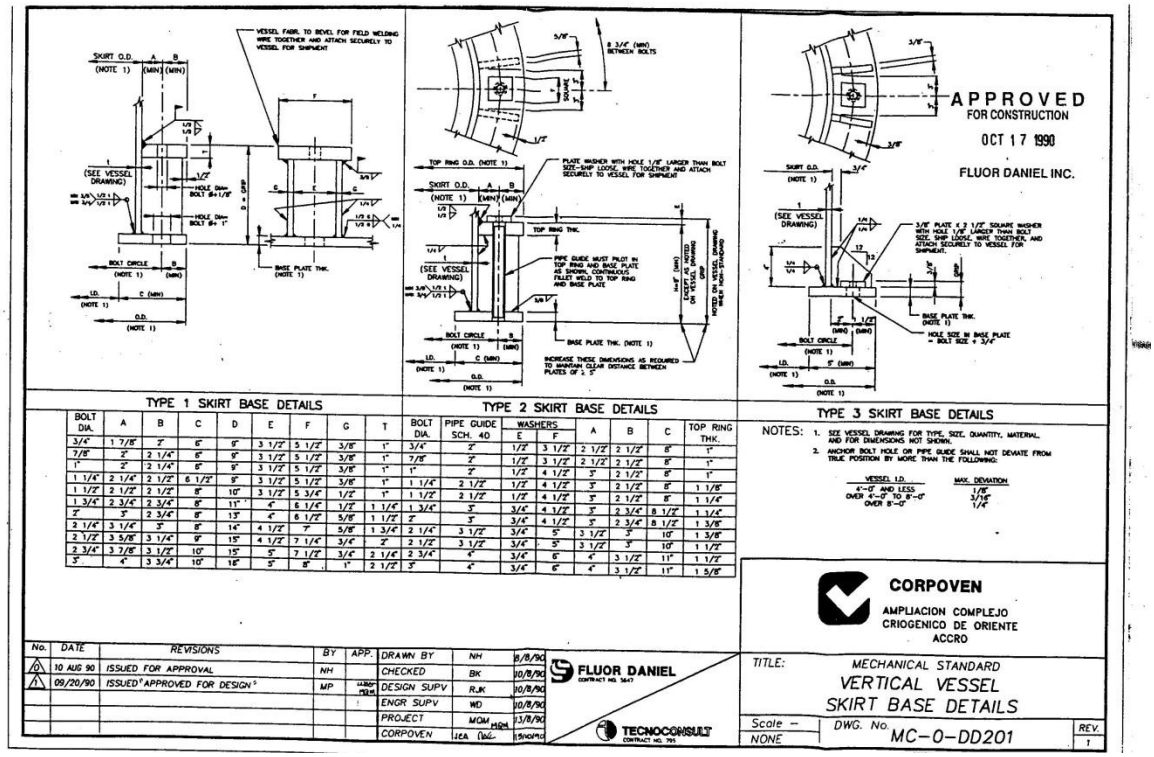
BOLT DATA
BOLT TYPE = A325
SIZE = 1.250 IN. DIAM. default
AREA = 1.227 SQ. IN. calculated
PRETENSION = 71.000 KIPS default



COMMENTS ON PAGE 1:

1. The weld from the skirt to base ring is not important for an internal beam as the skirt is not in direct compression. Therefore, the weld called out by the vessels group is okay.
2. The bolt circle information is not applicable (n/a).
3. The “b” & “c” dimensions referred to above are measured from the bottom of the basering down to the centerline of the pin hole and tail beam respectively. For an internal beam these dimensions are both the same and are measured from the bottom of the basering up to the center of the tailing lug and therefore are entered as negative distances.

4. See the drawing below that shows the various types of chairs, including the type 1 used in this example. It is listed below as “Type 1 Skirt Base Details”. Note that type 1 does not have a continuous top basering like the type 2 does.



TYPE 1 SKIRT BASE DETAILS

BOLT DIA.	A	B	C	D	E	F	G	T
3/4"	1 7/8"	2"	6"	9"	3 1/2"	5 1/2"	3/8"	1"
7/8"	2"	2 1/4"	6"	9"	3 1/2"	5 1/2"	3/8"	1"
1"	2"	2 1/4"	6"	9"	3 1/2"	5 1/2"	3/8"	1"
1 1/4"	2 1/4"	2 1/2"	6 1/2"	9"	3 1/2"	5 1/2"	3/8"	1"
1 1/2"	2 1/2"	2 1/2"	8"	10"	3 1/2"	5 3/4"	1/2"	1"
1 3/4"	2 3/4"	2 3/4"	8"	11"	4"	6 1/4"	1/2"	1 1/4"
2"	3"	2 3/4"	8"	13"	4"	6 1/2"	5/8"	1 1/4"
2 1/4"	3 1/4"	3"	8"	14"	4 1/2"	7"	5/8"	1 3/4"
2 1/2"	3 5/8"	3 1/4"	9"	15"	4 1/2"	7 1/4"	3/4"	2"
2 3/4"	3 7/8"	3 1/2"	10"	15"	5"	7 1/2"	3/4"	2 1/4"
3"	4"	3 3/4"	10"	18"	5"	8"	1"	2 1/2"

TYPE 2 SKIRT BASE DETAILS

BOLT DIA.	PIPE GUIDE SCH. 40	WASHERS E	WASHERS F	A	B	C	TOP RING THK.
3/4"	2"	1/2"	3 1/2"	2 1/2"	2 1/2"	8"	1"
7/8"	2"	1/2"	3 1/2"	2 1/2"	2 1/2"	8"	1"
1"	2"	1/2"	4 1/2"	3"	2 1/2"	8"	1"
1 1/4"	2 1/2"	1/2"	4 1/2"	3"	2 1/2"	8"	1 1/8"
1 1/2"	2 1/2"	1/2"	4 1/2"	3"	2 1/2"	8"	1 1/4"
1 3/4"	3"	3/4"	4 1/2"	3"	2 3/4"	8 1/2"	1 1/4"
2"	3"	3/4"	4 1/2"	3"	2 3/4"	8 1/2"	1 3/8"
2 1/4"	3 1/2"	3/4"	5"	3 1/2"	3"	10"	1 3/8"
2 1/2"	3 1/2"	3/4"	5"	3 1/2"	3"	10"	1 1/2"
2 3/4"	4"	3/4"	6"	4"	3 1/2"	11"	1 1/2"
3"	4"	3/4"	6"	4"	3 1/2"	11"	1 5/8"

TYPE 3 SKIRT BASE DETAILS

NOTES:
1. SEE VESSEL DRAWING FOR TYPE, SIZE, QUANTITY, MATERIAL, AND FOR DIMENSIONS NOT SHOWN.
2. ANCHOR BOLT HOLE OR PIPE GUIDE SHALL NOT DEVIATE FROM TRUE POSITION BY MORE THAN THE FOLLOWING:

VESSEL I.D.	MAX. DEVIATION
4'-0" AND LESS	1/8"
OVER 4'-0" TO 8'-0"	3/16"
OVER 8'-0"	1/4"

APPROVED FOR CONSTRUCTION
OCT 17 1990
FLUOR DANIEL INC.

CORPOVEN
AMPLIACION COMPLEJO CRIOGENICO DE ORIENTE ACCRO

No.	DATE	REVISIONS	BY	APP.
2	10 AUG 90	ISSUED FOR APPROVAL	NH	
1	09/20/90	ISSUED "APPROVED FOR DESIGN"	MP	

DRAWN BY	NH	8/8/90
CHECKED	BK	10/8/90
DESIGN SUPV	RJK	10/8/90
ENGR SUPV	WD	10/8/90
PROJECT	MQM	13/8/90
CORPOVEN		

FLUOR DANIEL CONTRACT NO. 3647
TECNOCONSULT CONTRACT NO. 795

TITLE: MECHANICAL STANDARD
VERTICAL VESSEL
SKIRT BASE DETAILS

Scale – NONE | DWG. No. MC-0-DD201 | REV. 1

BASE RING AND SKIRT ANALYSIS C 33

CONTRACT	456004	PAGE 2
CUSTOMER	SASOL II - SECUNDA, S. AFR	06-21-1985
VESSEL IDENT.	36-VL-102	14:21:44
VES. DESCRIPTION		

O U T P U T D A T A

TAIL LOAD = 228.14 KIPS INITIAL PICK LOAD = 265.79 KIPS

NUMBER OF CONNECTING BOLTS REQUIRED TOP = 6.20 BOTTOM = 6.44
SUGGESTED NUMBER OF CONNECTING BOLTS TOP AND BOTTOM = 8 EACH
ABOVE LOADS INCLUDE IMPACT

BASE RING PROPERTIES WITHOUT INSERTS

BASE RING MEAN RADIUS	= 101.180 IN.	AREA	= 10.949 IN.
BASE RING OD TO N.A.	= 4.215 IN.	BASE RING ID TO NA	= 2.755 IN.
EFFECTIVE SKIRT HEIGHT	= 5.997 IN.	MOMENT INERTIA	= 37.250 IN^4
SECTION MODULUS INSIDE	= 13.520 IN^3	OUTSIDE	= 8.838 IN^3

FOR TWO POINT SUPPORT

BASE RING STRESSES

COMBINED STRESS AT BOTTOM OF BASE RING ON INSIDE IS = 130.893 KSI
COMBINED STRESS AT BOTTOM OF BASE RING ON OUTSIDE IS = -212.817 KSI

MAX. COMBINED STRESS BETWEEN INSERT PLATES IS 84.28 KSI
AT ANGLE 55 DEGREES ON THE OUTSIDE OF THE BASE RING

*** BASE RING OVERSTRESSED BETWEEN INSERT PLATES ***
*** FOR TWO POINT SUPPORT. USE FOUR POINT SUPPORT ***

COMMENTS ON PAGE 2:

1. The tail load and IP load were calculated the same way as they would be if the upending program on my website had been used.
2. The reference to the number of connecting bolts is n/a.
3. Note the use of the term “insert plates” above. Insert plates are welded to the inside diameter of the basering, usually the same thickness, to increase the section modulus which reduces overstressing. Gusset plates, on the other hand, are used to connect the pipe struts to the skirt and to the internal beam.
4. Inserts are the plates welded to the inside diameter of the bottom basering to reduce the stress at 0 to 10°. If an external tail beam was being used, they would also be used to bolt it to the bottom of the basering.
5. Note the base ring stresses in this example are too great for a two-point support with insert plates. Therefore, a four-point support must be used.

BASE RING AND SKIRT ANALYSIS C34

CONTRACT 456004 PAGE 3
CUSTOMER SASOL II - SECUNDA, S. AFR 06-21-1985
VESSEL IDENT. 36-VL-102 14:21:47
VES. DESCRIPTION

BASE RING STRESSES FOR TWO POINT LOADING

VES. ANG. DEG.	TAN. FORCE KIPS	MOM. FT. KIPS	Ften KSI	INSIDE Fbi KSI	INSIDE Fci KSI	OUTSIDE Fbo KSI	OUTSIDE Fco KSI	OVER STRESS-ED
0	-54.46	153.07	-4.97	135.87	130.89	-207.84	-212.82	***
5	-58.95	112.91	-5.38	100.22	94.83	-153.30	-158.69	***
10	-62.44	76.52	-5.70	67.92	62.22	-103.90	-109.60	***
15	-64.91	44.14	-5.93	39.18	33.25	-59.93	-65.86	***
20	-66.35	15.92	-6.06	14.13	8.07	-21.61	-27.67	***
25	-66.77	-8.05	-6.10	-7.14	-13.24	10.93	4.83	
30	-66.18	-27.73	-6.04	-24.62	-30.66	37.66	31.61	***
35	-64.61	-43.17	-5.90	-38.32	-44.22	58.62	52.72	***
40	-62.09	-54.47	-5.67	-48.35	-54.02	73.96	68.29	***
45	-58.68	-61.78	-5.36	-54.84	-60.20	83.89	78.53	***
50	-54.43	-65.33	-4.97	-57.99	-62.96	88.71	83.74	***
55	-49.41	-65.39	-4.51	-58.04	-62.56	88.79	84.28	***
60	-43.70	-62.29	-3.99	-55.28	-59.28	84.57	80.58	***
65	-37.38	-56.38	-3.41	-50.04	-53.45	76.55	73.13	***
70	-30.54	-48.07	-2.79	-42.66	-45.45	65.26	62.48	***
75	-23.28	-37.80	-2.13	-33.55	-35.68	51.32	49.20	***
80	-15.70	-26.04	-1.43	-23.11	-24.55	35.36	33.92	***
85	-7.90	-13.27	-0.72	-11.78	-12.50	18.02	17.30	
90	0.00	-0.00	0.00	-0.00	-0.00	0.00	0.00	

COMMENTS ON PAGE 3:

1. Note that the 90° angles around the basering shown is for the first quadrant of the basering, ie, the Northeast quadrant looking at the end view of the vessel. The Northwest quadrant is a mirror image. Also the Southeast and Southwest quadrants are a mirror image of the two Northern quadrants, ie, the stress at 180° is the same as the stress at 0° and the stress at 90° is the same as the stress at 270°.
2. Note above that the basering is overstressed at almost every degree around it. Only 25°, 85° and 90° are not overstressed.

3. If the base ring was over stressed only in say the 0 to 5° range, the internal beam might be used without insert plates to reduce the stress. A layout would have to be made to see if the width of the flange would extend to the 5° on either side of the centerline of the beam on the base ring. If it didn't, then insert plates would have to be welded to the inside of the basering. The computer would generate the dimensions of the insert plates required, ie, say at 10° radials on either side of the centerline of the basering, protruding a certain distance from the inside edge of the skirt at 0° and also the thickness. See page 4 of the printout that shows the dimensions of the insert plates for this example.

BASE RING AND SKIRT ANALYSIS C35

CONTRACT	456004	PAGE 4
CUSTOMER	SASOL II - SECUNDA, S. AFR	06-21-1985
VESSEL IDENT.	36-VL-102	14:21:49
VES. DESCRIPTION		

FOR FOUR POINT SUPPORT

INTERNAL STRUTS FOR FOUR POINT SUPPORT

LENGTH OF STRUT INSIDE SKIRT TO INSIDE OF SKIRT 142.510 IN.
STRUT FORCE 62.41 KIPS

BASE RING STRESSES

COMBINED STRESS AT BOTTOM OF BASE RING ON INSIDE IS = 13.427 KSI
COMBINED STRESS AT BOTTOM OF BASE RING ON OUTSIDE IS = -26.631 KSI

MAX. COMBINED STRESS BETWEEN INSERT PLATES IS 21.70 KSI
AT ANGLE 2 DEGREES ON THE OUTSIDE OF THE BASE RING

INSERT PLATE DATA

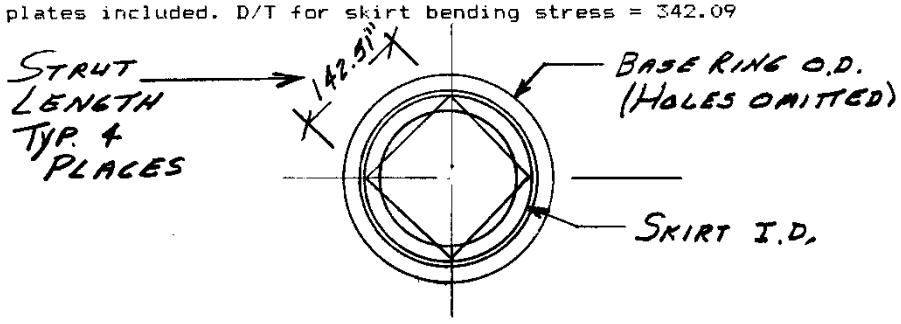
INSERTS ARE REQUIRED EITHER SIDE OF CENTER LINE FOR 2.00 DEGREES
DIMENSIONS ARE MEASURED RADIALLY
LOCATION AT 0 DEGREES (BOTTOM)
MINIMUM THICHNESS IS 0.50 INCHES
MIN. DISTANCE FROM INSIDE OF SKIRT 8.00 INCHES

*** MINIMUM WIDTH OF INSERT PLATE IS 3.44 ***
INCHES EITHER SIDE OF BEAM CENTERLINE.
THEREFORE A SECOND DIMENSION ISN'T GIVEN

SKIRT STRESS DATA

VESSEL ANGLE FOR MAX. SKIRT COMPRESSION	65.648 DEG.
MAXIMUM SKIRT COMPRESSION FORCE	205.648 KIPS
AXIAL TAIL LOAD FORCE	177.482 KIPS
MIN. SKIRT SUPPORT FOR WELD STRESS	24.623 IN.
CRIPPLING STRESS.	89.603 KSI
ALLOWABLE CRIPPLING STRESS	28.500 KSI
MIN. SKIRT SUPPORT FOR CRIPPLING STRESS	8.340 IN.
COMPRESSION STRESS	32.228 KSI
ALLOWABLE COMPRESSION STRESS	12.551 KSI
MIN. SKIRT SUPPORT FOR COMPRESSION	16.957 IN.

Above calculations based on input data. No skirt support
plates included. D/T for skirt bending stress = 342.09



COMMENTS ON PAGE 4:

1. The Skirt Stress Data section does not apply to an internal beam.
2. Also note that the strut lengths are measured from inside of the skirt on the quarter points. The actual length of the struts will be shorter than this, ie, room is required to physical weld or bolt them to the insert plates in the case of an external tail beam, or to the gusset plates in the case of an internal beam.
3. For an external tail beam, the struts are generally made out of back to back angles or small wide flange beams welded to the top side of the insert plates. For internal beams, the struts are generally made out of pipe or square tubing that is split on the ends to fit over the gusset plates. The length of the split is determined by the required weld length needed to weld them to the gusset plates

BASE RING AND SKIRT ANALYSIS C36

CONTRACT 456004 PAGE 5
CUSTOMER SASOL II - SECUNDA, S. AFR 06-21-1985
VESSEL IDENT. 36-VL-102 14:21:53
VES. DESCRIPTION

BASE RING STRESSES FOR FOUR POINT LOADING

VES. ANG. DEG.	TAN. FORCE KIPS	MOM. FT. KIPS	Ften KSI	INSIDE Fbi KSI	INSIDE Fci KSI	OUTSIDE Fbo KSI	OUTSIDE Fco KSI	OVER STRESS-ED
0	-26.36	17.84	-2.41	15.83	13.43	-24.22	-26.63	***
5	-27.11	9.21	-2.48	8.17	5.70	-12.50	-14.98	
10	-27.10	2.31	-2.48	2.05	-0.42	-3.14	-5.61	
15	-26.34	-2.85	-2.41	-2.53	-4.93	3.87	1.46	
20	-24.85	-6.32	-2.27	-5.61	-7.88	8.58	6.31	
25	-22.65	-8.20	-2.07	-7.28	-9.35	11.14	9.07	
30	-19.78	-8.63	-1.81	-7.66	-9.47	11.72	9.91	
35	-16.27	-7.79	-1.49	-6.92	-8.40	10.58	9.10	
40	-12.19	-5.91	-1.11	-5.25	-6.36	8.03	6.92	
45	-7.60	-3.26	-0.69	-2.89	-3.58	4.42	3.73	
50	-2.55	-0.11	-0.23	-0.10	-0.33	0.15	-0.08	
55	2.86	3.19	0.26	2.84	3.10	-4.34	-4.08	
60	8.58	6.32	0.78	5.61	6.39	-8.58	-7.79	
65	14.50	8.88	1.32	7.89	9.21	-12.06	-10.74	
70	20.55	10.52	1.88	9.34	11.22	-14.29	-12.41	
75	26.63	10.84	2.43	9.62	12.05	-14.72	-12.29	
80	32.65	9.45	2.98	8.39	11.37	-12.83	-9.85	
85	38.52	5.96	3.52	5.29	8.81	-8.09	-4.57	
90	44.14	-0.00	4.03	-0.00	4.03	0.00	4.03	

START TIME
FINISH TIME 14:21:55
EXECUTION TIME 15 SECONDS

COMMENTS ON PAGE 5:

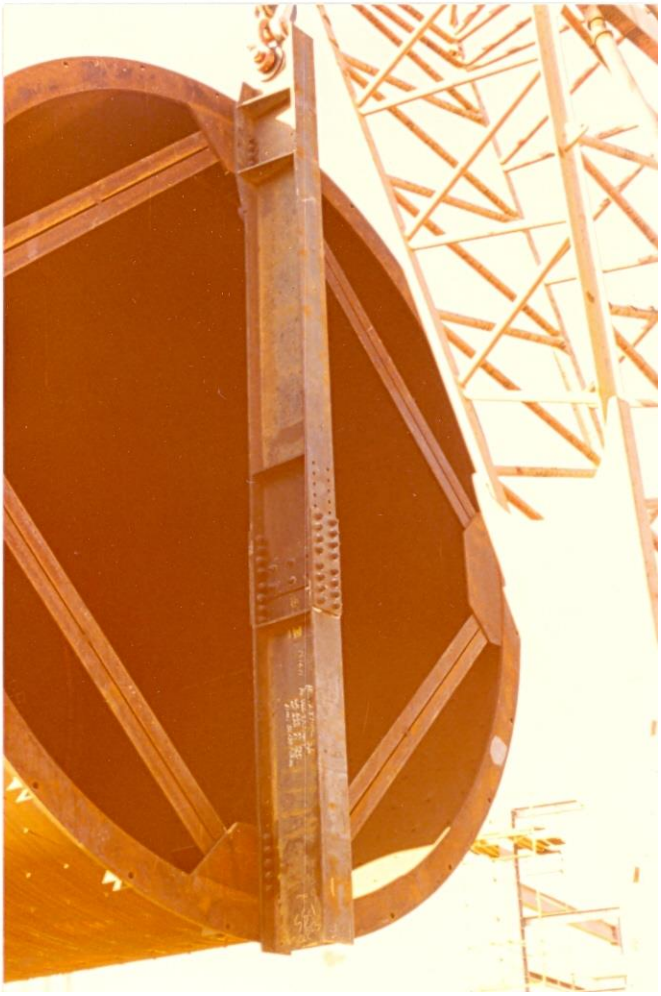
1. Note that the base ring is still slightly over stressed in a four point support at 0°. If an external tail beam is being used, the insert plates for bolting on the beam will be large enough to take care of this overstressing. If an internal beam is being used, the width of the flange welded to the basering would take care of this overstressing. A layout should be made to make sure of the above.

In the photo below, note the insert plates welded to the inside of the bottom basering in four places, with the back to back angle struts welded to their top side and the tail beam bolted to the bottom side. The size of the insert plates was increased over the dimensions required by the program, in order to allow room to weld the angle struts in place.

This is a typical example of a four point support with an external tail beam.

Notice that the tail beam has a splice joint so that its length could be adjusted to bolt on to several other vertical vessels that needed to be set on this project.

This is the first tail beam and internal basering reinforcement that I designed. When I saw the tail beam resting on the ground ready to be installed on the basering of the vessel, I marveled at how much bigger it looked in the flesh than it had on my drawing board.



The next photo shows a two crane lift using two American 11320 Guy Derricks, each 600 ton capacity, and tailing with a Manitowoc 4100, 230 ton capacity. And of course, utilizing my tail beam.

The reason that this vertical vessel is shown unpainted is that it was insulated once it was set. The field was supposed to insulate it on the ground in the horizontal, but someone decided that it needed to be set as soon as it arrived on site. After scaffolding and installing the insulation and cladding in the air, the cost and scheduling department determined that it would have been much cheaper to have taken the time to do it in the horizontal on the ground.

The photo below shows a 92 m vertical vessel with a four point support utilizing an internal beam and struts made out of small wide flange beams. A pad eye lug is being used as a tail lug because the skirt was 50 mm thick. The weld size required to weld the tail lug to the skirt and basering was just under 50 mm. So additional weld length was not needed.

Note that the designer of the basering did not notch out the metal on the outside of the anchor bolt holes so the full OD of the basering was used in calculating the section properties.

The red support beams under the saddles were used to stage the vessel at the foundation. Stanchions, 1.75 m high, were set up in four places on load spreaders. The trailers were pulled between them and the platforms lowered down until the support beams rested on the stanchions. The vessel was then dressed out completely with electrical, platforms, ladders, piping, etc., before it was upended and set. All the field had to do then was plug it in.

Appendix D: HELP FILE FOR L SHAPED TAIL LUG PLATE DESIGN

Tail lugs are normally used to tail a vertical vessel. They are welded to the skirt and basering. The lug plate is usually a single plate with or without pads at the lug hole.

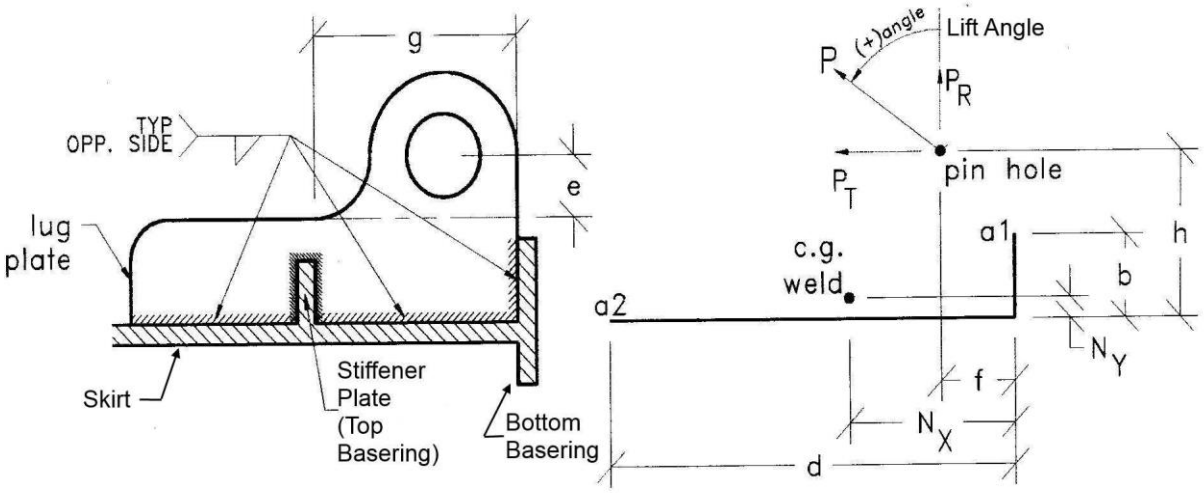
If the tail lug will be shaped like a traditional pad eye lug, ie, the width of the lug plate is two times the lug radius, the pad eye lug design program at www.maximumreach.com can be used to determine the dimensions and the weld requirements for connecting the tail lug to the skirt.

If the weld required is thicker than the skirt, then an L shaped tail lug must be used. The L Shaped Tail Lug Plate.xls program must be used to design it. The end area of the lug would still be designed by the pad eye program on the above website. See the drawing at the end of this help file for an example of an L shaped tail lug.

This program designs the L shaped tail lug plate and the weld for combined stress.

This program **does not check** the bending stresses in the skirt or the base ring.

When used with an impact factor of 1.8 , this design conforms to AISC and ASME B30.20.



HOW TO USE THE PROGRAM:

INPUT:

1. Design the end area of the lug using one of the above lug design programs.

2. Enter the force P.

   If the force on the lug is fixed at one angle, then the lug should be designed for the vertical and horizontal components of that force.

   If the force on the lug changes angles and moves through say 90 degrees, then the designer should make trial runs at 10 degree increments to see which angle creates the worst case of combined stress for both the lug plate and the weld.

   For a vertical vessel, the worst case for the tail lug design is usually at 0 degrees for tension and at about 65 degrees for combined stress, depending on the location of the CG and the offset of the tail lug. By running the upending program at www.maximumreach.com. , the exact angle where the maximum longitudinal force occurs can be found. Use the corresponding tail lug force at this angle for the P force.

3. Enter a "b" distance equal to the extension of the basering beyond the skirt.

4. As a first estimate, enter a "d" distance equal to 2*upper radius of the lug. If the calculated weld size is larger than the thickness of the skirt or shell, then increase "d" until the weld size is equal to or less than the skirt thickness. The shape of the tail lug could look like a pad eye lug but normally looks like the sketch shown on the tail lug plate program. This program takes into account the location of the CG of the weld to the load P, not matter what the shape of the lug plate.

   The weld between the tail lug plate and the top ring is not taken into account in the program, even though the weld is there. This makes the calculated weld size conservative.

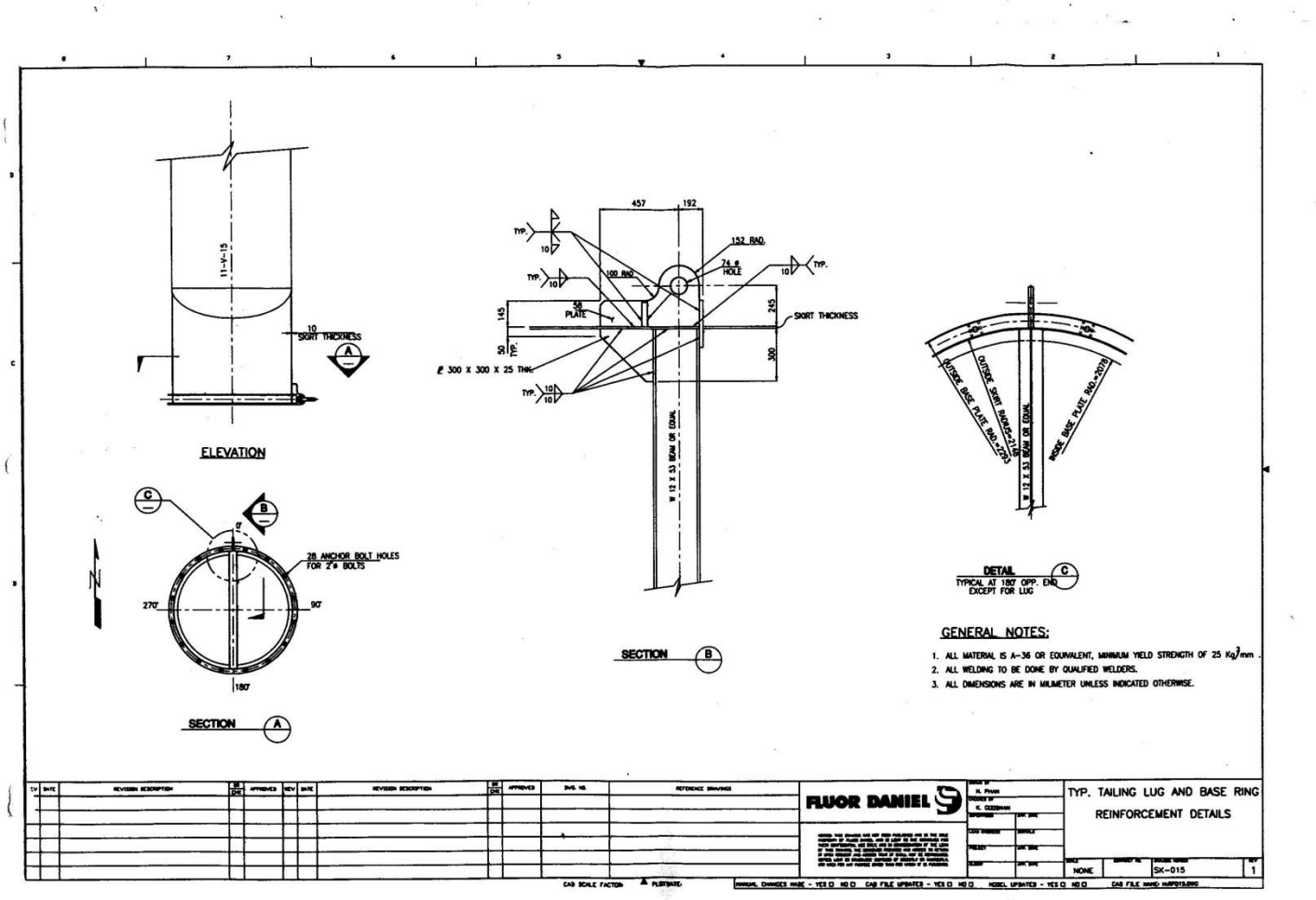
5. The eccentricity "e" should be as short as possible. A layout is usually required to show that the shackle boss or the pads will not interfere with the top ring or the base ring, and that the sling will not bear on the top of the lug when the vessel is vertical. "e" should be taken thru the narrowest part of the lug plate as shown.
6. "f", "g" and "h" will come from the layout of the tail lug.

OUTPUT:

1. Check the combined stress in the lug plate. It should be equal to or less than 1.0. Increasing the thickness of the lug, or the length "g" can lower it if it is greater than 1.0.
2. Check the min. weld size required. If it is greater than the skirt thickness, increase "d". See note 3 above in the INPUT section.

   When the minimum weld size is calculated, the designer should use the next higher 1/8th of an inch as the recommended weld size that will be shown on the drawing.

   As the top ring and the base plate are usually thicker than the skirt thickness, a larger weld size can be used between them and the tail lug plate, ie, for a skirt thickness of .5", a top ring thickness of 1", a base plate thickness of 1" and a lug plate of 1.5", the following welds can be used. A maximum weld size of .5" between the skirt and tail lug plate and a 1" weld size between the top ring/base plate and the tail lug plate. Calling out the 1" weld size between the tail lug plate and the top ring/base plate will provide a nice increase in the safety factor of the weld.



END OF THE HELP FILE