Table of Contents

Cover Page

DESIGN CALCULATION

ASME Code Version : 2013

Analysis Performed by : MAYER TOOL & MANUFACTURING

Job File : \\meyersvr01\users$\tvouris\My Documents\calcs\Q004694 DU

Date of Analysis : Nov 21,2014

PV Elite 2014, January 2014

Title Page

Input Echo, App Y Flange Item 1, Description: 44.62" Y Flange

Description of Flange Geometry (Type)		Loose Slip On	
Design Pressure	P	15.00	psig
Design Temperature		100.00	F
Corrosion Allowance	FCOR	0.0000	in.
Flange Inside Diameter	B	40.000	in.
Flange Outside Diameter	A	44.620	in.
Flange Thickness	T	1.5000	in.
Thickness of Hub at Small End	G0	0.0000	in.
Thickness of Hub at Large End	G1	0.0000	in.
Length of Hub	HL	0.0000	in.
Flange Material		SA-105	
Flange Material UNS Number		K03504	
Flange Allowable Stress At Temperature	SFO	20000.00	psi
Flange Allowable Stress At Ambient	SFA	20000.00	psi
Bolt Material		SA-193 B7	
Bolt Material UNS Number		G41400	
Bolt Allowable Stress At Temperature	SBO	25000.00	psi
Bolt Allowable Stress At Ambient	SBA	25000.00	psi
Diameter of Bolt Circle	C	42.500	in.
Nominal Bolt Diameter	DB	0.2938	in.
Type of Thread Series		Special, Root Area	
Root Area of a Single Bolt		0.0678	in²
Number of Bolts		68	
Gasket Outside Diameter	GOD	41.050	in.
Gasket Inside Diameter	GID	40.500	in.
Gasket Factor, m,	M	0.0000	
Gasket Design Seating Stress	Y	0.00	psi
Elastic Modulus of Bolt Material at Des. Temp		29461538	psi
Elastic Modulus of Flange Material at Des. Temp		29261538	psi

FLANGE ANALYSIS of Identical Flange Pairs Per Appendix Y

Code R Dimension,	R = (C-B)/2 - g1	1.250	in.
Gasket Contact Width,	N = (Goc-Gic) / 2	0.275	in.
Basic Gasket Width,	b0 = N / 2.0	0.137	in.
Effective Gasket Width,	b = b0	0.137	in.
Gasket Reaction Diameter,	G = (Go+Gi) / 2.0	40.775	in.
Radial Contact Dist.,	hcmax = (A - C) / 2	1.060	in.

Basic Flange and Bolt loads:

Hydrostatic End Load due to Pressure[H]:
= 0.785 * G * G * Peq
= 0.785 * 40.7750 *40.7750 *15.0000
= 19587.055 lb.

Contact Load on Gasket Surfaces[Hp]:
= 2 * b * PI * G * m * P

= 2 * 0.1375 * 3.1416 * 40.7750 * 0.0000 * 15.00
= 0.000 lb.

Hydrostatic End Load at Flange ID[Hd]:
= 0.785 * Bcor * Bcor * P
= 0.785 * 40.0000 * 40.0000 *15.0000
= 18849.557 lb.

Pressure Force on Flange Face[Ht]:
= H - Hd
= 19587 - 18849
= 737.498 lb.

Operating Bolt Load[Wm1]:
= H + Hp + H'p (cannot be < 0)
= (19587 + 0 + 0)
= 19587.055 lb.

Gasket Seating Bolt Load[Wm2]:
= y * b * PI * G + yPart * bPart * lp
= 0.00*0.1375*3.141*40.775+0.00*0.0000*0.00
= 0.000 lb.

Required Bolt Area[Am]:
= Maximum of Wm1/Sb, Wm2/Sa
= Maximum of 19587 / 25000 , 0 / 25000
= 0.783482 in²

ASME Maximum Circumferential Spacing between Bolts per App 2 eq. (3) [Bsmax]:
= 2a + 6t/(m + 0.5)
= 2 * 0.294 + 6 * 1.500 /(0.00 + 0.5)
= 18.588 in.

Actual Circumferential Bolt Spacing [Bs]:
= C * sin(pi / n)
= 42.500 * sin(3.142 / 68)
= 1.963 in.

ASME Moment Multiplier for Bolt Spacing per App. 2 eq. (7) [Bsc]:
= max(sqrt(Bs/(2a + t)), 1)
= max(sqrt(1.963 /(2 * 0.294 + 1.500)), 1)
= 1.0000

Bolting Information for User Defined Bolts (Non Mandatory):

	Minimum	Actual	Maximum
Bolt Area, in²	0.783	4.610	
Circumferential spacing between bolts	0.000	1.963	18.588

Flange Design Bolt Load, Gasket Seating[W]:
= Sa * (Am + Ab) / 2.0
= 25000.00 * (0.7835 + 4.6104) / 2.0
= 67423.53 lb.

Gasket Seating Force[Hg]:
= Wm1 - H

= 19587 - 19587
= 0.00 lb.

Moment Arm Calculations:

Distance to Gasket Load Reaction[hg]:
= (C - G) / 2.0
= (42.5000 - 40.7750) / 2.0
= 0.8625 in.

Distance to Face Pressure Reaction[ht]:
= (hd + hg) / 2.0
= (1.2500 + 0.8625) / 2.0
= 1.0562 in.

Distance to End Pressure Reaction[hd]:
= (C - Bcor)/ 2.0
= (42.5000 - 40.0000) / 2.0
= 1.2500 in.

Summary of Moments for Internal Pressure:

Loading		Force	Distance	Bolt Corr	Moment
End Pressure,	Md	18850.	1.2500	1.0000	1963. ft.lb.
Face Pressure,	Mt	737.	1.0562	1.0000	65. ft.lb.
Gasket Load,	Mg	0.	0.8625	1.0000	0. ft.lb.
Gasket Seating,	Ma	67424.	0.8625	1.0000	4846. ft.lb.

Total Moment for Operation,	Mo	2028. ft.lb.
Total Moment for Gasket Seating,	Ma	4846. ft.lb.

Effective Hub Length, ho =		0.000 in.
Hub Ratio,	h/ho = Defined as 0.0	0.000
Thickness Ratio,	g1/g0 = Defined as 0.0	0.000

Flange Factors for Loose Flange:

Factor Fl per 2-7.4	50.000
Factor Vl per 2-7.5	194.636
Factor f per 2-7.6	1.000

Factors from Figure 2-7.1		K =	1.115
	T = 1.872	U =	19.509
	Y = 17.753	Z =	9.185

STRESS ANALYSIS OF A CLASS 1 ASSEMBLY

Compute the Factor: F'
= $g0^2$ * (h0 + Fl * T) / Vl
= 0.0000^2 * (0.0000 + 50.0000 * 1.5000) / 194.6356
= 0.0000 in.^(3)

Factor: Js
= 1/B1 * (2*hd/beta + hc/a) + pi*rb
= 1/40.000(2*1.250/1.0312+1.0600/1.0890)+3.14159*0.001286
= 0.0890

Factor: Jp
= 1/B1 * (hd/beta + hc/a) + pi*rb
= 1/40.000(1.250/1.0312+1.0600/1.0890)+3.14159*0.001286
= 0.0587

Flange Moment due to Flange-Hub Interaction: Ms
= -(Jp * F' * Mp)/(t^3 + Js * F')
= -(0.0587 * 0.0000 * 24340.93)/(1.5000 + 0.0890 * 0.0000)
= 0.0000 ft.lb.

Slope of the Flange at the ID times E (Elastic Modulus): Ethetab
= 5.46/(pi*t^3) * (Js*Ms + Jp*Mp)
= 5.46/(3.14159 * 1.5000^3) * (0.0890 *0.0 + 0.0587 *24340.93)
= 735.4793 psi

Contact Force between Flanges at hc: Hc
= (Mp + Ms) / hc
= (24340.93 + 0.00) / 1.0600
= 22963. lb.

Operating Bolt Load: Wm1
= H + Hg + Hc
= 19587.05 + 0.00 + 22963.15
= 42550. lb.

Operating Bolt Stress: Sigmab
= Wm1 / Ab
= 42550.20 / 4.6104
= 9229. psi

Design Prestress in the Bolts: Si
= Sigmab - 1.159 * hc² * (Mp+Ms)/(a * t^3 * l * re * B1)
= 9229-1.159*1.060²*24340/(1.089*1.5000³*3.294*0.993*40.000)
= 9163. psi

Radial Flange Stress at the Bolt Circle: Sr
= 6 * (Mp + Ms)/(t² * (pi*C - n*D))
= 6 * (24340 + 0)/(1.5000²(pi * 42.5000 - 68 * 0.4188))
= 617.9560 psi

Tangential Flange Stress at the Inside Diameter: STid
= (t*Ethetab/B1)
= (1.5000 *735.48 /40.0000)
= 27.5805 psi

Summary of Flange Stresses :

	Actual	Allowable
Radial Flange Stress at the Bolt Circle	617.96	20000.00 psi
Tangential Flange Stress at the ID	27.58	20000.00 psi
Bolt Stress	9229.18	25000.00 psi

Results for Required Thickness and M.A.W.P.

Minimum Required Flange Thickness	0.3198	in.
Estimated M.A.W.P.	40.63	psig

Input Echo, App Y Flange Item 2, Description: 72" Appendix Y

Description of Flange Geometry (Type)		Loose Slip On	
Design Pressure	P	15.00	psig
Design Temperature		100.00	F
Corrosion Allowance	FCOR	0.0000	in.
Flange Inside Diameter	B	62.000	in.
Flange Outside Diameter	A	72.000	in.
Flange Thickness	T	2.0000	in.
Thickness of Hub at Small End	G0	0.0000	in.
Thickness of Hub at Large End	G1	0.0000	in.
Length of Hub	HL	0.0000	in.
Flange Material		SA-105	
Flange Material UNS Number		K03504	
Flange Allowable Stress At Temperature	SFO	20000.00	psi
Flange Allowable Stress At Ambient	SFA	20000.00	psi
Bolt Material		SA-193 B7	
Bolt Material UNS Number		G41400	
Bolt Allowable Stress At Temperature	SBO	25000.00	psi
Bolt Allowable Stress At Ambient	SBA	25000.00	psi
Diameter of Bolt Circle	C	69.964	in.
Nominal Bolt Diameter	DB	0.7500	in.
Type of Thread Series		UNC Thread Series	
Number of Bolts		110	
Gasket Outside Diameter	GOD	68.500	in.
Gasket Inside Diameter	GID	67.500	in.
Gasket Factor, m,	M	0.0000	
Gasket Design Seating Stress	Y	0.00	psi
Elastic Modulus of Bolt Material at Des. Temp		29461538	psi
Elastic Modulus of Flange Material at Des. Temp		29261538	psi

FLANGE ANALYSIS of Identical Flange Pairs Per Appendix Y

Code R Dimension,	R = (C-B)/2 - g1	3.982	in.
Gasket Contact Width,	N = (Goc-Gic) / 2	0.500	in.
Basic Gasket Width,	b0 = N / 2.0	0.250	in.
Effective Gasket Width,	b = b0	0.250	in.
Gasket Reaction Diameter,	G = (Go+Gi) / 2.0	68.000	in.
Radial Contact Dist.,	hcmax = (A - C) / 2	1.018	in.

Basic Flange and Bolt loads:

Hydrostatic End Load due to Pressure[H]:
= 0.785 * G * G * Peq
= 0.785 * 68.0000 *68.0000 *15.0000
= 54475.219 lb.

Contact Load on Gasket Surfaces[Hp]:
= 2 * b * PI * G * m * P
= 2 * 0.2500 * 3.1416 * 68.0000 * 0.0000 * 15.00

= 0.000 lb.

Hydrostatic End Load at Flange ID[Hd]:
= 0.785 * Bcor * Bcor * P
= 0.785 * 62.0000 * 62.0000 *15.0000
= 45286.059 lb.

Pressure Force on Flange Face[Ht]:
= H - Hd
= 54475 - 45286
= 9189.160 lb.

Operating Bolt Load[Wm1]:
= H + Hp + H'p (cannot be < 0)
= (54475 + 0 + 0)
= 54475.219 lb.

Gasket Seating Bolt Load[Wm2]:
= y * b * PI * G + yPart * bPart * lp
= 0.00*0.2500*3.141*68.000+0.00*0.0000*0.00
= 0.000 lb.

Required Bolt Area[Am]:
= Maximum of Wm1/Sb, Wm2/Sa
= Maximum of 54475 / 25000 , 0 / 25000
= 2.17901 in²

ASME Maximum Circumferential Spacing between Bolts per App. 2 eq (3) [Bsmax]:
= 2a + 6t/(m + 0.5)
= 2 * 0.750 + 6 * 2.000 /(0.00 + 0.5)
= 25.500 in.

Actual Circumferential Bolt Spacing [Bs]:
= C * sin(pi / n)
= 69.964 * sin(3.142 / 110)
= 1.998 in.

ASME Moment Multiplier for Bolt Spacing per App. 2 eq (7) [Bsc]:
= max(sqrt(Bs/(2a + t)), 1)
= max(sqrt(1.998 /(2 * 0.750 + 2.000)), 1)
= 1.0000

Bolting Information for UNC Thread Series (Non Mandatory):

	Minimum	Actual	Maximum
Bolt Area, in²	2.179	33.220	
Radial distance bet. hub and bolts	1.125	3.982	
Radial distance bet. bolts and the edge	0.812	1.018	
Circumferential spacing between bolts	1.750	1.998	25.500

Flange Design Bolt Load, Gasket Seating[W]:
= Sa * (Am + Ab) / 2.0
= 25000.00 * (2.1790 + 33.2200) / 2.0
= 442487.56 lb.

Gasket Seating Force[Hg]:

= Wm1 - H
= 54475 - 54475
= 0.00 lb.

Moment Arm Calculations:

Distance to Gasket Load Reaction[hg]:
= (C - G) / 2.0
= (69.9640 - 68.0000) / 2.0
= 0.9820 in.

Distance to Face Pressure Reaction[ht]:
= (hd + hg) / 2.0
= (3.9820 + 0.9820) / 2.0
= 2.4820 in.

Distance to End Pressure Reaction[hd]:
= (C - Bcor)/ 2.0
= (69.9640 - 62.0000) / 2.0
= 3.9820 in.

Summary of Moments for Internal Pressure:

Loading		Force	Distance	Bolt Corr	Moment	
End Pressure,	Md	45286.	3.9820	1.0000	15027.	ft.lb.
Face Pressure,	Mt	9189.	2.4820	1.0000	1901.	ft.lb.
Gasket Load,	Mg	0.	0.9820	1.0000	0.	ft.lb.
Gasket Seating,	Ma	442488.	0.9820	1.0000	36210.	ft.lb.

Total Moment for Operation,	Mo	16928.	ft.lb.
Total Moment for Gasket Seating,	Ma	36210.	ft.lb.

Effective Hub Length, ho =	0.000	in.
Hub Ratio, h/ho = Defined as 0.0	0.000	
Thickness Ratio, g1/g0 = Defined as 0.0	0.000	

Flange Factors for Loose Flange:

Factor Fl per 2-7.4	50.000
Factor Vl per 2-7.5	194.636
Factor f per 2-7.6	1.000

Factors from Figure 2-7.1		K =	1.161
T =	1.854	U =	14.340
Y =	13.049	Z =	6.737

STRESS ANALYSIS OF A CLASS 1 ASSEMBLY

Compute the Factor: F'
= g0² * (h0 + Fl * T) / Vl
= 0.0000² * (0.0000 + 50.0000 * 2.0000) / 194.6356
= 0.0000 in.^(3)

Factor: Js
= 1/B1 * (2*hd/beta + hc/a) + pi*rb
= 1/62.000(2*3.982/1.0642+1.0180/1.1449)+3.14159*0.004413

= 0.1489

Factor: Jp
= 1/B1 * (hd/beta + hc/a) + pi*rb
= 1/62.000(3.982/1.0642+1.0180/1.1449)+3.14159*0.004413
= 0.0886

Flange Moment due to Flange-Hub Interaction: Ms
= -(Jp * F' * Mp)/(t^3 + Js * F')
= -(0.0886 * 0.0000 * 203136.50)/(2.0000 + 0.1489 * 0.0000)
= 0.0000 ft.lb.

Slope of the Flange at the ID times E (Elastic Modulus): Ethetab
= 5.46/(pi*t^3) * (Js*Ms + Jp*Mp)
= 5.46/(3.14159 * 2.0000^3) * (0.1489 *0.0 + 0.0886 *203136.50)
= 3908. psi

Contact Force between Flanges at hc: Hc
= (Mp + Ms) / hc
= (203136.50 + 0.00) / 1.0180
= 199544. lb.

Operating Bolt Load: Wm1
= H + Hg + Hc
= 54475.22 + 0.00 + 199544.39
= 254020. lb.

Operating Bolt Stress: Sigmab
= Wm1 / Ab
= 254019.61 / 33.2200
= 7647. psi

Design Prestress in the Bolts: Si
= Sigmab - 1.159 * hc² * (Mp+Ms)/(a * t^3 * l * re * B1)
= 7646-1.159*1.018²*203136/(1.145*2.0000³*4.750*0.993*62.000)
= 7556. psi

Radial Flange Stress at the Bolt Circle: Sr
= 6 * (Mp + Ms)/(t² * (pi*C - n*D))
= 6 * (203136 + 0)/(2.0000²(pi * 69.9640 - 110 * 0.8750))
= 2466. psi

Tangential Flange Stress at the Inside Diameter: STid
= (t*Ethetab/B1)
= (2.0000 *3907.97 /62.0000)
= 126.0636 psi

Summary of Flange Stresses :

	Actual	Allowable
Radial Flange Stress at the Bolt Circle	2466.28	20000.00 psi
Tangential Flange Stress at the ID	126.06	20000.00 psi
Bolt Stress	7646.59	25000.00 psi

Results for Required Thickness and M.A.W.P.

Minimum Required Flange Thickness	0.7023	in.
Estimated M.A.W.P.	49.04	psig

Input Echo, Leg & Lug Item 1, Description: Lugs

Design Internal Pressure		15.00	psig
Design Temperature for Attachment	TEMP	100.00	F
Vessel Outside Diameter	OD	40.000	in.
Vessel Wall Thickness	Ts	0.1875	in.
Vessel Corrosion Allowance	Cas	0.0000	in.
Vessel Material		SA-516 70	
Vessel Material UNS Number		K02700	
Vessel Allowable Stress at Design	S	20000.00	psi
Analysis Type:		Lifting Lug	
Empty Weight of Vessel	Wemp	3200.00	lb.
Operating Weight of Vessel (vertical load)	W	0.00	lb.
Lifting Lug Material		SA-240 304	
Lifting Lug Material UNS Number		S30400	
Lifting Lug Yield Stress	YIELD	30000.00	psi
Lifting Lug Orientation to Vessel		Perpendicular	
Total Height of Lifting Lug	w	4.0000	in.
Thickness of Lifting Lug	t	0.2500	in.
Diameter of Hole in Lifting Lug	dh	1.0000	in.
Radius of Semi-Circular Arc of Lifting Lug	r	1.0000	in.
Height of Lug from bottom to Center of Hole	h	2.0000	in.
Offset from Vessel OD to Center of Hole	off	2.0000	in.
Minimum thickness of Fillet Weld around Lug	tw	0.1875	in.
Length of weld along side of Lifting Lug	wl	4.3750	in.
Length of Weld along Bottom of Lifting Lug	wb	0.6250	in.
Lift Orientation		Lifting Lug	
Force Along Vessel Axis	Fax	0.00	lb.
Force Normal to Vessel	Fn	0.00	lb.
Force Tangential to Vessel	Ft	0.00	lb.
Impact Factor	Impfac	1.50	
Occasional Load Factor (AISC A5.2)	Occfac	1.00	

Results for lifting lugs, Description : Lugs

Weld Group Inertia about the Circumferential Axis	ILC	3.837	in**4
Weld Group Centroid distance in the Long. Direction	YLL	2.375	in.
Dist. of Weld Group Centroid from Lug bottom	YLL_B	2.188	in.
Weld Group Inertia about the Longitudinal Axis	ILL	0.091	in**4
Weld Group Centroid Distance in the Circ. Direction	YLC	0.312	in.

Applying the Impact factor to the loads:

Primary Shear Stress in the Welds due to Shear Loads [Ssll]:

```
 = Sqrt( Fax^2+Ft^2+Fn^2 ) / ( (2*wl+wb) * tw )
 = Sqrt(0^2+0^2+0^2) / ( (2*4.4 +0.6 ) * 0.1875 )
 = 0.00 psi
```

Shear Stress in the Welds due to Bending Loads [Sblf]:

```
 = (Fn*(h-YLL_B)) *YLL/ILC + (Fax*off *YLL/ILC) + (Ft*off *YLC/ILL)
 = (0 *(2.000 -2.188 )) * 2.375 /3.837 +
   (0 *2.000 * 2.375 /3.837 ) +
   (0 *2.000 * 0.312 /0.091 )
```

= 0.00 psi

Total Shear Stress for Combined Loads [St]:
= Ssll + Sblf
= 0.000 + 0.000
= 0.00 psi

Allowable Shear Stress for Combined Loads [Sta]:
= 0.4 * Yield * Occfac (AISC Shear All.)
= 0.4 * 30000 * 1.00
= 12000.00 psi

Shear Stress in Lug above Hole [Shs]:
= Sqrt(Fax^2 + Fn^2 + Ft^2) / Sha
= Sqrt(0^2 + 0^2 + 0^2) / 0.250
= 0.00 psi

Allowable Shear Stress in Lug above Hole [Sas]:
= 0.4 * Yield * Occfac
= 0.4 * 30000 * 1.00
= 12000.00 psi

Pin Hole Bearing Stress [Pbs]:
= Sqrt(Fax^2 + Fn^2) / (t * dh)
= Sqrt(0^2 + 0^2) / (0.250 * 1.000)
= 0.00 psi

Allowable Bearing Stress [Pba]:
= Min(0.75 * Yield * Occfac, 0.9*Yield) AISC Bearing All.
= Min(0.75 * 30000 * 1.00 , 27000.0)
= 22500.00 psi

Bending stress at the base of the lug [Fbs]:
= Ft*off / (w*t^(2) / 6) + Fax*off / (w^(2)*t / 6)
= 0 * 2.000 / (4.000 * 0.250^(2) / 6) +
0 * 2.000 / (4.000^(2) * 0.250 / 6)
= 0.00 psi

Tensile stress at the base of the lug [Fa]:
= Fn / (w * t) = 0 / (4.000 * 0.250)
= 0.00 psi

Total Combined Stress at the base of the lug:
= Fbs + Fa = 0.0 psi

Lug Allowable Stress for Bending and Tension:
= Min(0.66 * Yield * Occfac, 0.75*Yield)
= Min(0.66 * 30000 * 1.00 , 22500.0) = 19800.0 psi

Note: Check the Shell Stresses using method such as WRC-107

Summary Of Results

Stress (psi)	Actual	Allowable	P/F
Primary Shear Stress of Weld :	0.00	12000.00	Ok
Shear Stress above Hole :	0.00	12000.00	Ok
Pin Hole Bearing Stress :	0.00	22500.00	Ok
Total Combined Stress at the lug base :	0.00	19800.00	Ok

Input Echo, Nozzle Item 1, Description: 14"OD Tube Nozz

Design Internal Pressure (Case 1)	P	15.00	psig
Temperature for Internal Pressure	TEMP	100.00	F
Design External Pressure (Case 2)	PEXT	15.00	psig
Temperature for External Pressure	TEMPEX	100.00	F
Include Hydrostatic Head Components		NO	
Shell or Head Material (Not Normalized or NA)		SA-240 304	
Material UNS Number		S30400	
Shell/Head Allowable Stress at Temperature	S	20000.00	psi
Shell/Head Allowable Stress At Ambient	SA	20000.00	psi

*** Note: Allowable Stresses Modified as UTS > 70 ksi, per App. 1-4.

Shell/Head Yield Stress at Temperature	Sy	30000.00	psi
Inside Crown Radius of Torispherical Head	L	40.000	in.
Inside Knuckle Radius of Torispherical Head	r	2.750	in.
Actual Thickness of Shell or Head	T	0.1875	in.
Corrosion Allowance for Shell or Head	CAS	0.0000	in.
Is this Nozzle a Radial Nozzle		YES	
Is the Nozzle Outside the 80% diameter Limit		NO	
Nozzle Material (Not Normalized or NA)		SA-312 TP304L	
Material UNS Number		S30403	
Nozzle Allowable Stress at Temperature	SN	16700.00	psi
Nozzle Allowable Stress At Ambient	SNA	16700.00	psi
Diameter Basis for Nozzle	BASISN	OD	
Nominal Diameter of Nozzle	DIA	14.000	in.
Nozzle Size and Thickness Basis	DBN	Nominal	
Nominal Thickness of Nozzle	THKNOM	SCH 10S	
Corrosion Allowance for Nozzle	CAN	0.0000	in.
Joint Efficiency of Shell Seam at Nozzle	ES	1.00	
Joint Efficiency of Nozzle Neck	EN	1.00	
Insert or Abutting Nozzle Type	NTYP	Insert	
Outward Projection of Nozzle	HO	2.000	in.
Weld leg size between Nozzle and Pad/Shell	WO	0.2500	in.
Groove weld depth between Nozzle and Vessel	WGNV	0.0000	in.
ASME Code Weld Type per UW-16.1		K	
Method used for checking Nozzle opening		UG-37	
Method used for checking Large Nozzles		App. 1-10	
Is this is Manway/Access/Inspection Opening		No	
Skip Iterative Failure Thickness Calculations		Yes	

Reinforcement CALCULATION, Description: 14"OD Tube Nozz

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.

Internal Pressure Results for SHELL/HEAD :

Reqd thk per UG-37(a) of Torispherical Head, Tr Internal Pressure
M factor for Torispherical Heads [M]:
= 1.0000

Thickness Due to Internal Pressure:
= (P*(L+T-CAE)*M) / (2*S*E+P*(M-0.2)) per Appendix 1-4 (d)
= (15.00*40.1875*1.0000)/(2*20000.00*1.00+15.00*(1.0000-0.2))
= 0.0151 + 0.0000 = 0.0151 in.

External Pressure Results for SHELL/HEAD :

External Pressure Results, Shell Number 1, Desc.: 14"OD Tube Nozz
ASME Code, Section VIII, Division 1, 2013

External Pressure Chart	HA-1	at 100.00	F
Elastic Modulus for Material		28000000.00	psi

Results for Max. Allowable External Pressure (Emawp):

Corroded Thickness of Head	TCA	0.1875	in.
Outside Crown Radius	Ro	40.188	in.
Crown Rad / Thickness Ratio	(Ro/T)	214.3333	
Geometry Factor, A (.125/(Ro/T))	A	0.0005832	
Materials Factor, B, f(A, Chart)	B	7561.9565	psi
Maximum Allowable Working Pressure		35.28	psig

EMAWP = B/(Ro/T) = 7561.9565 /214.3333 = 35.2813

Results for Reqd Thickness for Ext. Pressure (Tca):

Corroded Thickness of Head	TCA	0.1177	in.
Outside Crown Radius	Ro	40.188	in.
Crown Rad / Thickness Ratio	(Ro/T)	341.5482	
Geometry Factor, A (.125/(Ro/T))	A	0.0003660	
Materials Factor, B, f(A, Chart)	B	5123.7271	psi
Maximum Allowable Working Pressure		15.00	psig

EMAWP = B/(Ro/T) = 5123.7271 /341.5482 = 15.0015

Summary of External Pressure Results:

Allowable Pressure at Corroded thickness	35.28	psig
Required Pressure as entered by User	15.00	psig
Required Thickness including Corrosion all.	0.1177	in.
Actual Thickness as entered by User	0.1875	in.

Internal Pressure Results for NOZZLE :

Reqd thk per UG-37(a) of Nozzle Wall, Trn Internal Pressure
Thickness Due to Internal Pressure:
= (P*(D/2-CAE)) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (15.00*(14.0000/2-0.000)/(16700.00*1.00+0.4*15.00)
= 0.0063 + 0.0000 = 0.0063 in.

External Pressure Results for Nozzle per UG-28 :

External Pressure Results, Shell Number 1, Desc.: 14"OD Tube Nozz
ASME Code, Section VIII, Division 1, 2013

External Pressure Chart	HA-3 at	100.00	F
Elastic Modulus for Material		28000000.00	psi

Results for Max. Allowable External Pressure (Emawp):

Corroded Thickness of Shell	TCA	0.1880	in.
Outside Diameter of Shell	ODCA	14.000	in.
Design Length of Cylinder or Cone	SLEN	2.000	in.
Diameter / Thickness Ratio	(D/T)	74.4681	
Length / Diameter Ratio	LD	0.1429	
Geometry Factor, A f(DT,LD)	A	0.0223013	
Materials Factor, B, f(A, Chart)	B	14325.9980	psi
Maximum Allowable Working Pressure		256.50	psig

EMAWP = (4*B)/(3*(D/T)) = (4 *14325.9980)/(3 *74.4681) = 256.5036

Results for Reqd Thickness for Ext. Pressure (Tca):

Corroded Thickness of Shell	TCA	0.0206	in.
Outside Diameter of Shell	ODCA	14.000	in.
Design Length of Cylinder or Cone	SLEN	2.000	in.
Diameter / Thickness Ratio	(D/T)	678.5862	
Length / Diameter Ratio	LD	0.1429	
Geometry Factor, A f(DT,LD)	A	0.0005856	
Materials Factor, B, f(A, Chart)	B	7634.8965	psi
Maximum Allowable Working Pressure		15.00	psig

EMAWP = (4*B)/(3*(D/T)) = (4 *7634.8965)/(3 *678.5862) = 15.0016

Results for Maximum Length Calculation: No Conversion

Corroded Thickness of Shell	TCA	0.1880	in.
Outside Diameter of Shell	ODCA	14.000	in.
Design Length of Cylinder or Cone	SLEN	0.478E+20	in.
Diameter / Thickness Ratio	(D/T)	74.4681	
Length / Diameter Ratio	LD	50.0000	
Geometry Factor, A f(DT,LD)	A	0.0001984	
Materials Factor, B, f(A, Chart)	B	2777.0288	psi
Maximum Allowable Working Pressure		49.72	psig

EMAWP = (4*B)/(3*(D/T)) = (4 *2777.0288)/(3 *74.4681) = 49.7220

Summary of External Pressure Results:

Allowable Pressure at Corroded thickness	256.50	psig
Required Pressure as entered by User	15.00	psig
Required Thickness including Corrosion all.	0.0206	in.
Actual Thickness as entered by User	0.1880	in.
Maximum Length for Thickness and Pressure	0.4785E+20	in.
Actual Length as entered by User	2.00	in.

UG-40, Limits of Reinforcement : Internal Pressure

Effective material diameter limit,	DL	27.248	in.
Effective material thickness limit, no pad	TLNP	0.469	in.

Results of Nozzle Reinforcement Area Calculations:

Area Available, A1 to A5		Design	External	Mapnc	
Area Required	Ar	0.206	0.805	NA	in²
Area in Shell	A1	2.339	0.947	NA	in²
Area in Nozzle Wall	A2	0.142	0.131	NA	in²
Area in Inward Nozzle	A3	0.000	0.000	NA	in²
Area in Welds	A4	0.052	0.052	NA	in²
Area in Pad	A5	0.000	0.000	NA	in²
Total Area Available	Atot	2.533	1.130	NA	in²

External Pressure Case Governs the Analysis

Nozzle Tangent Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle:
Ar = 0.5*(DLR*TR+2*THK*TR*(1-FFR1)) per UG-37(d) or UG-39
Ar = 0.5*(13.6240*0.1177+2*(0.1880-0.0000)*0.1177*(1.00-0.83))
Ar = 0.805 in²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Nozzle Opening size:
Area Available in Shell (A1):
A1 = (DL-DLR)*(ES*(T-CAS)-TR)-2*(THK-CAN)*(ES*(T-CAS)-TR)*(1-FFR1)
A1 = (27.248-13.624)*(1.00*(0.1875-0.000)-0.118)-2*(0.188-0.000)
(1.00(0.1875-0.0000)-0.1177)*(1.0-0.83)
A1 = 0.947 in²

Area Available in Nozzle Wall, no Pad:
A2np = (2 * MIN(TLNP,HO)) * (THK - CAN - TRN) * FFR2
A2np = (2 * 0.4688) * (0.1880 - 0.0000 - 0.0206) * 0.83)
A2np = 0.131 in²

Area Available in Welds, no Pad:
A4np = (Wo^2 - Area Lost)*FFR2 + ((Wi-Can/0.707)^2 - Area Lost)*FFR2
A4np = (0.2500^2 - 0.0000) * 0.8350 + (0.1880^2 -0.0353) * 0.8350
A4np = 0.052 in²

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
Wall Thickness for Internal/External pressures ta = 0.0206 in.
Wall Thickness per UG16(b), tr16b = 0.0625 in.
Wall Thickness, shell/head, internal pressure trb1 = 0.0257 in.
Wall Thickness tb1 = max(trb1, tr16b) = 0.0625 in.
Wall Thickness, shell/head, external pressure trb2 = 0.0151 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(0.063 , 0.063)]
= 0.0625 in.

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)
= max(0.0206 , 0.0625)
= 0.0625 in.

Available Nozzle Neck Thickness = 0 875 * 0 1874 = 0.1640 in. --> OK

Weight of Nozzle, Nozzle Neck Only, Uncorroded 5.17 lb.
Weight of Nozzle, Nozzle Neck Only, Corroded 5.17 lb.

Note: Shell MDMT skipped as Shell is not a Carbon Steel.

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

Note: Nozzle-Shell Weld for Nozzle skipped as it is not a Carbon Steel.

Note: Could not compute Nozzle MDMT. Either the materials are impact tested

or an error was encountered.

Weld Size Calculations, Nozzle Number 1, Desc.: 14"OD Tube Nozz

Intermediate Calcs. for nozzle/shell welds Tmin 0.1875 in.

Results Per UW-16.1:

	Required Thickness	Actual Thickness	
Nozzle Weld	0.1312 = 0.7 * Tmin	0.1768 = 0.707 * WO	, in.
Total Weld	0.2344 = 1.25 * Tmin	0.3097 = 0.707*WO+0.7	, in.

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

Weld Load [W]:
```
= (AR-A1+2*(THK-Can)*Ffr1*(E1(T-Cas)-Tr))*S
= (0.8052 - 0.9471 + 2 * ( 0.1880 - 0.0000 ) * 0.8350 *
  (1.00 * ( 0.1875 - 0.0000 ) - 0.1177 ) ) * 20000
= 0.00 lb.
```

Weld Load [W1]:
```
= (A2+A5+A4-(WI-CAN/.707)^2*Ffr2)*S
= ( 0.1310 + 0.0000 + 0.0522 - 0.0353 * 0.83 ) * 20000
= 3073.87 lb.
```

Weld Load [W2]:
```
= (A2+A3+A4+(2*(THK-CAN)*(T-CAS)*Fr1))*S
= ( 0.1310 + 0.0000 + 0.0522 + 0.0589 ) * 20000
= 4841.47 lb.
```

Weld Load [W3]:
```
= (A2+A3+A4+A5+(2*(THK-CAN)*(T-CAS)*Fr1))*S
= ( 0.1310 + 0.0000 + 0.0000 + 0.0522 + 0.0589 ) * 20000
= 4841.47 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 * 0.2500 * 0.49 * 16700
= 44988. lb.
```

Shear, Inward Nozzle Weld [Sinw]:
```
= (PI/2) * Dlo * Wo * 0.49 * Snw
= ( 3.1416 / 2.0 ) * 14.0000 * 0.1880 * 0.49 * 16700
= 33831. lb.
```

Shear, Nozzle Wall [Snw]:
```
= (PI * (DLR+Dlo) /4.0) * (THK-Can) * 0.7 * Sn
= ( 3.1416 * 6.9060 ) * ( 0.1880 - 0.0000 ) * 0.7 * 16700
= 47681. lb.
```

Strength of Failure Paths:
```
PATH11 = ( Sonw + Snw ) = ( 44988 + 47681 ) = 92669 lb.
PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
       = ( 44988 + 0 + 0 + 33831 ) = 78819 lb.
PATH33 = ( Sonw + Tngw + Sinw )
       = ( 44988 + 0 + 33831 ) = 78819 lb.
```

Summary of Failure Path Calculations:

Path 1-1 = 92669 lb., must exceed W = 0 lb. or W1 = 3073 lb.
Path 2-2 = 78819 lb., must exceed W = 0 lb. or W2 = 4841 lb.

Path 3-3 = 78819 lb., must exceed W = 0 lb. or W3 = 4841 lb.

Percent Elongation Calculations:

Percent Elongation per UHA-44 (50 * tnom/Rf * (1-Rf/Ro)) 1.361 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

M.A.W.P. Results Based on Areas, Head and Nozzle neck:

Converged M.A.W.P for given geometry	AMAWP	99.100	psig
Best M.A.P.(NC) for given geometry	AMAPnc	96.520	psig

Note: To determine if the nozzle is governing the design, Compare Nozzle MAWP/MAPnc with that of the Head computed from the Shell/Head Module

Input Echo, Nozzle Item 2, Description: 8"OD Tube

Design Internal Pressure (Case 1)	P	15.00	psig
Temperature for Internal Pressure	TEMP	100.00	F
Design External Pressure (Case 2)	PEXT	15.00	psig
Temperature for External Pressure	TEMPEX	100.00	F
Include Hydrostatic Head Components		NO	
Shell or Head Material (Not Normalized or NA)		SA-240 304	
Material UNS Number		S30400	
Shell/Head Allowable Stress at Temperature	S	20000.00	psi
Shell/Head Allowable Stress At Ambient	SA	20000.00	psi
Shell/Head Yield Stress at Temperature	Sy	30000.00	psi
Outside Diameter of Cylindrical Shell	D	40.000	in.
Design Length of Section	L	6.000	in.
Actual Thickness of Shell or Head	T	0.1875	in.
Corrosion Allowance for Shell or Head	CAS	0.0000	in.
Is this Nozzle a Radial Nozzle		YES	
Is this Nozzle a Lateral Nozzle (Y-angle)		NO	
Nozzle Material (Not Normalized or NA)		SA-249 TP304L	
Material UNS Number		S30403	
Nozzle Allowable Stress at Temperature	SN	14200.00	psi
Nozzle Allowable Stress At Ambient	SNA	14200.00	psi
Diameter Basis for Nozzle	BASISN	OD	
Outside Diameter of Nozzle	DIA	8.000	in.
Nozzle Size and Thickness Basis	DBN	Actual	
Actual Thickness of Nozzle	THK	0.1080	in.
Corrosion Allowance for Nozzle	CAN	0.0000	in.
Joint Efficiency of Shell Seam at Nozzle	ES	1.00	
Joint Efficiency of Nozzle Neck	EN	1.00	
Insert or Abutting Nozzle Type	NTYP	Insert	
Outward Projection of Nozzle	HO	3.000	in.
Weld leg size between Nozzle and Pad/Shell	WO	0.1250	in.
Groove weld depth between Nozzle and Vessel	WGNV	0.0000	in.
Inside Projection of Nozzle	H	0.1250	in.
Weld leg size, Inside Nozzle to Shell	WI	0.1250	in.
ASME Code Weld Type per UW-16.1		K	
Method used for checking Nozzle opening		UG-37	
Method used for checking Large Nozzles		App. 1-10	
Is this is Manway/Access/Inspection Opening		No	
Skip Iterative Failure Thickness Calculations		Yes	

Reinforcement CALCULATION, Description: 8"OD Tube

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

Actual Outside Diameter Used in Calculation	8.000	in.
Actual Thickness Used in Calculation	0.108	in.

Internal Pressure Results for SHELL/HEAD :

Reqd thk per UG-37(a) of Cylindrical Shell, Tr Internal Pressure
Thickness Due to Internal Pressure:
= (P*(D/2-CAE)) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (15.00*(40.0000/2-0.000)/(20000.00*1.00+0.4*15.00)
= 0.0150 + 0.0000 = 0.0150 in.

External Pressure Results for SHELL/HEAD :

Summary of External Pressure Results:

Allowable Pressure at Corroded thickness	79.13	psig
Required Pressure as entered by User	15.00	psig
Required Thickness including Corrosion all.	0.0601	in.
Actual Thickness as entered by User	0.1875	in.
Maximum Length for Thickness and Pressure	98.574	in.
Actual Length as entered by User	6.00	in.

Internal Pressure Results for NOZZLE :

Reqd thk per UG-37(a) of Nozzle Wall, Trn Internal Pressure
Thickness Due to Internal Pressure:
= (P*(D/2-CAE)) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (15.00*(8.0000/2-0.000)/(14200.00*1.00+0.4*15.00)
= 0.0042 + 0.0000 = 0.0042 in.

External Pressure Results for Nozzle per UG-28 :

Summary of External Pressure Results:

Allowable Pressure at Corroded thickness	223.32	psig
Required Pressure as entered by User	15.00	psig
Required Thickness including Corrosion all.	0.0173	in.
Actual Thickness as entered by User	0.1080	in.
Maximum Length for Thickness and Pressure	0.7567E+20	in.
Actual Length as entered by User	3.00	in.

UG-40, Limits of Reinforcement : Internal Pressure

Effective material diameter limit,	DL	15.568	in.
Effective material thickness limit, no pad	TLNP	0.270	in.

Results of Nozzle Reinforcement Area Calculations:

Area Available, A1 to A5		Design	External	Mapnc	
Area Required	Ar	0.118	0.236	NA	in²
Area in Shell	A1	1.332	0.984	NA	in²
Area in Nozzle Wall	A2	0.040	0.035	NA	in²
Area in Inward Nozzle	A3	0.019	0.019	NA	in²
Area in Welds	A4	0.022	0.022	NA	in²
Area in Pad	A5	0.000	0.000	NA	in²
Total Area Available	Atot	1.413	1.060	NA	in²

External Pressure Case Governs the Analysis

Nozzle Tangent Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle:
Ar = 0.5*(DLR*TR+2*THK*TR*(1-FFR1)) per UG-37(d) or UG-39

Ar = 0.5*(7.7840*0.0601+2*(0.1080-0.0000)*0.0601*(1.00-0.71))
Ar = 0.236 in²

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Nozzle Opening size:
Area Available in Shell (A1):
A1 = (DL-DLR)*(ES*(T-CAS)-TR)-2*(THK-CAN)*(ES*(T-CAS)-TR)*(1-FFR1)
A1 = (15.568-7.784)*(1.00*(0.1875-0.000)-0.060)-2*(0.108-0.000)
(1.00(0.1875-0.0000)-0.0601)*(1.0-0.71)
A1 = 0.984 in²

Area Available in Nozzle Wall, no Pad:
A2np = (2 * MIN(TLNP,HO)) * (THK - CAN - TRN) * FFR2
A2np = (2 * 0.2700) * (0.1080 - 0.0000 - 0.0173) * 0.71)
A2np = 0.035 in²

Area Available in Nozzle Penetration:
A3 = 2 * (TN-CAN-CAN) * MIN(H-CAN, TL, 2.5*(TN-CAN-CAN)) * FFR2
A3 = 2 * (0.1080) * (0.1250) * 0.71
A3 = 0.019 in²

Area Available in Welds, no Pad:
A4np = Wo^2*FFR2 + (Wi-Can/0.707)^2*FFR2
A4np = 0.1250^2 * 0.7100 + (0.1250)^2 * 0.7100
A4np = 0.022 in²

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 = 0.0150 in.
Wall Thickness tb1 = max(trb1, tr16b) = 0.0625 in.
Wall Thickness, shell/head, external pressure trb2 = 0.0150 in.
Wall Thickness tb2 = max(trb2, tr16b) = 0.0625 in.
Wall Thickness per table UG-45 tb3 = 0.2820 in.

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[0.282 , max(0.063 , 0.063)]
= 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 = 0.1080 in. --> OK

Weight of Nozzle, Nozzle Neck Only, Uncorroded 2.57 lb.
Weight of Nozzle, Nozzle Neck Only, Corroded 2.57 lb.

Note: Shell MDMT skipped as Shell is not a Carbon Steel.

Note: Nozzle to Flange Weld skipped as Nozzle is not a Carbon Steel

Note: Nozzle-Shell Weld for Nozzle skipped as it is not a Carbon Steel.

Note: Could not compute Nozzle MDMT Either the materials are impact tested or an error was encountered.

Weld Size Calculations, Nozzle Number 2, Desc.: 8"OD Tube

Intermediate Calcs. for nozzle/shell welds Tmin 0.1080 in.
Intermediate Calcs. for nozzle/shell Inside weld TminInt 0.1080 in.

Results Per UW-16.1:

	Required Thickness	Actual Thickness	
Nozzle Weld	0.0756 = 0.7 * Tmin	0.0884 = 0.707 * WO	, in.
Inward Weld	0.0756 = 0.7*TminIns	0.0884 = 0.707 * WI-CAN	, in.
Total Weld	0.1350 = 1.25 * Tmin	0.1768 = 0.707*WO+0.7	, in.

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

Weld Load [W]:
```
= (AR-A1+2*(THK-Can)*Ffr1*(E1(T-Cas)-Tr))*S
= (0.2358 - 0.9837 + 2 * ( 0.1080 - 0.0000 ) * 0.7100 *
  (1.00 * ( 0.1875 - 0.0000 ) - 0.0601 ) ) * 20000
= 0.00 lb.
```

Weld Load [W1]:
```
= (A2+A5+A4-(WI-CAN/.707)^2*Ffr2)*S
= ( 0.0348 + 0.0000 + 0.0222 - 0.0156 * 0.71 ) * 20000
= 917.02 lb.
```

Weld Load [W2]:
```
= (A2+A3+A4+(2*(THK-CAN)*(T-CAS)*Fr1))*S
= ( 0.0348 + 0.0192 + 0.0222 + 0.0288 ) * 20000
= 2097.40 lb.
```

Weld Load [W3]:
```
= (A2+A3+A4+A5+(2*(THK-CAN)*(T-CAS)*Fr1))*S
= ( 0.0348 + 0.0192 + 0.0000 + 0.0222 + 0.0288 ) * 20000
= 2097.40 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 ) * 8.0000 * 0.1250 * 0.49 * 14200
= 10930. lb.
```

Shear, Inward Nozzle Weld [Sinw]:
```
= (PI/2) * Dlo * Wo * 0.49 * Snw
= ( 3.1416 / 2.0 ) * 8.0000 * 0.1250 * 0.49 * 14200
= 10930. lb.
```

Shear, Nozzle Wall [Snw]:
```
= (PI * (DLR+Dlo) /4.0) * (THK-Can) * 0.7 * Sn
= ( 3.1416 * 3.9460 ) * ( 0.1080 - 0.0000 ) * 0.7 * 14200
= 13308. lb.
```

Strength of Failure Paths:
```
PATH11 = ( Sonw + Snw ) = ( 10929 + 13308 ) = 24237 lb.
PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
       = ( 10929 + 0 + 0 + 10929 ) = 21859 lb.
PATH33 = ( Sonw + Tngw + Sinw )
       = ( 10929 + 0 + 10929 ) = 21859 lb.
```

Summary of Failure Path Calculations:

Path 1-1 = 24237 lb., must exceed W = 0 lb. or W1 = 917 lb.
Path 2-2 = 21859 lb., must exceed W = 0 lb. or W2 = 2097 lb.
Path 3-3 = 21859 lb., must exceed W = 0 lb. or W3 = 2097 lb.

Percent Elongation Calculations:

Percent Elongation per UHA-44 (50 * tnom/Rf * (1-Rf/Ro)) 1.368 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

M.A.W.P. Results Based on Areas, Shell and Nozzle neck:

Best M.A.W.P for given geometry	AMAWP	97.800	psig
Best M.A.P.(NC) for given geometry	AMAPnc	97.800	psig

Note: To determine if the nozzle is governing the design, Compare Nozzle MAWP/MAPnc with that of the Shell computed from the Shell/Head Module

Input Echo, Component 1, Description: 40" OD Shell

Design Internal Pressure	P	15.00	psig
Temperature for Internal Pressure		100.00	F
User Entered Minimum Design Metal Temperature		-20.00	F
Design External Pressure	PEXT	15.00	psig
Temperature for External Pressure		100.00	F
External Pressure Chart Name		CS-2	
Include Hydrostatic Head Components		NO	
Material Specification (Not Normalized)		SA-516 70	
Material UNS Number		K02700	
Material Form used		Plate	
Allowable Stress At Temperature	S	20000.00	psi
Allowable Stress At Ambient	SA	20000.00	psi
Yield Stress At Temperature	Sy	38000.00	psi
Curve Name for Chart UCS 66		B	
Joint efficiency for Shell Joint	E	0.70	
Maximum Thickness before Full Radiography		1.2500	in.
Design Length of Section	L	76.000	in.
Length of Cylinder for Volume Calcs.	CYLLEN	76.000	in.
Outside Diameter of Cylindrical Shell	D	40.000	in.
Minimum Thickness of Pipe or Plate	T	0.1875	in.
Nominal Thickness of Pipe or Plate	Tnom	0.1875	in.
Shell/Head Int. Corrosion Allowance	CA	0.0000	in.
Skip UG-16(b) Min. thickness calculation		NO	
Type of Element:		Cylindrical Shell	

Internal pressure results, Shell Number 1, Desc.: 40" OD Shell

ASME Code, Section VIII, Division 1, 2013

Thickness Due to Internal Pressure (Tr):
= (P*(D/2-CAE)) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (15.00*(40.0000/2-0.000)/(20000.00*0.70+0.4*15.00)
= 0.0214 + 0.0000 = 0.0214 in.
= 0.0625 in. (Per Ug 16b)

Max All. Working Pressure at Given Thickness (MAWP):
= (S*E*(T-CA-CAE)) / ((D/2-CAE)-0.4*(T-CA-CAE)) per Appendix 1-1 (a)(1)
= (20000.00*0.70*(0.1875))/(40.0000/2-0.000-0.4*0.1875)
= 131.74 psig

Maximum Allowable Pressure, New and Cold (MAPNC):
= (SA*E*T) / (D/2-0.4*T) per Appendix 1-1 (a)(1)
= (20000.00*0.70*0.1875)/(40.0000/2-0.4*0.1875)
= 131.74 psig

Actual stress at given pressure and thickness (Sact):
= (P*((D/2-CAE)-0.4*(T-CA-CAE))) / (E*(T-CA-CAE))
= (15.00*(((40.0000/2-0.000)-0.4*(0.1875)))/(0.70*(0.1875))
= 2277.14 psi

SUMMARY OF INTERNAL PRESSURE RESULTS:

Required Thickness plus Corrosion Allowance, Trca		0.0625	in.
Actual Thickness as Given in Input		0.1875	in.
Maximum Allowable Working Pressure	MAWP	131.744	psig
Maximum Allowable Pressure, NC	MAPNC	131.744	psig
Design Pressure as Given in Input	P	15.000	psig

Hydrostatic Test Pressures (Measured at High Point):

Hydrotest per UG-99(b); 1.3 * MAWP * Sa/S	171.27	psig
Hydrotest per UG-99(c); 1.3 * MAPNC	171.27	psig
Pneumatic per UG-100 ; 1.1 * MAWP * Sa/S	144.92	psig

Percent Elongation per UCS-79 (50 * tnom/Rf * (1-Rf/Ro)) 0.471 %

Minimum Design Metal Temperature per UCS-66 Curve : B
tg = 0.188 , tg_sr = 0.188 , tr = 0.063 , c = 0.0000 in. , E* = 0.80
Stress Ratio = tr * (E*) / (tg_sr - c) = 0.267 , Temp. Reduction = 140 F

Min. Metal Temp. w/o impact per Fig. UCS-66	-20	F
Min. Metal Temp. at Req'd thk. (UCS 66.1)	-155	F
Min. Metal Temp. w/o impact per UG-20(f)	-20	F

External Pressure Results, Shell Number 1, Desc.: 40" OD Shell
ASME Code, Section VIII, Division 1, 2013

External Pressure Chart	CS-2	at 100.00	F
Elastic Modulus for Material		29000000.00	psi

Results for Max. Allowable External Pressure (Emawp):

Corroded Thickness of Shell	TCA	0.1875	in.
Outside Diameter of Shell	ODCA	40.000	in.
Design Length of Cylinder or Cone	SLEN	76.000	in.
Diameter / Thickness Ratio	(D/T)	213.3333	
Length / Diameter Ratio	LD	1.9000	
Geometry Factor, A f(DT,LD)	A	0.0002232	
Materials Factor, B, f(A, Chart)	B	3236.4558	psi
Maximum Allowable Working Pressure		20.23	psig

EMAWP = (4*B)/(3*(D/T)) = (4 *3236.4558)/(3 *213.3333) = 20.2278

Results for Reqd Thickness for Ext. Pressure (Tca):

Corroded Thickness of Shell	TCA	0.1664	in.
Outside Diameter of Shell	ODCA	40.000	in.
Design Length of Cylinder or Cone	SLEN	76.000	in.
Diameter / Thickness Ratio	(D/T)	240.3421	
Length / Diameter Ratio	LD	1.9000	
Geometry Factor, A f(DT,LD)	A	0.0001865	
Materials Factor, B, f(A, Chart)	B	2703.9521	psi
Maximum Allowable Working Pressure		15.00	psig

EMAWP = (4*B)/(3*(D/T)) = (4 *2703.9521)/(3 *240.3421) = 15.0006

Results for Maximum Length Between Stiffeners (Slen):

Corroded Thickness of Shell	TCA	0.1875	in.
Outside Diameter of Shell	ODCA	40.000	in.
Design Length of Cylinder or Cone	SLEN	102.051	in.
Diameter / Thickness Ratio	(D/T)	213.3333	
Length / Diameter Ratio	LD	2.5513	
Geometry Factor, A f(DT,LD)	A	0.0001655	
Materials Factor, B, f(A, Chart)	B	2400.1755	psi

Maximum Allowable Working Pressure 15.00 psig
EMAWP = (4*B)/(3*(D/T)) = (4 *2400.1755)/(3 *213.3333) = 15.0011

Summary of External Pressure Results:

Allowable Pressure at Corroded thickness		20.23	psig
Required Pressure as entered by User		15.00	psig
Required Thickness including Corrosion all.		0.1664	in.
Actual Thickness as entered by User		0.1875	in.
Maximum Length for Thickness and Pressure		102.051	in.
Actual Length as entered by User		76.00	in.

Weight and Volume Results, No C.A. :

Volume of Shell Component	VOLMET	1782.3	in.^3
Weight of Shell Component	WMET	499.0	lb.
Inside Volume of Component	VOLID	93722.1	in.^3
Weight of Water in Component	WWAT	3384.4	lb.

Input Echo, Component 2, Description: 40in Tori head

Design Internal Pressure	P	15.00	psig
Temperature for Internal Pressure		100.00	F
User Entered Minimum Design Metal Temperature		-20.00	F
Design External Pressure	PEXT	15.00	psig
Temperature for External Pressure		100.00	F
External Pressure Chart Name		CS-2	
Include Hydrostatic Head Components		NO	
Material Specification (Not Normalized)		SA-516 70	
Material UNS Number		K02700	
Material Form used		Plate	
Allowable Stress At Temperature	S	20000.00	psi
Allowable Stress At Ambient	SA	20000.00	psi
Yield Stress At Temperature	Sy	38000.00	psi
Curve Name for Chart UCS 66		B	
Joint efficiency for Head Joint	E	0.85	
Maximum Thickness before Full Radiography		1.2500	in.
Outside Diameter of Torispherical Head	D	40.000	in.
Minimum Thickness of Pipe or Plate	T	0.1875	in.
Nominal Thickness of Pipe or Plate	Tnom	0.1875	in.
Shell/Head Int. Corrosion Allowance	CA	0.0000	in.
Inside Crown Radius of Tori. Head	L	40.000	in.
Inside Knuckle Radius of Tori. Head	r	2.750	in.
Length of Straight Flange	STRTFLG	2.0000	in.
Skip UG-16(b) Min. thickness calculation		NO	
Type of Element:		Torispherical Head	

Internal pressure results, Shell Number 2, Desc.: 40in Tori head

ASME Code, Section VIII, Division 1, 2013

M factor for Torispherical Heads [M]:
= (3+Sqrt((L+Ca)/(r+Ca)))/4 per Appendix 1-4 (b & d)
= (3+SQRT((40.000 +0.0000)/(2.750 +0.0000)))/4
= 1.7035

Thickness Due to Internal Pressure (Tr):
= (P*(L+T-CAE)*M) / (2*S*E+P*(M-0.2)) per Appendix 1-4 (d)
= (15.00*40.1875*1.7035)/(2*20000.00*0.85+15.00*(1.7035-0.2))
= 0.0302 + 0.0000 = 0.0302 in.
= 0.0625 in. (Per Ug 16b)

Max All. Working Pressure at Given Thickness (MAWP):
= (2*S*E*(T-CA-CAE)) / (M*(L+T-CAE)-(T-CA-CAE)*(M-0.2)) per Appendix 1-4(d)
= (2*20000.00*0.85*(0.1875))/(1.7035*40.1875-(0.1875)*(1.70-0.2))
= 93.51 psig

Maximum Allowable Pressure, New and Cold (MAPNC):
= (2*SA*E*T) / (M*(L+T)-T*(M-0.2)) per Appendix 1-4 (d)
= (2*20000.00*0.85*0.1875)/(1.7035*40.1875-0.1875*(1.70-0.2))

= 93.51 psig

Actual stress at given pressure and thickness (Sact):
= (P*(M*(L+T-CAE)-(T-CA-CAE)*(M-0.2))) / (2*E*(T-CA-CAE))
= (15.00*(1.7035*40.1875-(0.1875)*(1.7035-0.2)))/(2*0.85*(0.1875))
= 3208.28 psi

SUMMARY OF INTERNAL PRESSURE RESULTS:

Required Thickness plus Corrosion Allowance, Trca		0.0625	in.
Actual Thickness as Given in Input		0.1875	in.
Maximum Allowable Working Pressure	MAWP	93.508	psig
Maximum Allowable Pressure, NC	MAPNC	93.508	psig
Design Pressure as Given in Input	P	15.000	psig

Hydrostatic Test Pressures (Measured at High Point):

Hydrotest per UG-99(b); 1.3 * MAWP * Sa/S	121.56	psig
Hydrotest per UG-99(c); 1.3 * MAPNC	121.56	psig
Pneumatic per UG-100 ; 1.1 * MAWP * Sa/S	102.86	psig

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 4.945 %

Minimum Design Metal Temperature per UCS-66 Curve : B
tg = 0.188 , tg_sr = 0.188 , tr = 0 063 , c = 0.0000 in. , E* = 0 85
Stress Ratio = tr * (E*) / (tg_sr - c) = 0.283 , Temp. Reduction = 140 F

Min. Metal Temp. w/o impact per Fig. UCS-66	-20	F
Min. Metal Temp. at Req'd thk. (UCS 66.1)	-155	F
Min. Metal Temp. w/o impact per UG-20(f)	-20	F

External Pressure Results, Shell Number 2, Desc.: 40in Tori head
ASME Code, Section VIII, Division 1, 2013

External Pressure Chart	CS-2 at	100.00	F
Elastic Modulus for Material		29000000.00	psi

Results for Max. Allowable External Pressure (Emawp):

Corroded Thickness of Head	TCA	0.1875	in.
Outside Crown Radius	Ro	40.188	in.
Crown Rad / Thickness Ratio	(Ro/T)	214.3333	
Geometry Factor, A (.125/(Ro/T))	A	0.0005832	
Materials Factor, B, f(A, Chart)	B	8456.4541	psi
Maximum Allowable Working Pressure		39.45	psig

EMAWP = B/(Ro/T) = 8456.4541 /214.3333 = 39.4547

Results for Reqd Thickness for Ext. Pressure (Tca):

Corroded Thickness of Head	TCA	0.1156	in.
Outside Crown Radius	Ro	40.188	in.
Crown Rad / Thickness Ratio	(Ro/T)	347.6020	
Geometry Factor, A (.125/(Ro/T))	A	0.0003596	
Materials Factor, B, f(A, Chart)	B	5214.2969	psi
Maximum Allowable Working Pressure		15.00	psig

EMAWP = B/(Ro/T) = 5214.2969 /347.6020 = 15.0008

Summary of External Pressure Results:

Allowable Pressure at Corroded thickness	39.45	psig
Required Pressure as entered by User	15.00	psig
Required Thickness including Corrosion all.	0.1156	in.
Actual Thickness as entered by User	0.1875	in.

Weight and Volume Results, No C.A. :

Volume of Shell Component	VOLMET	328.3	in.^3
Weight of Shell Component	WMET	91.9	lb.
Inside Volume of Component	VOLID	5276.3	in.^3
Weight of Water in Component	WWAT	279.6	lb.
Inside Vol. of 2.00 in. Straight	VOLSCA	2466.4	in.^3
Total Volume for Head + Straight	VOLTOT	7742.7	in.^3

Input Echo, Component 3, Description: 62"OD Shell

Design Internal Pressure	P	15.00	psig
Temperature for Internal Pressure		100.00	F
User Entered Minimum Design Metal Temperature		-20.00	F
Design External Pressure	PEXT	15.00	psig
Temperature for External Pressure		100.00	F
External Pressure Chart Name		CS-2	
Include Hydrostatic Head Components		NO	
Material Specification (Not Normalized)		SA-516 70	
Material UNS Number		K02700	
Material Form used		Plate	
Allowable Stress At Temperature	S	20000.00	psi
Allowable Stress At Ambient	SA	20000.00	psi
Yield Stress At Temperature	Sy	38000.00	psi
Curve Name for Chart UCS 66		B	
Joint efficiency for Shell Joint	E	0.70	
Maximum Thickness before Full Radiography		1.2500	in.
Design Length of Section	L	72.000	in.
Length of Cylinder for Volume Calcs.	CYLLEN	72.000	in.
Outside Diameter of Cylindrical Shell	D	62.000	in.
Minimum Thickness of Pipe or Plate	T	0.2500	in.
Nominal Thickness of Pipe or Plate	Tnom	0.2500	in.
Shell/Head Int. Corrosion Allowance	CA	0.0000	in.
Skip UG-16(b) Min. thickness calculation		NO	
Type of Element:		Cylindrical Shell	

Internal pressure results, Shell Number 3, Desc.: 62"OD Shell
ASME Code, Section VIII, Division 1, 2013

Thickness Due to Internal Pressure (Tr):
= (P*(D/2-CAE)) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (15.00*(62.0000/2-0.000)/(20000.00*0.70+0.4*15.00)
= 0.0332 + 0.0000 = 0.0332 in.
= 0.0625 in. (Per Ug 16b)

Max. All. Working Pressure at Given Thickness (MAWP):
= (S*E*(T-CA-CAE)) / ((D/2-CAE)-0.4*(T-CA-CAE)) per Appendix 1-1 (a)(1)
= (20000.00*0.70*(0.2500))/(62.0000/2-0.000-0.4*0.2500)
= 113.27 psig

Maximum Allowable Pressure, New and Cold (MAPNC):
= (SA*E*T) / (D/2-0.4*T) per Appendix 1-1 (a)(1)
= (20000.00*0.70*0.2500)/(62.0000/2-0.4*0.2500)
= 113.27 psig

Actual stress at given pressure and thickness (Sact):
= (P*((D/2-CAE)-0.4*(T-CA-CAE))) / (E*(T-CA-CAE))
= (15.00*(((62.0000/2-0.000)-0.4*(0.2500)))/(0.70*(0.2500))
= 2648.57 psi

SUMMARY OF INTERNAL PRESSURE RESULTS:

Required Thickness plus Corrosion Allowance, Trca		0.0625	in.
Actual Thickness as Given in Input		0.2500	in.
Maximum Allowable Working Pressure	MAWP	113.269	psig
Maximum Allowable Pressure, NC	MAPNC	113.269	psig
Design Pressure as Given in Input	P	15.000	psig

Hydrostatic Test Pressures (Measured at High Point):

Hydrotest per UG-99(b); 1.3 * MAWP * Sa/S	147.25	psig
Hydrotest per UG-99(c); 1.3 * MAPNC	147.25	psig
Pneumatic per UG-100 ; 1.1 * MAWP * Sa/S	124.60	psig

Percent Elongation per UCS-79 (50 * tnom/Rf * (1-Rf/Ro)) 0.405 %

Minimum Design Metal Temperature per UCS-66 Curve : B
tg = 0.250 , tg_sr = 0.250 , tr = 0 063 , c = 0.0000 in. , E* = 0 80
Stress Ratio = tr * (E*) / (tg_sr - c) = 0.200 , Temp Reduction = 140 F

Min. Metal Temp. w/o impact per Fig. UCS-66	-20	F
Min. Metal Temp. at Req'd thk. (UCS 66.1)	-155	F
Min. Metal Temp. w/o impact per UG-20(f)	-20	F

External Pressure Results, Shell Number 3, Desc.: 62"OD Shell
ASME Code, Section VIII, Division 1, 2013

External Pressure Chart	CS-2	at 100.00	F
Elastic Modulus for Material		29000000.00	psi

Results for Max. Allowable External Pressure (Emawp):

Corroded Thickness of Shell	TCA	0.2500	in.
Outside Diameter of Shell	ODCA	62.000	in.
Design Length of Cylinder or Cone	SLEN	72.000	in.
Diameter / Thickness Ratio	(D/T)	248.0000	
Length / Diameter Ratio	LD	1.1613	
Geometry Factor, A f(DT,LD)	A	0.0002939	
Materials Factor, B, f(A, Chart)	B	4261.0146	psi
Maximum Allowable Working Pressure		22.91	psig

EMAWP = (4*B)/(3*(D/T)) = (4 *4261.0146)/(3 *248.0000) = 22.9087

Results for Reqd Thickness for Ext. Pressure (Tca):

Corroded Thickness of Shell	TCA	0.2112	in.
Outside Diameter of Shell	ODCA	62.000	in.
Design Length of Cylinder or Cone	SLEN	72.000	in.
Diameter / Thickness Ratio	(D/T)	293.5300	
Length / Diameter Ratio	LD	1.1613	
Geometry Factor, A f(DT,LD)	A	0.0002278	
Materials Factor, B, f(A, Chart)	B	3302.3821	psi
Maximum Allowable Working Pressure		15.00	psig

EMAWP = (4*B)/(3*(D/T)) = (4 *3302.3821)/(3 *293.5300) = 15.0008

Results for Maximum Length Between Stiffeners (Slen):

Corroded Thickness of Shell	TCA	0.2500	in.
Outside Diameter of Shell	ODCA	62.000	in.
Design Length of Cylinder or Cone	SLEN	109.022	in.
Diameter / Thickness Ratio	(D/T)	248.0000	
Length / Diameter Ratio	LD	1.7584	
Geometry Factor, A f(DT,LD)	A	0.0001924	
Materials Factor, B, f(A, Chart)	B	2790.1436	psi

Maximum Allowable Working Pressure 15.00 psig
EMAWP = (4*B)/(3*(D/T)) = (4 *2790.1436)/(3 *248.0000) = 15.0008

Summary of External Pressure Results:

Allowable Pressure at Corroded thickness		22.91	psig
Required Pressure as entered by User		15.00	psig
Required Thickness including Corrosion all.		0.2112	in.
Actual Thickness as entered by User		0.2500	in.
Maximum Length for Thickness and Pressure		109.022	in.
Actual Length as entered by User		72.00	in.

Weight and Volume Results, No C.A. :

Volume of Shell Component	VOLMET	3491.9	in.^3
Weight of Shell Component	WMET	977.7	lb.
Inside Volume of Component	VOLID	213881.2	in.^3
Weight of Water in Component	WWAT	7723.5	lb.

Input Echo, Component 4, Description: 62" Tori Head

Design Internal Pressure	P	15.00	psig
Temperature for Internal Pressure		100.00	F
User Entered Minimum Design Metal Temperature		-20.00	F
Design External Pressure	PEXT	15.00	psig
Temperature for External Pressure		100.00	F
External Pressure Chart Name		CS-2	
Include Hydrostatic Head Components		NO	
Material Specification (Not Normalized)		SA-516 70	
Material UNS Number		K02700	
Material Form used		Plate	
Allowable Stress At Temperature	S	20000.00	psi
Allowable Stress At Ambient	SA	20000.00	psi
Yield Stress At Temperature	Sy	38000.00	psi
Curve Name for Chart UCS 66		B	
Joint efficiency for Head Joint	E	0.85	
Maximum Thickness before Full Radiography		1.2500	in.
Outside Diameter of Torispherical Head	D	62.000	in.
Minimum Thickness of Pipe or Plate	T	0.1880	in.
Nominal Thickness of Pipe or Plate	Tnom	0.2500	in.
Shell/Head Int. Corrosion Allowance	CA	0.0000	in.
Inside Crown Radius of Tori. Head	L	62.000	in.
Inside Knuckle Radius of Tori. Head	r	3.750	in.
Length of Straight Flange	STRTFLG	2.0000	in.
Skip UG-16(b) Min. thickness calculation		NO	
Type of Element:		Torispherical Head	

Internal pressure results, Shell Number 4, Desc.: 62" Tori Head

ASME Code, Section VIII, Division 1, 2013

M factor for Torispherical Heads [M]:
= (3+Sqrt((L+Ca)/(r+Ca)))/4 per Appendix 1-4 (b & d)
= (3+SQRT((62.000 +0.0000)/(3.750 +0.0000)))/4
= 1.7665

Thickness Due to Internal Pressure (Tr):
= (P*(L+T-CAE)*M) / (2*S*E+P*(M-0.2)) per Appendix 1-4 (d)
= (15.00*62.1880*1.7665)/(2*20000.00*0.85+15.00*(1.7665-0.2))
= 0.0484 + 0.0000 = 0.0484 in.
= 0.0625 in. (Per Ug 16b)

Max All Working Pressure at Given Thickness (MAWP):
= (2*S*E*(T-CA-CAE)) / (M*(L+T-CAE)-(T-CA-CAE)*(M-0.2)) per Appendix 1-4(d)
= (2*20000.00*0.85*(0.1880))/(1.7665*62.1880-(0.1880)*(1.77-0.2))
= 58.34 psig

Maximum Allowable Pressure, New and Cold (MAPNC):
= (2*SA*E*T) / (M*(L+T)-T*(M-0.2)) per Appendix 1-4 (d)
= (2*20000.00*0.85*0.1880)/(1.7665*62.1880-0.1880*(1.77-0.2))

= 58.34 psig

Actual stress at given pressure and thickness (Sact):
= (P*(M*(L+T-CAE)-(T-CA-CAE)*(M-0.2))) / (2*E*(T-CA-CAE))
= (15.00*(1.7665*62.1880-(0.1880)*(1.7665-0.2)))/(2*0.85*(0.1880))
= 5142.17 psi

SUMMARY OF INTERNAL PRESSURE RESULTS:

Required Thickness plus Corrosion Allowance, Trca		0.0625	in.
Actual Thickness as Given in Input		0.1880	in.
Maximum Allowable Working Pressure	MAWP	58.341	psig
Maximum Allowable Pressure, NC	MAPNC	58.341	psig
Design Pressure as Given in Input	P	15.000	psig

Hydrostatic Test Pressures (Measured at High Point):

Hydrotest per UG-99(b); 1.3 * MAWP * Sa/S	75.84	psig
Hydrotest per UG-99(c); 1.3 * MAPNC	75.84	psig
Pneumatic per UG-100 ; 1.1 * MAWP * Sa/S	64.18	psig

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 4.839 %

Minimum Design Metal Temperature per UCS-66 Curve : B
tg = 0.188 , tg_sr = 0.188 , tr = 0 063 , c = 0.0000 in. , E* = 0 85
Stress Ratio = tr * (E*) / (tg_sr - c) = 0 283 , Temp. Reduction = 140 F

Min. Metal Temp. w/o impact per Fig. UCS-66	-20	F
Min. Metal Temp. at Req'd thk. (UCS 66.1)	-155	F
Min. Metal Temp. w/o impact per UG-20(f)	-20	F

External Pressure Results, Shell Number 4, Desc.: 62" Tori Head
ASME Code, Section VIII, Division 1, 2013

External Pressure Chart	CS-2 at	100.00	F
Elastic Modulus for Material		29000000.00	psi

Results for Max. Allowable External Pressure (Emawp):

Corroded Thickness of Head	TCA	0.1880	in.
Outside Crown Radius	Ro	62.188	in.
Crown Rad / Thickness Ratio	(Ro/T)	330.7872	
Geometry Factor, A (.125/(Ro/T))	A	0.0003779	
Materials Factor, B, f(A, Chart)	B	5479.3530	psi
Maximum Allowable Working Pressure		16.56	psig

EMAWP = B/(Ro/T) = 5479.3530 /330.7872 = 16.5646

Results for Reqd Thickness for Ext. Pressure (Tca):

Corroded Thickness of Head	TCA	0.1789	in.
Outside Crown Radius	Ro	62.188	in.
Crown Rad / Thickness Ratio	(Ro/T)	347.5945	
Geometry Factor, A (.125/(Ro/T))	A	0.0003596	
Materials Factor, B, f(A, Chart)	B	5214.4102	psi
Maximum Allowable Working Pressure		15.00	psig

EMAWP = B/(Ro/T) = 5214.4102 /347.5945 = 15.0014

Summary of External Pressure Results:

Allowable Pressure at Corroded thickness	16.56	psig
Required Pressure as entered by User	15.00	psig
Required Thickness including Corrosion all.	0.1789	in.
Actual Thickness as entered by User	0.1880	in.

Weight and Volume Results, No C.A. :

Volume of Shell Component	VOLMET	988.7	in.^3
Weight of Shell Component	WMET	276.8	lb.
Inside Volume of Component	VOLID	18977.4	in.^3
Weight of Water in Component	WWAT	900.7	lb.
Inside Vol. of 2.00 in. Straight	VOLSCA	5965.1	in.^3
Total Volume for Head + Straight	VOLTOT	24942.5	in.^3

Input Echo, Component 5, Description: 14 in nozzle

Design Internal Pressure	P	15.00	psig
Temperature for Internal Pressure		100.00	F
User Entered Minimum Design Metal Temperature		-20.00	F
Design External Pressure	PEXT	15.00	psig
Temperature for External Pressure		100.00	F
External Pressure Chart Name		HA-3	
Include Hydrostatic Head Components		NO	
Material Specification		SA-312 TP304L	
Material UNS Number		S30403	
Material Form used		Smls. & wld. pipe	
Allowable Stress At Temperature	S	16700.00	psi
Allowable Stress At Ambient	SA	16700.00	psi
Yield Stress At Temperature	Sy	25000.00	psi
Joint efficiency for Shell Joint	E	0.70	
Design Length of Section	L	4.000	in.
Length of Cylinder for Volume Calcs.	CYLLEN	4.000	in.
Outside Diameter of Cylindrical Shell	D	14.000	in.
Minimum Thickness of Pipe or Plate	T	0.1645	in.
Nominal Thickness of Pipe or Plate	Tnom	0.1880	in.
Shell/Head Int. Corrosion Allowance	CA	0.0000	in.
Skip UG-16(b) Min. thickness calculation		NO	
Type of Element:		Cylindrical Shell	

Internal pressure results, Shell Number 5, Desc.: 14 in nozzle
ASME Code, Section VIII, Division 1, 2013

Thickness Due to Internal Pressure (Tr):
= (P*(D/2-CAE)) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (15.00*(14.0000/2-0.000)/(16700.00*0.70+0.4*15.00)
= 0.0090 + 0.0000 = 0.0090 in.
= 0.0625 in. (Per Ug 16b)

Max. All. Working Pressure at Given Thickness (MAWP):
= (S*E*(T-CA-CAE)) / ((D/2-CAE)-0.4*(T-CA-CAE)) per Appendix 1-1 (a)(1)
= (16700.00*0.70*(0.1645))/(14.0000/2-0.000-0.4*0.1645)
= 277.32 psig

Maximum Allowable Pressure, New and Cold (MAPNC):
= (SA*E*T) / (D/2-0.4*T) per Appendix 1-1 (a)(1)
= (16700.00*0.70*0.1645)/(14.0000/2-0.4*0.1645)
= 277.32 psig

Actual stress at given pressure and thickness (Sact):
= (P*((D/2-CAE)-0.4*(T-CA-CAE))) / (E*(T-CA-CAE))
= (15.00*(((14.0000/2-0.000)-0.4*(0.1645)))/(0.70*(0.1645))
= 903.28 psi

SUMMARY OF INTERNAL PRESSURE RESULTS:
Required Thickness plus Corrosion Allowance, Trca 0.0625 in.

Actual Thickness as Given in Input		0.1645	in.
Maximum Allowable Working Pressure	MAWP	277.322	psig
Maximum Allowable Pressure, NC	MAPNC	277.322	psig
Design Pressure as Given in Input	P	15.000	psig

Hydrostatic Test Pressures (Measured at High Point):

Hydrotest per UG-99(b); 1.3 * MAWP * Sa/S	360.52	psig
Hydrotest per UG-99(c); 1.3 * MAPNC	360.52	psig
Pneumatic per UG-100 ; 1.1 * MAWP * Sa/S	305.05	psig

Percent Elongation per UHA-44 (50 * tnom/Rf * (1-Rf/Ro)) 1.361 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

External Pressure Results, Shell Number 5, Desc.: 14 in nozzle
ASME Code, Section VIII, Division 1, 2013

External Pressure Chart	HA-3 at	100.00	F
Elastic Modulus for Material		28000000.00	psi

Results for Max. Allowable External Pressure (Emawp):

Corroded Thickness of Shell	TCA	0.1645	in.
Outside Diameter of Shell	ODCA	14.000	in.
Design Length of Cylinder or Cone	SLEN	4.000	in.
Diameter / Thickness Ratio	(D/T)	85.1063	
Length / Diameter Ratio	LD	0.2857	
Geometry Factor, A f(DT,LD)	A	0.0069883	
Materials Factor, B, f(A, Chart)	B	12575.2842	psi
Maximum Allowable Working Pressure		197.01	psig

EMAWP = (4*B)/(3*(D/T)) = (4 *12575.2842)/(3 *85.1063) = 197.0130

Results for Reqd Thickness for Ext. Pressure (Tca):

Corroded Thickness of Shell	TCA	0.0271	in.
Outside Diameter of Shell	ODCA	14.000	in.
Design Length of Cylinder or Cone	SLEN	4.000	in.
Diameter / Thickness Ratio	(D/T)	517.1990	
Length / Diameter Ratio	LD	0.2857	
Geometry Factor, A f(DT,LD)	A	0.0004156	
Materials Factor, B, f(A, Chart)	B	5818.6499	psi
Maximum Allowable Working Pressure		15.00	psig

EMAWP = (4*B)/(3*(D/T)) = (4 *5818.6499)/(3 *517.1990) = 15.0004

Results for Maximum Length Calculation: No Conversion

Corroded Thickness of Shell	TCA	0.1645	in.
Outside Diameter of Shell	ODCA	14.000	in.
Design Length of Cylinder or Cone	SLEN	0.247E+16	in.
Diameter / Thickness Ratio	(D/T)	85.1063	
Length / Diameter Ratio	LD	50.0000	
Geometry Factor, A f(DT,LD)	A	0.0001519	
Materials Factor, B, f(A, Chart)	B	2126.1672	psi
Maximum Allowable Working Pressure		33.31	psig

EMAWP = (4*B)/(3*(D/T)) = (4 *2126.1672)/(3 *85.1063) = 33.3100

Summary of External Pressure Results:

Allowable Pressure at Corroded thickness	197.01	psig
Required Pressure as entered by User	15.00	psig
Required Thickness including Corrosion all.	0.0271	in.
Actual Thickness as entered by User	0.1645	in.
Maximum Length for Thickness and Pressure	0.2469E+16	in.

Actual Length as entered by User 4.00 in.

Weight and Volume Results, No C.A. :

Volume of Shell Component	VOLMET	32.7	in.^3
Weight of Shell Component	WMET	9.5	lb.
Inside Volume of Component	VOLID	587.2	in.^3
Weight of Water in Component	WWAT	21.2	lb.

Input Echo, Component 6, Description: 8" OD Nozzle

Design Internal Pressure	P	15.00	psig
Temperature for Internal Pressure		100.00	F
User Entered Minimum Design Metal Temperature		-20.00	F
Design External Pressure	PEXT	15.00	psig
Temperature for External Pressure		100.00	F
External Pressure Chart Name		HA-3	
Include Hydrostatic Head Components		NO	
Material Specification		SA-249 TP304L	
Material UNS Number		S30403	
Material Form used		Wld. tube	
Allowable Stress At Temperature	S	14200.00	psi
Allowable Stress At Ambient	SA	14200.00	psi
Yield Stress At Temperature	Sy	25000.00	psi
Joint efficiency for Shell Joint	E	0.70	
Design Length of Section	L	4.000	in.
Length of Cylinder for Volume Calcs.	CYLLEN	4.000	in.
Outside Diameter of Cylindrical Shell	D	8.000	in.
Minimum Thickness of Pipe or Plate	T	0.1120	in.
Nominal Thickness of Pipe or Plate	Tnom	0.1250	in.
Shell/Head Int. Corrosion Allowance	CA	0.0000	in.
Skip UG-16(b) Min. thickness calculation		NO	
Type of Element:		Cylindrical Shell	

Internal pressure results, Shell Number 6, Desc.: 8" OD Nozzle
ASME Code, Section VIII, Division 1, 2013

Thickness Due to Internal Pressure (Tr):
= (P*(D/2-CAE)) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (15.00*(8.0000/2-0.000)/(14200.00*0.70+0.4*15.00)
= 0.0060 + 0.0000 = 0.0060 in.
= 0.0625 in. (Per Ug 16b)

Max All. Working Pressure at Given Thickness (MAWP):
= (S*E*(T-CA-CAE)) / ((D/2-CAE)-0.4*(T-CA-CAE)) per Appendix 1-1 (a)(1)
= (14200.00*0.70*(0.1120))/(8.0000/2-0.000-0.4*0.1120)
= 281.47 psig

Maximum Allowable Pressure, New and Cold (MAPNC):
= (SA*E*T) / (D/2-0.4*T) per Appendix 1-1 (a)(1)
= (14200.00*0.70*0.1120)/(8.0000/2-0.4*0.1120)
= 281.47 psig

Actual stress at given pressure and thickness (Sact):
= (P*((D/2-CAE)-0.4*(T-CA-CAE))) / (E*(T-CA-CAE))
= (15.00*(((8.0000/2-0.000)-0.4*(0.1120)))/(0.70*(0.1120))
= 756.73 psi

SUMMARY OF INTERNAL PRESSURE RESULTS:
Required Thickness plus Corrosion Allowance, Trca 0.0625 in.

Actual Thickness as Given in Input		0.1120	in.
Maximum Allowable Working Pressure	MAWP	281.473	psig
Maximum Allowable Pressure, NC	MAPNC	281.473	psig
Design Pressure as Given in Input	P	15.000	psig

Hydrostatic Test Pressures (Measured at High Point):

Hydrotest per UG-99(b); 1.3 * MAWP * Sa/S	365.91	psig
Hydrotest per UG-99(c); 1.3 * MAPNC	365.91	psig
Pneumatic per UG-100 ; 1.1 * MAWP * Sa/S	309.62	psig

Percent Elongation per UHA-44 (50 * tnom/Rf * (1-Rf/Ro)) 1.587 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

External Pressure Results, Shell Number 6, Desc.: 8" OD Nozzle
ASME Code, Section VIII, Division 1, 2013

External Pressure Chart	HA-3 at	100.00	F
Elastic Modulus for Material		28000000.00	psi

Results for Max. Allowable External Pressure (Emawp):

Corroded Thickness of Shell	TCA	0.1120	in.
Outside Diameter of Shell	ODCA	8.000	in.
Design Length of Cylinder or Cone	SLEN	4.000	in.
Diameter / Thickness Ratio	(D/T)	71.4286	
Length / Diameter Ratio	LD	0.5000	
Geometry Factor, A f(DT,LD)	A	0.0048202	
Materials Factor, B, f(A, Chart)	B	11939.2812	psi
Maximum Allowable Working Pressure		222.87	psig

EMAWP = (4*B)/(3*(D/T)) = (4 *11939.2812)/(3 *71.4286) = 222.8666

Results for Reqd Thickness for Ext. Pressure (Tca):

Corroded Thickness of Shell	TCA	0.0196	in.
Outside Diameter of Shell	ODCA	8.000	in.
Design Length of Cylinder or Cone	SLEN	4.000	in.
Diameter / Thickness Ratio	(D/T)	409.1472	
Length / Diameter Ratio	LD	0.5000	
Geometry Factor, A f(DT,LD)	A	0.0003288	
Materials Factor, B, f(A, Chart)	B	4603.0801	psi
Maximum Allowable Working Pressure		15.00	psig

EMAWP = (4*B)/(3*(D/T)) = (4 *4603.0801)/(3 *409.1472) = 15.0006

Results for Maximum Length Calculation: No Conversion

Corroded Thickness of Shell	TCA	0.1120	in.
Outside Diameter of Shell	ODCA	8.000	in.
Design Length of Cylinder or Cone	SLEN	0.924E+21	in.
Diameter / Thickness Ratio	(D/T)	71.4286	
Length / Diameter Ratio	LD	50.0000	
Geometry Factor, A f(DT,LD)	A	0.0002156	
Materials Factor, B, f(A, Chart)	B	3018.4006	psi
Maximum Allowable Working Pressure		56.34	psig

EMAWP = (4*B)/(3*(D/T)) = (4 *3018.4006)/(3 *71.4286) = 56.3435

Summary of External Pressure Results:

Allowable Pressure at Corroded thickness	222.87	psig
Required Pressure as entered by User	15.00	psig
Required Thickness including Corrosion all.	0.0196	in.
Actual Thickness as entered by User	0.1120	in.
Maximum Length for Thickness and Pressure	0.9239E+21	in.

Actual Length as entered by User 4.00 in.

Weight and Volume Results, No C.A. :

Volume of Shell Component	VOLMET	12.4	in.^3
Weight of Shell Component	WMET	3.6	lb.
Inside Volume of Component	VOLID	190.0	in.^3
Weight of Water in Component	WWAT	6.9	lb.

Appendix Y Results For Item 1 : 44.62" Y Flange

Minimum Required Flange Thickness	0.3198	in.
Estimated M.A.W.P.	40.63	psig

Appendix Y Results For Item 2 : 72" Appendix Y

Minimum Required Flange Thickness	0.7023	in.
Estimated M.A.W.P.	49.04	psig

Leg Lug Results Summary for Item 1 : Lugs

The Vessel outside diameter is 40.000 in.

Summary Of Results

Stress (psi)	Actual	Allowable	P/F
Primary Shear Stress of Weld :	0.00	12000.00	Ok
Shear Stress above Hole :	0.00	12000.00	Ok
Pin Hole Bearing Stress :	0.00	22500.00	Ok
Total Combined Stress at the lug base :	0.00	19800.00	Ok

Summary for Nozzles :

Description	MAWP psig	FLG. MAWP	EXT. P CHECK	MAWPNC	UG-45 CHECK	WLD CHECK	MDMT F	Angle
14"OD Tube Nozz	99.10	...	OK	96.52	OK	OK	...	90°
8"OD Tube	97.80	...	OK	97.80	OK	OK	...	90°
Min. Press.	97.80	---		96.52				

Summary for shell/head, Div 1:

Description	MAPNC psig	MAWP psig	Min. T in.	Tr-int in.	Tr-ext in.	EMAWP psig
40" OD Shell	131.744	131.744	0.188	0.063	0.166	20.228
40in Tori head	93.508	93.508	0.188	0.063	0.116	39.455
62"OD Shell	113.269	113.269	0.250	0.063	0.211	22.909
62" Tori Head	58.341	58.341	0.188	0.063	0.179	16.565
14 in nozzle	277.322	277.322	0.165	0.063	0.027	197.013
8" OD Nozzle	281.473	281.473	0.112	0.063	0.020	222.867
Minimum MAWP	58.341	58.341				16.565

Note: Reqd. thk. reported above includes Corrosion Allowance.

Total Shell/Head weight is (New-Cold)	1858.6	lb.
Total Shell/Head weight is (Corroded)	1858.6	lb.
Total Shell/Head weight, filled with Water (New)	14174.9	lb.
Total Shell/Head volume is (New-Cold)	341065.7	in.**3

Total Shell/Head volume is (Corroded) 341065.7 in.**3

Least MAWP and Overall Weight Results :
The Least MAWP (N C) for 62" Tori Head was 58.34 psig .
The Least MAWP (Cor) for 44.62" Y Flange was 40.63 psig .

The total sum of the Weights (N C) was 1858.60 lb. .
The total sum of the Weights (Cor) was 1858.60 lb. .