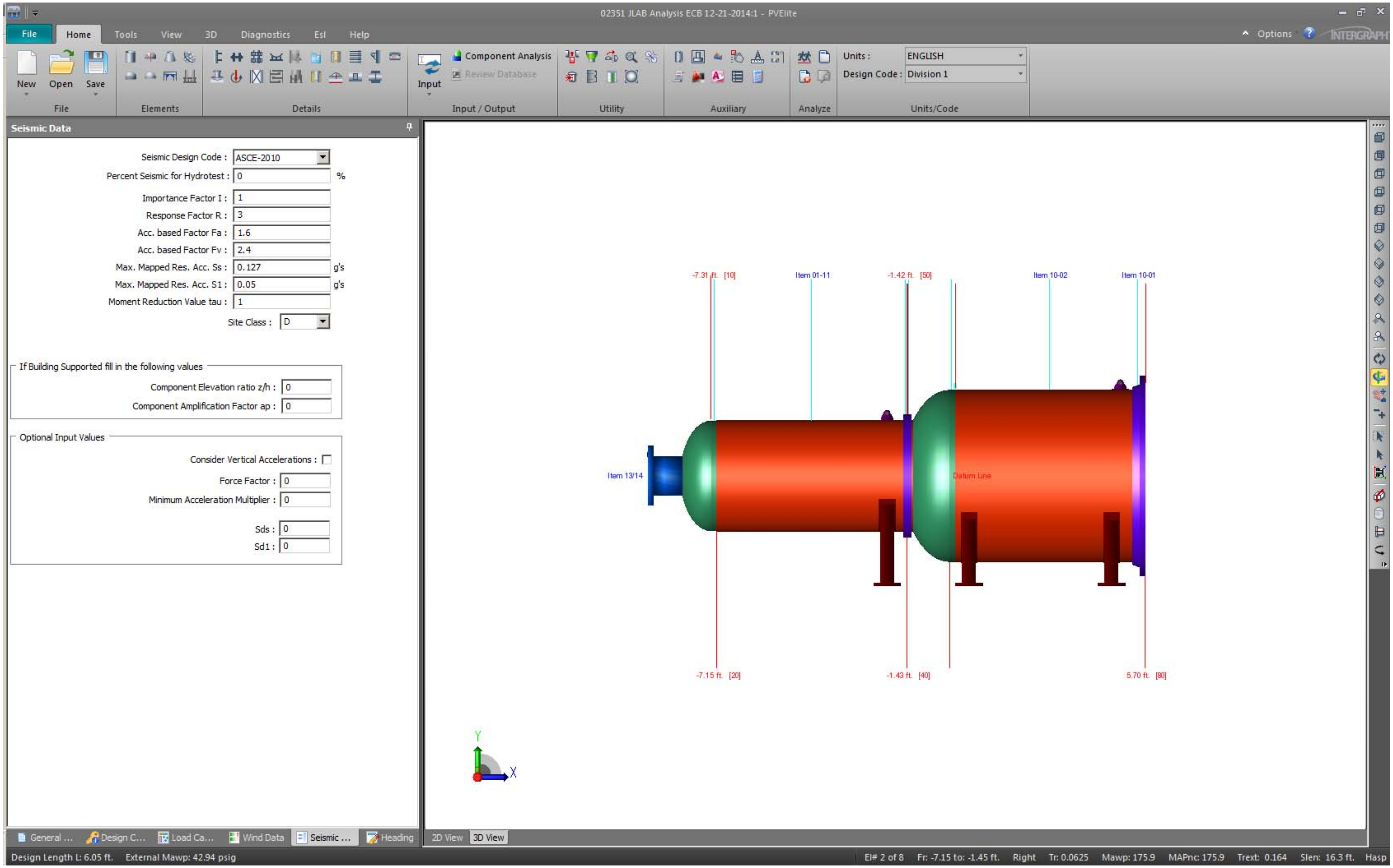
Jefferson Science Associates, LLC PO # 15-P0128

Meyer Tool & Mfg., Inc . Project 02351 Proton Radius Vacuum Chambers

Additional Calculations 01-28-2015

1. Seismic Analysis
   a. PV Elite Pressure Vessel Design software was used to analyze the two Chambers assembled together under the following inputs provided by Jefferson Lab.
      i. Short Period Spectral Response Acceleration, Ss = 0.127
      ii. 1 Second Period Spectral Response Acceleration, S1 = 0.05
      iii. Soil Site Class D.
   b. The Chambers were modeled as assembled together as shown in the screen shot. Per discussion the Chambers were mounted on only three of the four leg sets In the model the Chamber #1 legs were lengthened so all three leg sets were on the same plane.
   c. The Analysis was performed per ASCE-7-2010.
   d. Results, shown in page 3 and 4 of this report, show minimal loads.
2. Nozzle Load Analysis
   a. PV Elite Pressure Vessel Design Software was used to analyze the two nozzles on Chamber #1.
   b. The Nozzle in the head per Jefferson Lab 150# vertical down shear load. From the Jefferson Lab provided screen shot it was obvious that this load was located some distance from the nozzle flange face. We conservatively considered it to be 18" from the face and added an additional 225 Ft-lb moment to the inputs of the analysis. The WRC-107 analysis results are attached. The stresses are minimal and well below allowables
   c. The Nozzle in the shell per Jefferson Lab 50# vertical down shear load From the Jefferson Lab provided screen shot it was obvious that this load was located some distance from the nozzle flange face. We conservatively considered it to be 18" from the face and added an additional 75 Ft-lb moment to the inputs of the analysis. The WRC-107 analysis results are attached The stresses are minimal and well below allowables.
3. Lifting Lug Analysis
   a. While PVElite has a lug analysis module the geometry of this design did not lend itself to its use. Instead we performed hand calculations based on standard principles and the method proposed by Ranendra.
   b. As a worst case, we assumed that the four lugs would be rigged with straps to a central lift point instead of the use of a spreader bar to achieve a straight lift. The sketches accompanying the calculations define the rigging assumptions.
   c. The Lug calculations indicate stresses that in no case exceed a 2.7 x safety factor on yield and a 5 x safety factor on tensile strength. We believe this to be an acceptable result.


02351 JLAB Analysis ECB 12-21-2014:1 - PVElite
File
Home
Tools
View
3D
Diagnostics
Esl
Help
Options
New
Open
Save
File
Elements
Details
Input
Component Analysis
Review Database
Input / Output
Utility
Auxiliary
Analyze
Units : ENGLISH
Design Code : Division 1
Units/Code
Seismic Data
Seismic Design Code : ASCE-2010
Percent Seismic for Hydrotest : 0 %
Importance Factor I : 1
Response Factor R : 3
Acc. based Factor Fa : 1.6
Acc. based Factor Fv : 2.4
Max. Mapped Res. Acc. Ss : 0.127 g's
Max. Mapped Res. Acc. S1 : 0.05 g's
Moment Reduction Value tau : 1
Site Class : D
If Building Supported fill in the following values
Component Elevation ratio z/h : 0
Component Amplification Factor ap : 0
Optional Input Values
Consider Vertical Accelerations :
Force Factor : 0
Minimum Acceleration Multiplier : 0
Sds : 0
Sd1 : 0
-7.31 ft. [10]
Item 01-11
-1.42 ft. [50]
Item 10-02
Item 10-01
Item 13/14
Datum Line
-7.15 ft. [20]
-1.43 ft. [40]
5.70 ft. [80]
Y
X
General ...
Design C...
Load Ca...
Wind Data
Seismic ...
Heading
2D View
3D View
Design Length L: 6.05 ft. External Mawp: 42.94 psig
El# 2 of 8 Fr: -7.15 to: -1.45 ft. Right Tr: 0.0625 Mawp: 175.9 MAPnc: 175.9 Trext: 0.164 Slen: 16.3 ft. Hasp

Input Values:

Earthquake Analysis per ASCE 7-2010

Short-period site coefficient 11.4-1	Fa: 1.600
Long -period site coefficient 11.4-2	Fv: 2.400
Maximum Mapped Acceleration Value for Short Periods	Ss: 0.127 ✓
Maximum Mapped Acceleration Value for 1 Sec. Period	S1: 0.050 ✓
Response Modification Factor	R: 3.000
Importance Factor	Ie: 1.000
Site Class	D ✓ JLAB RESULTS

Seismic Analysis Results:

```
Sms = Fa * Ss = 1.600 * 0.127 = 0.203
Sm1 = Fv * S1 = 2.400 * 0.050 = 0.120
Sds = 2/3 * Sms = 2/3 * 0.203 = 0.135
Sd1 = 2/3 * Sm1 = 2/3 * 0.120 = 0.080
```

Check Approximate Fundamental Period from 12.8-7 [Ta]:

```
= Ct * hn^(x) where Ct = 0.020, x = 0.75 and hn = Structural Height (ft.)
= 0.020 * ( 5.1353^(0.75))
= 0.068 seconds
```

The Coefficient Cu from Table 12.8-1 is : 1.700

Fundamental Period (1/Frequency) [T]:

```
= ( 1/Natural Frequency ) = ( 1/33.000 )
= 0.030
```

Check the Value of T which is the smaller of Cu*Ta and T:

```
= Minimum Value of (1.700 * 0.068 , 0.030 ) per 12.8.2
= 0.030
```

As the time period is < 0.06 second, use section 15.4.2.

Compute the Base Shear per equation 15.4-5, [V]:

```
= 0.3 * Sds * W * I
= 0.3 * 0.135 * 3774 * 1.00
= 153.389 lb. ✓
```

Note: Loads multiplied by the Scalar multiplier value of 0.7000

Final Base Shear, V = 107.37 lb. ✓

Earthquake Load Calculation

From	To	Earthquake Height ft.	Earthquake Weight lb.	Element Ope Load lb.
10	20	1.64583	343.121	8.18759
20	30	1.64583	343.121	8.18759
20	30	1.64583	343.121	8.18759
30	40	0.53667	343.121	2.66978
40	50	1.64583	343.121	8.18759
50	60	1.64583	343.121	8.18759
60	70	2.56767	343.121	12.7735

④

70	0	2.56250	343.121	12.7478
70	80	2.56250	343.121	12.7478
70	80	2.56250	343.121	12.7478
80	90	2.56250	343.121	12.7478

okay

(5)

NOTE IN ADDITION TO 150# SHEAR LOAD REQ'D BY JSA EMAIL ASSUMED $150 \times \frac{18''}{12} =$ 225 FT-lb MOMENT ON NOZZLE AS 150# IS NOT LOCATED AT NOZZLE BUT FURTHER OK.

INPUT VALUES, Nozzle Description: Item 13/14 From : 10

Pressure for Reinforcement Calculations	P	15.000	psig
Temperature for Internal Pressure	Temp	100	°F
Design External Pressure	Pext	15.00	psig
Temperature for External Pressure	Tempex	100	°F
Shell Material		SA-516 70	
Shell Allowable Stress at Temperature	S	20000.00	psi
Shell Allowable Stress At Ambient	Sa	20000.00	psi
Inside Crown Radius of Torispherical Head	L	39.7760	in.
Inside Knuckle Radius of Torispherical Head	r	2.3866	in.
Head Finished (Minimum) Thickness	t	0.1880	in.
Head Internal Corrosion Allowance	c	0.0000	in.
Head External Corrosion Allowance	co	0.0000	in.
Distance from Head Centerline	L1	0.0000	in.
User Entered Minimum Design Metal Temperature		-20.00	°F

Type of Element Connected to the Shell : Nozzle

Material		SA-312	
Material UNS Number		S30600	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	22300.00	psi
Allowable Stress At Ambient	Sna	22300.00	psi
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		14.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	10S	
Flange Material		SA-240 304L	
Flange Type		Slip on	
Corrosion Allowance	can	0.0000	in.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	6.0000	in.
Weld leg size between Nozzle and Pad/Shell	Wo	0.1900	in.
Groove weld depth between Nozzle and Vessel	Wgnv	0.0000	in.
Inside Projection	h	0.1900	in.
Weld leg size, Inside Element to Shell	Wi	0.1900	in.
ASME Code Weld Type per UW-16		None	
Class of attached Flange		75	
Grade of attached Flange		GR 2.3	

The Pressure Design option was Design Pressure + static head

Nozzle Sketch (may not represent actual weld type/configuration)

| |

```
                   |  |
                   |  |
                   |  |
  ________________/|  |
 |             \   |  |
 |              \  |  |
 |_______________\|  |
                  \|  |
                   |__|
```

Insert/Set-in Nozzle No Pad, with Inside projection

Reinforcement CALCULATION, Description: Item 13/14

ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

Actual Outside Diameter Used in Calculation	14.000	in.
Actual Thickness Used in Calculation	0.188	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Torispherical Head, Tr [Int. Press]
= (P*L*M)/(2*S*E-0.2*P) Appendix 1-4 (d)
= (15.00*39.7760*1.00)/(2*20000*1.00-0.2*15.00)
= 0.0149 in.

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
= (P*Ro)/(S*E+0.4*P) per Appendix 1-1 (a)(1)
= (15.00*7.0000)/(22300*1.00+0.4*15.00)
= 0.0047 in.

Required Nozzle thickness under External Pressure per UG-28 : 0.0320 in.

UG-40, Limits of Reinforcement : [Internal Pressure]

Parallel to Vessel Wall (Diameter Limit)	Dl	27.2480	in.
Parallel to Vessel Wall, opening length	d	13.6240	in.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	0.4700	in.
Normal to Vessel Wall, Inward		0.1900	in.

Weld Strength Reduction Factor [fr1]:
= min(1, Sn/S)
= min(1, 22300.0/20000.0)
= 1.000

Weld Strength Reduction Factor [fr2]:
= min(1, Sn/S)
= min(1, 22300.0/20000.0)
= 1.000

Weld Strength Reduction Factor [fr3]:
= min(fr2, fr4)
= min(1.0 , 1.0)
= 1.000

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	0.203	0.783	NA	sq.in.
Area in Shell	A1	2.358	0.995	NA	sq.in.
Area in Nozzle Wall	A2	0.172	0.147	NA	sq.in.

7

Area in Inward Nozzle	A3	0.071	0.071	NA	sq.in.
Area in Welds	A41+A42+A43	0.072	0.072	NA	sq.in.
Area in Element	A5	0.000	0.000	NA	sq.in.
TOTAL AREA AVAILABLE	Atot	2.674	1.285	NA	sq.in.

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:

```
 = 0.5( d * tr*F + 2 * tn * tr*F * (1-fr1) ) per UG-37(d) or UG-39
 = 0.5(13.6240*0.1150*1+2*0.1880*0.1150*1*(1-1.00))
 = 0.783 sq.in.
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

```
 = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
 = 13.624 ( 1.00 * 0.1880 - 1.0 * 0.115 ) - 2 * 0.188
   ( 1.00 * 0.1880 - 1.0 * 0.1150 ) * ( 1 - 1.000 )
 = 0.995 sq.in.
```

Area Available in Nozzle Projecting Outward [A2]:

```
 = ( 2 * tlnp ) * ( tn - trn ) * fr2
 = ( 2 * 0.470 ) * ( 0.1880 - 0.0320 ) * 1.0000
 = 0.147 sq.in.
```

Area Available in Inward Nozzle [A3]:

```
 = 2 * ti * min( h, Tl, 2.5 * ti) * fr2
 = 2 * 0.1880 * ( 0.1900 ) * 1.0000
 = 0.071 sq.in.
```

Area Available in Inward Weld + Outward Weld [A41 + A43]:

```
 = Wo² * fr2 + ( Wi-can/0.707 )² * fr2
 = 0.1900² * 1.0000 + ( 0.1900 )² * 1.0000
 = 0.072 sq.in.
```

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

```
Wall Thickness for Internal/External pressures        ta = 0.0320 in.
Wall Thickness per UG16(b),                        tr16b = 0.0625 in.
Wall Thickness, shell/head, internal pressure       trb1 = 0.0264 in.
Wall Thickness                 tb1 = max(trb1, tr16b) = 0.0625 in.
Wall Thickness, shell/head, external pressure       trb2 = 0.0264 in.
Wall Thickness                 tb2 = max(trb2, tr16b) = 0.0625 in.
Wall Thickness per table UG-45                       tb3 = 0.3280 in.
```

Determine Nozzle Thickness candidate [tb]:

```
 = min[ tb3, max( tb1,tb2) ]
 = min[ 0.328 , max( 0.0625 , 0.0625 ) ]
 = 0.0625 in.
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
 = max( ta, tb )
 = max( 0.0320 , 0.0625 )
 = 0.0625 in.
```

Available Nozzle Neck Thickness = 0.875 * 0.188 = 0.164 in --> OK

(8)

Stresses on Nozzle due to External and Pressure Loads per the ASME B31.3 Piping Code (see 319.4.4 and 302.3.5):

```
Sustained  :   365.2,  Allowable :  22300.0 psi  Passed
Expansion  :     0.0,  Allowable :  55384.8 psi  Passed
Occasional :   268.1,  Allowable :  29659.0 psi  Passed
Shear      :    37.3,  Allowable :  15610.0 psi  Passed
```

Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle to Flange Weld skipped as Nozzle is not a Carbon Steel material.

Nozzle-Shell Weld for Nozzle skipped as Nozzle is not a Carbon Steel material.

Weld Size Calculations, Description: Item 13/14

```
Intermediate Calc. for nozzle/shell Welds   Tmin       0.1880  in.
Intermediate Calc. for Inward Weld        TminIns      0.1880  in.
```

Results Per UW-16.1:

```
                         Required Thickness    Actual Thickness
Nozzle Weld             0.1316 = 0.7 * tmin.  0.1343 = 0.7 * Wo in.
Inward Weld             0.1316 = 0.7 * TMinIn 0.1343 = 0.7 * Wi-Can in.
```

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

```
 = (A-A1+2*tn*fr1*(E1*t-tr))*Sv
 = (0.7832 - 0.9950 + 2 * 0.1880 * 1.0000 *
   (1.00 * 0.1880 - 0.1150 ) ) * 20000
 = 0.00 lb.
```

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

```
 = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
 = ( 0.1466 + 0.0000 + 0.0722 - 0.0361 * 1.00 ) * 20000
 = 3654.95 lb.
```

Weld Load [W2]:

```
 = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
 = ( 0.1466 + 0.0714 + 0.0722 + ( 0.0707 ) ) * 20000
 = 7219.51 lb.
```

Weld Load [W3]:

```
 = (A2+A3+A4+A5+(2*tn*t*fr1))*S
 = ( 0.1466 + 0.0714 + 0.0722 + 0.0000 + ( 0.0707 ) ) * 20000
 = 7219.51 lb.
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
 = (pi/2) * Dlo * Wo * 0.49 * Snw
 = ( 3.1416/2.0 ) * 14.0000 * 0.1900 * 0.49 * 20000
 = 40948. lb.
```

9

Shear, Inward Nozzle Weld [Sinw]:

```
 = (pi/2) * Dlo * Wo * 0.49 * Snw
 = ( 3.1416/2.0 ) * 14.0000 * 0.1900 * 0.49 * 20000
 = 40948. lb.
```

Shear, Nozzle Wall [Snw]:

```
 = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
 = (3.1416 * 6.9060 ) * ( 0.1880 - 0.0000 ) * 0.7 * 22300
 = 63670. lb.
```

Strength of Failure Paths:

```
 PATH11 = ( SONW + SNW ) = ( 40947 + 63670 ) = 104617 lb.
 PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
        = ( 40947 + 0 + 0 + 40947 ) = 81895 lb.
 PATH33 = ( Sonw + Tngw + Sinw )
        = ( 40947 + 0 + 40947 ) = 81895 lb.
```

Summary of Failure Path Calculations:

```
Path 1-1 = 104617 lb., must exceed W = 0 lb. or W1 = 3654 lb.
Path 2-2 = 81895 lb., must exceed W = 0 lb. or W2 = 7219 lb.
Path 3-3 = 81895 lb., must exceed W = 0 lb. or W3 = 7219 lb.
```

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 90.711 psig

Note: The MAWP of this junction was limited by the parent Shell/Head

Nozzle is O.K. for the External Pressure 15.000 psig

The Drop for this Nozzle is : 0.6178 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 6.8058 in.

Input Echo, WRC107/537 Item 1, Description: Item 13/14 :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Spherical	
Internal Corrosion Allowance	Cas	0.0000	in.
Vessel Diameter	Dv	79.552	in.
Vessel Thickness	Tv	0.188	in.
Design Temperature		100.00	°F
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	20000.00	psi
Vessel Hot S.I. Allowable	Smh	20000.00	psi
Attachment Type	Type	Round	
WRC107 Attachment Classification	Holsol	Hollow	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	0.0000	in.
Nozzle Diameter	Dn	14.000	in.
Nozzle Thickness	Tn	0.188	in.
Nozzle Material		SA-312	
Nozzle Cold S.I. Allowable	SNmc	22300.00	psi
Nozzle Hot S.I. Allowable	SNmh	22300.00	psi
Design Internal Pressure	Dp	15.000	psig
Include Pressure Thrust		No	

10

External Forces and Moments in WRC 107/537 Convention:

Radial Load	(SUS)		P	0.0	lb.
Longitudinal Shear	(SUS)	(Vl)	V1	0.0	lb.
Circumferential Shear	(SUS)	(Vc)	V2	150.0	lb.
Circumferential Moment	(SUS)	(Mc)	M1	0.0	ft.lb.
Longitudinal Moment	(SUS)	(Ml)	M2	225.0	ft.lb.
Torsional Moment	(SUS)		Mt	0.0	ft.lb.

Use Interactive Control No
WRC107 Version Version March 1979

Include Pressure Stress Indices per Div. 2 No
Compute Pressure Stress per WRC-368 No

WRC 107 Stress Calculation for SUStained loads:

Radial Load		P	0.0	lb.
Circumferential Shear	(VC)	V2	150.0	lb.
Longitudinal Shear	(VL)	V1	0.0	lb.
Circumferential Moment	(MC)	M1	0.0	ft.lb.
Longitudinal Moment	(ML)	M2	225.0	ft.lb.
Torsional Moment		MT	0.0	ft.lb.

Dimensionless Param: U = 2.56 TAU = 36.73 RHO = 4.00 (1.00)

Dimensionless Loads for Spherical Shells at Attachment Junction:

Curves read for 1979	Figure	Value	Location
N(x) * T / P	SP 7	0.01332	(A,B,C,D)
M(x) / P	SP 7	0.00327	(A,B,C,D)
N(x) * T * SQRT(Rm * T) / MC	SM 7	0.01223	(A,B,C,D)
M(x) * SQRT(Rm * T) / MC	SM 7	0.00282	(A,B,C,D)
N(x) * T * SQRT(Rm * T) / ML	SM 7	0.01223	(A,B,C,D)
M(x) * SQRT(Rm * T) / ML	SM 7	0.00282	(A,B,C,D)
N(y) * T / P	SP 7	0.07277	(A,B,C,D)
M(y) / P	SP 7	0.00527	(A,B,C,D)
N(y) * T * SQRT(Rm * T) / MC	SM 7	0.06395	(A,B,C,D)
M(y) * SQRT(Rm * T) / MC	SM 7	0.00531	(A,B,C,D)
N(y) * T * SQRT(Rm * T) / ML	SM 7	0.06395	(A,B,C,D)
M(y) * SQRT(Rm * T) / ML	SM 7	0.00531	(A,B,C,D)

Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction

Type of		Stress Values at (psi)							
Stress	Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad. Memb.	P	0	0	0	0	0	0	0	0
Rad. Bend.	P	0	0	0	0	0	0	0	0
Rad. Memb.	MC	0	0	0	0	0	0	0	0
Rad. Bend.	MC	0	0	0	0	0	0	0	0
Rad. Memb.	ML	-341	-341	341	341	0	0	0	0
Rad. Bend.	ML	-471	471	471	-471	0	0	0	0

11

Tot. Rad. Str.	-813	130	813	-130	0	0	0	0
Tang. Memb. P	0	0	0	0	0	0	0	0
Tang. Bend. P	0	0	0	0	0	0	0	0
Tang. Memb. MC	0	0	0	0	0	0	0	0
Tang. Bend. MC	0	0	0	0	0	0	0	0
Tang. Memb. ML	-1784	-1784	1784	1784	0	0	0	0
Tang. Bend. ML	-888	888	888	-888	0	0	0	0
Tot. Tang. Str.	-2672	-896	2672	896	0	0	0	0
Shear VC	36	36	-36	-36	0	0	0	0
Shear VL	0	0	0	0	0	0	0	0
Shear MT	0	0	0	0	0	0	0	0
Tot. Shear	36	36	-36	-36	0	0	0	0
Str. Int.	2673	1029	2673	1029	0	0	0	0

WRC 107/537 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (psi)							
Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad. Pm (SUS)	1586	1586	1586	1586	1586	1586	1586	1586
Rad. Pl (SUS)	-341	-341	341	341	0	0	0	0
Rad. Q (SUS)	-471	471	471	-471	0	0	0	0
Long. Pm (SUS)	1586	1586	1586	1586	1586	1586	1586	1586
Long. Pl (SUS)	-1784	-1784	1784	1784	0	0	0	0
Long. Q (SUS)	-888	888	888	-888	0	0	0	0
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	36	36	-36	-36	0	0	0	0
Shear Q (SUS)	0	0	0	0	0	0	0	0
Pm (SUS)	1586	1586	1586	1586	1586	1586	1586	1586
Pm+Pl (SUS)	1444	1444	3372	3372	1586	1586	1586	1586
Pm+Pl+Q (Total)	1860	1718	4260	2484	1586	1586	1586	1586

Type of Stress Int.	Max. S.I. psi	S.I. Allowable	Result
Pm (SUS)	1586	20000	Passed
Pm+Pl (SUS)	3372	30000	Passed
Pm+Pl+Q (TOTAL)	4260	60000	Passed

✓

(12)

INPUT VALUES, Nozzle Description: Side Nozzle C1 From : 20
CHAMBER #1

Pressure for Reinforcement Calculations	P	15.000	psig
Temperature for Internal Pressure	Temp	100	°F
Design External Pressure	Pext	15.00	psig
Temperature for External Pressure	Tempex	100	°F
Shell Material		SA-516 70	
Shell Allowable Stress at Temperature	S	20000.00	psi
Shell Allowable Stress At Ambient	Sa	20000.00	psi
Inside Diameter of Cylindrical Shell	D	39.5000	in.
Design Length of Section	L	72.5949	in.
Shell Finished (Minimum) Thickness	t	0.2500	in.
Shell Internal Corrosion Allowance	c	0.0000	in.
Shell External Corrosion Allowance	co	0.0000	in.
Distance from Bottom/Left Tangent		4.8552	ft.
User Entered Minimum Design Metal Temperature		-20.00	°F

NOTE IN ADDITION TO 50# SHEAR LOAD PER JSA EMAIL ASSUMED $50 \times \frac{18}{12} =$ 75 FT·LBS MOMENT ON NOZZLE AS 50# IS NOT LOCATED AT NOZZLE BUT FURTHER OUT.

Type of Element Connected to the Shell : Nozzle

Material		SA-249 TP304L	
Material UNS Number		S30403	
Material Specification/Type		Wld. tube	
Allowable Stress at Temperature	Sn	14200.00	psi
Allowable Stress At Ambient	Sna	14200.00	psi
Diameter Basis (for tr calc only)		ID	
Layout Angle		0.00	deg
Diameter		8.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	0.1200	in.
Flange Material		SA-105	
Flange Type		None	
Corrosion Allowance	can	0.0000	in.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	2.9000	in.
Weld leg size between Nozzle and Pad/Shell	Wo	0.1200	in.
Groove weld depth between Nozzle and Vessel	Wgnv	0.0000	in.
Inside Projection	h	0.0000	in.
Weld leg size, Inside Element to Shell	Wi	0.0000	in.
ASME Code Weld Type per UW-16		None	

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)

```
| |
| |
| |
```

```
                 |  |
 ______________/|  |
|            \  |  |
|             \ |  |
|______________\|__|
```

Insert/Set-in Nozzle No Pad, no Inside projection

Reinforcement CALCULATION, Description: Side Nozzle C1

ASME Code, Section VIII, Div. 1, 2013, UG-37 to UG-45

```
Actual Inside Diameter Used in Calculation              8.000  in.
Actual Thickness Used in Calculation                    0.120  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]

```
 = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
 = (15.00*19.7500)/(20000*1.00-0.6*15.00)
 = 0.0148 in.
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]

```
 = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
 = (15.00*4.00)/(14200*1.00-0.6*15.00)
 = 0.0042 in.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.0173 in.

UG-40, Limits of Reinforcement : [External Pressure]

```
Parallel to Vessel Wall (Diameter Limit)            Dl     16.0000  in.
Parallel to Vessel Wall, opening length              d      8.0000  in.
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp      0.3000  in.
```

Weld Strength Reduction Factor [fr1]:

```
 = min( 1, Sn/S )
 = min( 1, 14200.0/20000.0 )
 = 0.710
```

Weld Strength Reduction Factor [fr2]:

```
 = min( 1, Sn/S )
 = min( 1, 14200.0/20000.0 )
 = 0.710
```

Weld Strength Reduction Factor [fr3]:

```
 = min( fr2, fr4 )
 = min( 0.7 , 1.0 )
 = 0.710
```

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	NA	0.663	NA	sq.in.
Area in Shell	A1	NA	0.679	NA	sq.in.
Area in Nozzle Wall	A2	NA	0.044	NA	sq.in.
Area in Inward Nozzle	A3	NA	0.000	NA	sq.in.
Area in Welds	A41+A42+A43	NA	0.010	NA	sq.in.
Area in Element	A5	NA	0.000	NA	sq.in.
TOTAL AREA AVAILABLE	Atot	NA	0.733	NA	sq.in.

(14)

```
Nozzle Angle Used in Area Calculations                    90.00  Degs.
```

The area available without a pad is Sufficient.

Area Required [A]:
```
 = 0.5( d * tr*F + 2 * tn * tr*F * (1-fr1) ) per UG-37(d) or UG-39
 = 0.5(8.0000*0.1644*1+2*0.1200*0.1644*1*(1-0.71))
 = 0.663 sq.in.
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
 = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
 = 8.000 ( 1.00 * 0.2500 - 1.0 * 0.164 ) - 2 * 0.120
   ( 1.00 * 0.2500 - 1.0 * 0.1644 ) * ( 1 - 0.710 )
 = 0.679 sq.in.
```

Area Available in Nozzle Projecting Outward [A2]:
```
 = ( 2 * tlnp ) * ( tn - trn ) * fr2
 = ( 2 * 0.300 ) * ( 0.1200 - 0.0173 ) * 0.7100
 = 0.044 sq.in.
```

Area Available in Inward Weld + Outward Weld [A41 + A43]:
```
 = Wo² * fr2 + ( Wi-can/0.707 )² * fr2
 = 0.1200² * 0.7100 + ( 0.0000 )² * 0.7100
 = 0.010 sq.in.
```

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
Wall Thickness for Internal/External pressures          ta = 0.0173 in.
Wall Thickness per UG16(b),                          tr16b = 0.0625 in.
Wall Thickness, shell/head, internal pressure         trb1 = 0.0148 in.
Wall Thickness                     tb1 = max(trb1, tr16b) = 0.0625 in.
Wall Thickness, shell/head, external pressure         trb2 = 0.0148 in.
Wall Thickness                     tb2 = max(trb2, tr16b) = 0.0625 in.
Wall Thickness per table UG-45                         tb3 = 0.2819 in.
```

Determine Nozzle Thickness candidate [tb]:
```
 = min[ tb3, max( tb1,tb2) ]
 = min[ 0.282 , max( 0.0625 , 0.0625 ) ]
 = 0.0625 in.
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
 = max( ta, tb )
 = max( 0.0173 , 0.0625 )
 = 0.0625 in.
```

Available Nozzle Neck Thickness = 0 1200 in --> OK

Stresses on Nozzle due to External and Pressure Loads per the ASME B31.3 Piping Code (see 319.4.4 and 302.3.5):
```
Sustained  :    393.2,  Allowable :  14200.0 psi  Passed
Expansion  :      0.0,  Allowable :  35106.8 psi  Passed
Occasional :    246.3,  Allowable :  18886.0 psi  Passed
Shear      :     33.2,  Allowable :   9940.0 psi  Passed
```

Note . The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

15

Nozzle to Flange Weld skipped as Nozzle is not a Carbon Steel material.

Nozzle-Shell Weld for Nozzle skipped as Nozzle is not a Carbon Steel material.

Nozzle Calculations per App. 1-10: Internal Pressure Case:

Thickness of Nozzle [tn]:
```
 = thickness - corrosion allowance
 = 0.120 - 0.000
 = 0.120 in.
```

Effective Pressure Radius [Reff]:
```
 = Di/2 + corrosion allowance
 = 39.500/2 + 0.000
 = 19.750 in.
```

Effective Length of Vessel Wall [LR]:
```
 = 8 * t
 = 8 * 0.250
 = 2.000 in.
```

Thickness Limit Candidate [LH1]:
```
 = t + 0.78 * sqrt( Rn * tn )
 = 0.250 + 0.78 * sqrt( 4.000 * 0.120 )
 = 0.790 in.
```

Thickness Limit Candidate [LH2]:
```
 = Lpr1 + T
 = 2.900 + 0.250
 = 3.150 in.
```

Thickness Limit Candidate [LH3]:
```
 = 8( t + te )
 = 8( 0.250 + 0.000 )
 = 2.000 in.
```

Effective Nozzle Wall Length Outside the Vessel [LH]:
```
 = min[ LH1, LH2, LH3 ]
 = min[ 0.790 , 3.150 , 2.000 )
 = 0.790 in.
```

Effective Vessel Thickness [teff]:
```
 = t
 = 0.250 in.
```

Determine Parameter [Lamda]:
```
 = min( 10, ( Dn + Tn )/( sqrt( ( Di + teff ) * teff )) )
 = min( 10, (8.00 + 0.120 )/( sqrt((39.50 + 0.250 ) * 0.250 )) )
 = 2.576
```

Compute Areas A1-A43 (No Pad) or A1-A5 (With Pad) :

Area Contributed by the Vessel Wall [A1]:
```
 = t * LR * max( Lamda/4, 1 )
 = 0.250 * 2.000 * max( 2.576/4, 1 )
 = 0.500 sq.in.
```

16

Area Contributed by the Nozzle Outside the Vessel Wall [A2]:
= tn * LH
= 0.120 * 0.790
= 0.095 sq.in.

Area Contributed by the Outside Fillet Weld [A41]:
= 0.5 * Leg41^(2)
= 0.5 * 0.120^(2)
= 0.007 sq.in.

The total area contributed by A1 through A43 [AT]:
= A1 + frn(A2 + A3) + A41 + A42 + A43
= 0.500+1.000(0.095+0.000)+0.007+0.000+0.000
= 0.602 sq.in.

Allowable Local Primary Membrane Stress [Sallow]:
= 1.5 * S * E
= 1.5 * 20000.000 * 1.000
= 30000.0 psi

Determine Force acting on the Nozzle [fN]:
= P * Rn(LH - t)
= 15.000 * 4.000 (0.790 - 0.250)
= 32.4 lb.

Determine Force acting on the Shell [fS]:
= P * Reff(LR + tn)
= 15.000 * 19.750 (2.000 + 0.120)
= 628.0 lb.

Discontinuity Force from Internal Pressure [fY]:
= P * Reff * Rnc
= 15.000 * 19.750 * 4.000
= 1185.0 lb.

Area Resisting Internal Pressure [Ap]:
= Rn(LH - t) + Reff(LR + tn + Rnc)
= 4.000 (0.790 - 0.250) + 19.750 (2.000 + 0.120 + 4.000)
= 123.0 sq.in.

Maximum Allowable Working Pressure Candidate [Pmax1]:
= Sallow /(2 * Ap/AT - Rxs/teff)
= 30000.000/(2 * 123.032/0.602 - 19.750/0.250)
= 91.0 psig

Maximum Allowable Working Pressure Candidate [Pmax2]:
= S[t/Reff]
= 20000.000 [0.250/19.750]
= 253.2 psig

Maximum Allowable Working Pressure [Pmax]:
= min(Pmax1, Pmax2)
= min(90.989 , 253.165)
= 90.989 psig

Average Primary Membrane Stress [SigmaAvg]:
= (fN + fS + fY) / AT
= (32.424 + 628.050 + 1185.000)/0.602
= 3065.327 psi

17

General Primary Membrane Stress [SigmaCirc]:
= P * Reff / teff
= 15.000 * 19.750/0.250
= 1185.0 psi

Maximum Local Primary Membrane Stress [PL]:
= max(2 * SigmaAvg - SigmaCirc, SigmaCirc)
= max(2 * 3065.327 - 1185.000 , 1185.000)
= 4945.7 psi

Summary of Nozzle Pressure/Stress Results:

Allowed Local Primary Membrane Stress	Sallow	30000.00	psi
Local Primary Membrane Stress	PL	4945.65	psi
Maximum Allowable Working Pressure	Pmax	90.99	psig

Strength of Nozzle Attachment Welds per 1-10 and U-2(g)

Discontinuity Force Factor [ky]:
= (Rnc + tn) / Rnc
= (4.000 + 0.120)/4.000
= 1.030 For set-in Nozzles

Weld Length of Nozzle to Shell Weld [Ltau]:
= pi/2 * (Rn + tn)
= pi/2 * (4.000 + 0.120)
= 6.472 in.

Weld Throat Dimensions, (0 7071*Leg Dimensions) [L41T, L42T, L43T]:
= 0.085, 0.000, 0.000, in.

Weld Load Value [fwelds]:
= min(fy * ky, 1.5 * Sn(A2 + A3), pi/4*P*Rn^2*ky^2)
= min(1185*1.03,1.5*14200.0(0.095+0.000),pi/4*15.0*4.00^2*1.03^2)
= 199.975 lb.

Weld Stress Value [tau]:
= fwelds/(Ltau(0.49*L41T + 0.6*tw1 + 0.49*L43T))
= 199.975/(6.472 (0.49*0.085 + 0.6*0.001 + 0.49*0.000))
= 732.618 < or = to 20000.000 Weld Size is OK

Weld Size Calculations, Description: Side Nozzle C1

Intermediate Calc. for nozzle/shell Welds Tmin 0.1200 in.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	0.0840 = 0.7 * tmin.	0.0848 = 0.7 * Wo in.

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 90.976 psig

Nozzle is O.K. for the External Pressure 15.000 psig

The Drop for this Nozzle is : 0 4345 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 3 5845 in.

Input Echo, WRC107/537 Item 1, Description: Side Nozzle C1:

18

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	0.0000	in.
Vessel Diameter	Dv	39.500	in.
Vessel Thickness	Tv	0.250	in.
Design Temperature		100.00	°F
Vessel Material		SA-516 70	
Vessel Cold S.I. Allowable	Smc	20000.00	psi
Vessel Hot S.I. Allowable	Smh	20000.00	psi
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	0.0000	in.
Nozzle Diameter	Dn	8.000	in.
Nozzle Thickness	Tn	0.120	in.
Nozzle Material		SA-249 TP304L	
Nozzle Cold S.I. Allowable	SNmc	14200.00	psi
Nozzle Hot S.I. Allowable	SNmh	14200.00	psi
Design Internal Pressure	Dp	15.000	psig
Include Pressure Thrust		No	

External Forces and Moments in WRC 107/537 Convention:

Radial Load	(SUS)	P	0.0	lb.
Longitudinal Shear	(SUS)	Vl	0.0	lb.
Circumferential Shear	(SUS)	Vc	50.0	lb.
Circumferential Moment	(SUS)	Mc	75.0	ft.lb.
Longitudinal Moment	(SUS)	Ml	0.0	ft.lb.
Torsional Moment	(SUS)	Mt	0.0	ft.lb.

Use Interactive Control		No
WRC107 Version	Version	March 1979
Include Pressure Stress Indices per Div. 2		No
Compute Pressure Stress per WRC-368		No

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	0.0	lb.
Circumferential Shear	VC	50.0	lb.
Longitudinal Shear	VL	0.0	lb.
Circumferential Moment	MC	75.0	ft.lb.
Longitudinal Moment	ML	0.0	ft.lb.
Torsional Moment	MT	0.0	ft.lb.

Dimensionless Parameters used : Gamma = 79.50

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.181	4C	9.903	(A,B)
N(PHI) / (P/Rm)	0.181	3C	5.423	(C,D)
M(PHI) / (P)	0.181	2C1	0.025	(A,B)
M(PHI) / (P)	0.181	1C !	0.068	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.181	3A	2.985	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.181	1A	0.066	(A,B,C,D)

19

N(PHI) / (ML/(Rm**2 * Beta))	0.181	3B	7.033	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.181	1B	0.018	(A,B,C,D)
N(x) / (P/Rm)	0.181	3C	5.423	(A,B)
N(x) / (P/Rm)	0.181	4C	9.903	(C,D)
M(x) / (P)	0.181	1C1	0.054	(A,B)
M(x) / (P)	0.181	2C !	0.036	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.181	4A	6.738	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.181	2A	0.030	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.181	4B	3.105	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.181	2B	0.023	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction

Type of Stress Load	Stress Values at (psi) Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0	0	0	0	0	0	0	0
Circ. Bend. P	0	0	0	0	0	0	0	0
Circ. Memb. MC	0	0	0	0	-149	-149	149	149
Circ. Bend. MC	0	0	0	0	-1580	1580	1580	-1580
Circ. Memb. ML	0	0	0	0	0	0	0	0
Circ. Bend. ML	0	0	0	0	0	0	0	0
Tot. Circ. Str.	0	0	0	0	-1730	1430	1730	-1430
Long. Memb. P	0	0	0	0	0	0	0	0
Long. Bend. P	0	0	0	0	0	0	0	0
Long. Memb. MC	0	0	0	0	-338	-338	338	338
Long. Bend. MC	0	0	0	0	-708	708	708	-708
Long. Memb. ML	0	0	0	0	0	0	0	0
Long. Bend. ML	0	0	0	0	0	0	0	0
Tot. Long. Str.	0	0	0	0	-1046	369	1046	-369
Shear VC	15	15	-15	-15	0	0	0	0
Shear VL	0	0	0	0	0	0	0	0
Shear MT	0	0	0	0	0	0	0	0
Tot. Shear	15	15	-15	-15	0	0	0	0
Str. Int.	30	30	30	30	1730	1430	1730	1430

WRC 107/537 Stress Summations:

Vessel Stress Summation at Attachment Junction

Type of Stress Int.	Stress Values at (psi)

20

Location	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	1177	1192	1177	1192	1177	1192	1177	1192
Circ. Pl (SUS)	0	0	0	0	-149	-149	149	149
Circ. Q (SUS)	0	0	0	0	-1580	1580	1580	-1580
Long. Pm (SUS)	588	588	588	588	588	588	588	588
Long. Pl (SUS)	0	0	0	0	-338	-338	338	338
Long. Q (SUS)	0	0	0	0	-708	708	708	-708
Shear Pm (SUS)	0	0	0	0	0	0	0	0
Shear Pl (SUS)	15	15	-15	-15	0	0	0	0
Shear Q (SUS)	0	0	0	0	0	0	0	0
Pm (SUS)	1177	1192	1177	1192	1177	1192	1177	1192
Pm+Pl (SUS)	1177	1192	1177	1192	1027	1042	1327	1342
Pm+Pl+Q (Total)	1177	1192	1177	1192	552	2622	2907	456

Type of Stress Int.	Max. S.I. psi	S.I. Allowable	Result
Pm (SUS)	1192	20000	Passed
Pm+Pl (SUS)	1342	30000	Passed
Pm+Pl+Q (TOTAL)	2907	60000	Passed

VOKAY

Lifting Lug Calculations Proton Radius Vacuum Chamber #1 and #2

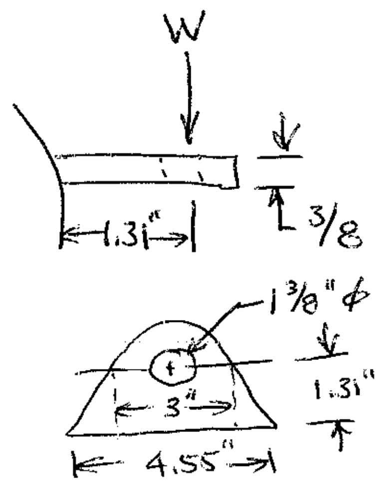
Chamber #1 Estimate Weight	1006	
Chamber #2 Estimate Weight	2268	
Added weight for flanges and unknowns	1000	
Estimate weight to use in calculations	**4274 lbs**	WGT

See sketches 1 and 2 for rigging assumptions

Number of Lugs	4.0		N
Load per lug (Vertical)	1068.5	lbs	L = WGT/N
Angle of strap to lift point	45.0	degrees	A1
Load on Lug for "Radendra" Method Calculation	1511.1	lbs	F = L/SIN(A1)
Angle of strap from end view to lift point	60.0	degrees	A2
Horizontal Load on Lug	755.5	lbs	FH = F*SIN(A2/2)

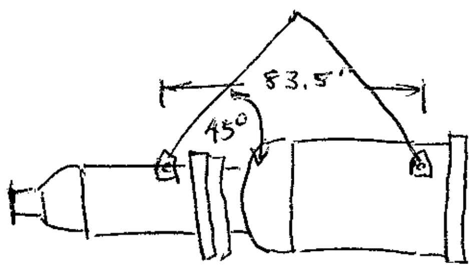
Look at Horzontal Load on Lug: Treat Lug as simple beam. See sketch 3.

Horizontal Load on Lug	755.5	lbs	W
Shell to lug hole centerline dimension	1.31	IN	L
Lug thickness	0.375	IN	h
Lug width	3.0	IN	b
Lug Material	SA516 GR70		
Tensile Strength	70000.0	PSI	TS
Yield Strength	38000.0	PSI	TS
Modulus of Elasticity	30000000.0	PSI	E



SKETCH # 3

Moment of Inertia of Lug	0.013	I =b*h^3/12	
Secton Modulus	0.071	Z = b*h^2/6	
Maximum stress at root of Lug	13937.2	Smax = W*L/Z	PSI
Maximum deflection at center of hole	0.001	D=W*L^3/(3*E*I)	IN
Safety Factor based on Tensile Strength	5.0	FSt=TS/Smax	PASS
Safety Factor based on Yield Strength	2.7	Fsy=YS/Smax	PASS



SKETCH #1

SKETCH #2

Lifting lugs per Design/Evaluation of Overhead Lifting Lugs Clement Rajedra, PE 2012

1st iteration

a	0.828	distance, hole to edge side to side	
e	0.63	distance, hole edge side to top	
t	0.375	lug thickness	
Fu	70000	Ultimate strength	
FY	38000	Yield strength	
d	1.375	Hole dia	
AW	1511.087	Actual weight	
Sfu	5	Safety factor ultimate	14000
Sfy	3	Safety factor yield	12666.67
Pd	0.875	Pin diameter	

Failure mode 1, Tension failure both sides hole
8,694.0 Allowable load, pounds
PASS

Failure mode 2, Bearing failure at pin/lifting lug
3740.625 Allowable load, pounds
Pass

Failure mode 3, shear failure, pin push out
2394 Allowable load, pounds
Pass

Failure mode 4, tensile failure pin push out
1534.134 Allowable load, pounds
Pass

ASIC CODE CHECKS

Requirement 1		
A1	0 23625	=t*e
A2	0.621	=2*a*t
2/3 of A2	0.414	Test, should be less than A1
Fail - need to reduce a for tensile capacity		

Note: Only portion of lug considered in calculation is reduced, not the physical lug

Requirement 2
1.5 =4x t at pin, dimension a shall not exceed
Pass

Requirement 3
1.035 Hole pin diameter not less than 1.25 x a
Pass

Lifting lugs per Design/Evaluation of Overhead Lifting Lugs Clement Rajedra, PE 2012

With reduced a for tensile calculation, to pass ASIC Code check

Second iteration

a	0.47	distance, hole to edge side to side	
e	0.63	distance, hole edge side to top	
t	0.375	lug thickness	
Fu	70000	Ultimate strength	
FY	38000	Yield strength	
d	1.375	Hole dia	
AW	1511.087	Actual weight	
Sfu	5	Safety factor ultimate	14000
Sfy	3	Safety factor yield	12666.67
Pd	0.875	Pin diameter	

Failure mode 1, Tension failure both sides hole
4,935.0 Allowable load, pounds
PASS

Failure mode 2, Bearing failure at pin/lifting lug
3740.625 Allowable load, pounds
Pass

Failure mode 3, shear failure, pin push out.
2394 Allowable load, pounds
Pass

Failure mode 4, tensile failure pin push out
1534.134 Allowable load, pounds
Pass

ASIC CODE CHECKS

Requirement 1

A1	0.23625	=t*e
A2	0.3525	=2*a*t
2/3 of A2	0.235	Test, should be less than A1

Pass - with reduced a in calculations

Requirement 2
1.5 =4x t at pin, dimension a shall not exceed
Pass

Requirement 3
0.5875 Hole pin diameter not less than 1.25 x a
Pass