HASIL PERHITUNGAN PV ELITE 2016

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2015

Analysis Performed by : SPLM Licensed User

Job File : E:\VESSEL SUKSES (TERBARU) WITH PAD.Pvdb

Date of Analysis : May 23,2017 6:22pm

PV Elite 2016, January 2016

Internal Pressure Calculations

Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd psig	Nominal Thickness in.	Total Corr Allowance in.	Element Diameter in.	Allowable Stress(SE) psi
SKIRT		...	0.50000	0.11811	111.410	...
BOTTOM HEA		143.590	0.50000	0.11811	111.174	23200.0
SHELL		143.590	0.50000	0.11811	111.174	23200.0
TOP HEAD		143.590	0.50000	0.11811	111.174	23200.0

Element Required Thickness and MAWP :

From	To	Design Pressure psig	M.A.W.P. Corroded psig	M.A.P. New & Cold psig	Minimum Thickness in.	Required Thickness in.
SKIRT		...	No Calc	No Calc	0.50000	No Calc
BOTTOM HEA		143.590	158.398	208.495	0.50000	0.46212
SHELL		143.590	158.398	207.562	0.50000	0.46417
TOP HEAD		143.590	158.398	208.494	0.50000	0.46212
Minimum			**158.398**	**207.561**		

MAWP: 156.648 psig, limited by: Nozzle Reinforcement.

Internal Pressure Calculation Results :

ASME Code, Section VIII, Division 1, 2015

Elliptical Head From 20 To 30 SA-516 70 , UCS-66 Crv. B at 159 °F

BOTTOM HEAD

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

= (P*D*Kcor)/(2*S*E-0.2*P) Appendix 1-4(c)

= (143.590*111.4100*0.997)/(2*23200.00*1.00-0.2*143.590)

= 0.3440 + 0.1181 = 0.4621 in.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

= (2*S*E*t)/(Kcor*D+0.2*t) per Appendix 1-4 (c)

= (2*23200.00*1.00*0.3819)/(0.997*111.4100+0.2*0.3819)

= 159.389 psig

Maximum Allowable Pressure, New and Cold [MAPNC]:

= (2*S*E*t)/(K*D+0.2*t) per Appendix 1-4 (c)

= (2*23200.00*1.00*0.5000)/(1.000*111.1738+0.2*0.5000)

= 208.495 psig

Actual stress at given pressure and thickness, corroded [Sact]:

= (P*(Kcor*D+0.2*t))/(2*E*t)

= (143.590*(0.997*111.4100+0.2*0.3819))/(2*1.00*0.3819)

= 20900.324 psi

Straight Flange Required Thickness:

= (P*R)/(S*E-0.6*P) + c per UG-27 (c)(1)

= (143.590*55.7050)/(23200.00*1.00-0.6*143.590)+0.118

= 0.464 in.

Straight Flange Maximum Allowable Working Pressure:

= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)

= (23200.00 * 1.00 * 0.3819)/(55.7050 + 0.6 * 0.3819)

= 158.398 psig

Factor K, corroded condition [Kcor]:

= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6

= (2 + (111.410/(2 * 27.912))^2)/6

= 0.997182

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 1.958 %

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 0.500 , tr = 0.375 , c = 0.1181 in. , E* = 1.00

Stress Ratio = tr * (E*)/(tg - c) = 0.983 , Temp. Reduction = 2 °F

Min Metal Temp. w/o impact per UCS-66, Curve B	-6 °F
Min Metal Temp. at Required thickness (UCS 66.1)	-8 °F
Min Metal Temp. w/o impact per UG-20(f)	-20 °F

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 0.500 , tr = 0.378 , c = 0.1181 in. , E* = 1.00

Stress Ratio = tr * (E*)/(tg - c) = 0.989 , Temp. Reduction = 1 °F

Min Metal Temp. w/o impact per UCS-66, Curve B	-6 °F
Min Metal Temp. at Required thickness (UCS 66.1)	-7 °F
Min Metal Temp. w/o impact per UG-20(f)	-20 °F

Cylindrical Shell From 30 To 40 SA-516 70 , UCS-66 Crv. B at 159 °F

SHELL

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)

= (143.590*55.7051)/(23200.00*1.00-0.6*143.590)

= 0.3461 + 0.1181 = 0.4642 in.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)

= (23200.00*1.00*0.3819)/(55.7051+0.6*0.3819)

= 158.398 psig

Maximum Allowable Pressure, New and Cold [MAPNC]:

= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)

= (23200.00*1.00*0.5000)/(55.5870+0.6*0.5000)

= 207.562 psig

Actual stress at given pressure and thickness, corroded [Sact]:

= (P*(R+0.6*t))/(E*t)

= (143.590*(55.7051+0.6*0.3819))/(1.00*0.3819)

= 21031.182 psi

Percent Elongation per UCS-79 (50*tnom/Rf)*(1-Rf/Ro) 0.448 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 0.500 , tr = 0.378 , c = 0.1181 in. , E* = 1.00

Stress Ratio = tr * (E*)/(tg - c) = 0.989 , Temp. Reduction = 1 °F

Min Metal Temp. w/o impact per UCS-66, Curve B	-6 °F
Min Metal Temp. at Required thickness (UCS 66.1)	-7 °F
Min Metal Temp. w/o impact per UG-20(f)	-20 °F

Elliptical Head From 40 To 50 SA-516 70 , UCS-66 Crv. B at 159 °F

TOP HEAD

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

= (P*D*Kcor)/(2*S*E-0.2*P) Appendix 1-4(c)

= (143.590*111.4102*0.997)/(2*23200.00*1.00-0.2*143.590)

= 0.3440 + 0.1181 = 0.4621 in.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

= (2*S*E*t)/(Kcor*D+0.2*t) per Appendix 1-4 (c)

= (2*23200.00*1.00*0.3819)/(0.997*111.4102+0.2*0.3819)

= 159.389 psig

Maximum Allowable Pressure, New and Cold [MAPNC]:

= (2*S*E*t)/(K*D+0.2*t) per Appendix 1-4 (c)

= (2*23200.00*1.00*0.5000)/(1.000*111.1740+0.2*0.5000)

= 208.494 psig

Actual stress at given pressure and thickness, corroded [Sact]:

= (P*(Kcor*D+0.2*t))/(2*E*t)

= (143.590*(0.997*111.4102+0.2*0.3819))/(2*1.00*0.3819)

= 20900.361 psi

Straight Flange Required Thickness:

= (P*R)/(S*E-0.6*P) + c per UG-27 (c)(1)

= (143.590*55.7051)/(23200.00*1.00-0.6*143.590)+0.118

= 0.464 in.

Straight Flange Maximum Allowable Working Pressure:

= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)

= (23200.00 * 1.00 * 0.3819)/(55.7051 + 0.6 * 0.3819)

= 158.398 psig

Factor K, corroded condition [Kcor]:

= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6

= (2 + (111.410/(2 * 27.912))^2)/6

= 0.997182

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 1.958 %

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 0.500 , tr = 0.375 , c = 0.1181 in. , E* = 1.00

Stress Ratio = tr * (E*)/(tg - c) = 0.983 , Temp. Reduction = 2 °F

Min Metal Temp. w/o impact per UCS-66, Curve B	-6 °F
Min Metal Temp. at Required thickness (UCS 66.1)	-8 °F
Min Metal Temp. w/o impact per UG-20(f)	-20 °F

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 0.500 , tr = 0.378 , c = 0.1181 in. , E* = 1.00

Stress Ratio = tr * (E*)/(tg - c) = 0.989 , Temp. Reduction = 1 °F

Min Metal Temp. w/o impact per UCS-66, Curve B	-6 °F
Min Metal Temp. at Required thickness (UCS 66.1)	-7 °F
Min Metal Temp. w/o impact per UG-20(f)	-20 °F

Note: Heads and Shells Exempted to -20F (-29C) by paragraph UG-20F

Hydrostatic Test Pressure Results:

Pressure per UG99b	= 1.3 * M.A.W.P. * Sa/S	203.642	psig
Pressure per UG99b[36]	= 1.3 * Design Pres * Sa/S	186.667	psig
Pressure per UG99c	= 1.3 * M.A.P. - Head(Hyd)	258.802	psig
Pressure per UG100	= 1.1 * M.A.W.P. * Sa/S	172.312	psig
Pressure per PED	= 1.43 * MAWP	224.006	psig
Pressure per App 27-4	= 1.3 * M.A.W.P. * Sa/S	203.642	psig

UG-99(b), Test Pressure Calculation:

= Test Factor * MAWP * Stress Ratio

= 1.3 * 156.648 * 1.000

= 203.642 psig

Vertical Test performed per: UG-99b

Please note that Nozzle, Shell, Head, Flange, etc MAWPs are all considered when determining the hydrotest pressure for those test types that are based on the MAWP of the vessel.

Stresses on Elements due to Test Pressure:

From To	Stress	Allowable	Ratio	Pressure
BOTTOM HEAD	24006.6	26000.0	0.923	215.74
SHELL	23994.4	26000.0	0.923	214.67
TOP HEAD	22779.7	26000.0	0.876	204.72

Stress ratios for Nozzle and Pad Materials:

Description	Pad/Nozzle	Ambient	Operating	ratio
N9	Nozzle	22000.00	22000.00	1.000
N9	Pad	20000.00	20000.00	1.000

M1	Nozzle	22000.00	22000.00	1.000
M1	Pad	20000.00	20000.00	1.000
N1	Nozzle	22000.00	22000.00	1.000
N1	Pad	20000.00	20000.00	1.000
N2	Nozzle	22000.00	22000.00	1.000
N2	Pad	20000.00	20000.00	1.000
N3	Nozzle	22000.00	22000.00	1.000
N3	Pad	20000.00	20000.00	1.000
N4	Nozzle	22000.00	22000.00	1.000
N4	Pad	20000.00	20000.00	1.000
N5	Nozzle	22000.00	22000.00	1.000
N5	Pad	20000.00	20000.00	1.000
N6	Nozzle	22000.00	22000.00	1.000
N6	Pad	20000.00	20000.00	1.000
N8	Nozzle	22000.00	22000.00	1.000
N8	Pad	20000.00	20000.00	1.000
N7	Nozzle	22000.00	22000.00	1.000
N7	Pad	20000.00	20000.00	1.000
Minimum				1.000

Stress ratios for Vessel Elements:

Description	Ambient	Operating	ratio
SKIRT	18300.00	18300.00	1.000
BOTTOM HEAD	23200.00	23200.00	1.000
SHELL	23200.00	23200.00	1.000
TOP HEAD	23200.00	23200.00	1.000
Minimum			1.000

Elements Suitable for Internal Pressure.

Wind Load Calculation

Wind Analysis Results

User Entered Importance Factor is	1.000	
Gust Factor (Gh, Gbar) Static	1.249	
Shape Factor (Cf) for the Vessel is	0.543	
User Entered Basic Wind Speed	23.0	mile/hr
Exposure Category	C	
Table Lookup Value Alpha from Table C6	7.0000	
Table Lookup Value Zg from Table C6	900.0000	
Table Lookup Value Do from Table C6	0.0050	

Wind Load Results per ASCE-7 93:

Sample Calculation for the First Element:

Rougness Factor = 1.000

Values [cf1] and [cf2]

Because RoughFact = 1 and DQZ > 2.5 and H/D < 7.0

Interpolating to find the final cf:

Because H / D < 7.0

CF = CF1 + (CF2-CF1)*(H/D - 1) / (7 - 1)

= 0.500 + (0.600 -0.500)*(3.588 - 1)/(7 - 1)

= 0.543

Value of Alpha, Zg is taken from Table C6-2 [Alpha, Zg]

For Exposure Category C:

Alpha = 7.000 , Zg = 900.000 ft.

Height of Interest for First Element [z]

= Centroid Hgt + Base Height

= 3.609 + 0.000 = 3.609 ft.

but: z = Max(15.000 , 3.609) = 15.000 ft.

Note: Because z < 15 feet, use 15 feet to compute kz.

Velocity Pressure Coefficient [kZ]:

= 2.58(z/zg)$^{2/Alpha}$: z is Elevation of First Element

= 2.58(15.000/900)$^{2/7.0}$

= 0.801

Determine if Static or Dynamic Gust Factor Applies

Height to Diameter ratio :

= Maximum Height(length)^2 / Sum of Area of the Elements

= 32.870 (^2)/301.138

= 3.588

Vibration Frequency = 17.125 Hz

Because H/D < 5 And Frequency > 1.0: Static Analysis Implemented

The following two calculations allow for any user units

Compute [tz]

= 2.35 * Sqrt(DO / VesselHtg/30(feet)$^{1/Alpha}$

= 2.35 * Sqrt(0.005/32.870)$^{1/30.000}$

= 0.164

Compute [Gh]

= 0.65 + 3.65 * tz

= 0.65 + 3.65 * 0.164 = 1.249

Wind Pressure - (performed in Imperial Units) [qz]

Importance Factor: I = 1.000

Wind Speed = 23.020 mile/hr

qz = 0.00256 * kZ * (I * Vr)^2

= 0.00256 * 0.801 *(1.000 * 23.020)^2 = 1.086 psf

Force on the First Element [Fz]

= qz * Gh * CF * Wind Area

= 1.086 * 1.249 * 0.543 * 11683.483

= 59.784 lb.

Element	z	GH	Area	qz	Force

	ft.		sq.in.	psf	lb.
SKIRT	3.6	1.249	11683.5	1.1	59.8
BOTTOM HEAD	7.3	1.249	265.0	1.1	1.4
SHELL	18.9	1.249	37096.9	1.2	202.7
TOP HEAD	31.4	1.249	3256.2	1.3	20.6

Wind Vibration Calculations

This evaluation is based on work by Kanti Mahajan and Ed Zorilla

Nomenclature

Cf - Correction factor for natural frequency
D - Average internal diameter of vessel ft.
Df - Damping Factor < 0.75 Unstable, > 0.95 Stable
Dr - Average internal diameter of top half of vessel ft.
f - Natural frequency of vibration (Hertz)
f1 - Natural frequency of bare vessel based on a unit value of $(D/L^2)(10^4)$
L - Total height of structure ft.
Lc - Total length of conical section(s) of vessel ft.
tb - Uncorroded plate thickness at bottom of vessel in.
V30 - Design Wind Speed provided by user mile/hr
Vc - Critical wind velocity mile/hr
Vw - Maximum wind speed at top of structure mile/hr
W - Total corroded weight of structure lb.
Ws - Cor. vessel weight excl. weight of parts which do not effect stiff. lb.
Z - Maximum amplitude of vibration at top of vessel in.
Dl - Logarithmic decrement (taken as 0.03 for Welded Structures)
Vp - Vib. Chance, <= 0.200E+02 (High); 0.200E+02 < 0.250E+02 (Probable)
P30 - wind pressure 30 feet above the base

Check other Conditions and Basic Assumptions:

#1 - Total Cone Length / Total Length < 0.5

0.000/30.512 = 0.000

#2 - $(D / L^2) * 10^4 < 8.0$ (English Units)

- (9.35/30.51^2) * 10^4 = 100.460 [Geometry Violation]

Compute the vibration possibility. If Vp > 0.250E+02 no chance. [Vp]:

= W / (L * Dr^2)

= 21790/(30.51 * 9.284^2)

= 0.82853E+01

Compute the damping factor Df which is a measure of instability [Df]:

= W * Dl/ (L * Dr^2)

= 21790 * 0.03/(30.51 * 9.284^2)

= 0.249

Compute the critical wind velocity [Vc]:

= 3.4 * f * Dr

= 3.4 * 17.125 * 9.284

= 540.576 mile/hr

Compute the velocity at the top of the tower [Vw]:

= V30 * (L / (30 + BaseHeight))$^{0.143}$

= 23.02 * (30.51/(30 + 0.0))^0.143

= 23.076 mile/hr

Compute the maximum gust velocity using the gust response factor Gh [Vg]:

= Vw * Gh

= 23.076 * 1.249

= 28.814 mile/hr

Since Vc is greater than Vg the dynamic deflection Z, does not

need to be computed.

The Natural Frequency for the Vessel (Ope...) is 17.1251 Hz.

Wind Load Calculation

From	To	Wind Height ft.	Wind Diameter ft.	Wind Area sq.in.	Wind Pressure psf	Element Wind Load lb.

10	20	3.60890	11.2410	11683.5	1.08649	59.7838
20	30	7.29982	11.2174	264.974	1.08649	1.35586
30	40	18.8648	11.2174	37096.9	1.16004	202.672
40	50	31.4243	11.2174	3256.21	1.34212	20.5820

Earthquake Load Calculation

Earthquake Analysis Results

The UBC Zone Factor for the Vessel is	0.2000	
The Importance Factor as Specified by the User is .	1.000	
The UBC Frequency and Soil Factor (C) is	2.750	
The UBC Force Factor as Specified by the User is ..	3.000	
The UBC Total Weight (W) for the Vessel is	27535.8	lb.
The UBC Total Shear (V) for the Vessel is	5048.2	lb.
The UBC Top Shear (Ft) for the Vessel is	0.0	lb.

The Natural Frequency for the Vessel (Ope...) is 17.1251 Hz.

Earthquake Load Calculation

From	To	Earthquake Height ft.	Earthquake Weight lb.	Element Ope Load lb.	Element Emp Load lb.
10	20	3.60890	6574.82	285.536	285.536
20	30	7.29982	2423.24	212.868	212.868
30	40	18.8648	16084.0	3651.30	3651.30
40	50	30.4297	2453.77	898.533	898.533
Top Load		32.83		0	0

Nozzle N1 Calculation with Reinforcement Pad

INPUT VALUES, Nozzle Description: N1 From : 30

Pressure for Reinforcement Calculations	P	143.590	psig
Temperature for Internal Pressure	Temp	159	°F
Shell Material		SA-516 70	
Shell Allowable Stress at Temperature	Sv	23200.00	psi
Shell Allowable Stress At Ambient	Sva	23200.00	psi
Inside Diameter of Cylindrical Shell	D	111.1740	in.
Shell Finished (Minimum) Thickness	t	0.5000	in.
Shell Internal Corrosion Allowance	c	0.1181	in.
Shell External Corrosion Allowance	co	0.0000	in.
Distance from Bottom/Left Tangent		2.1640	ft.
User Entered Minimum Design Metal Temperature		-20.00	°F

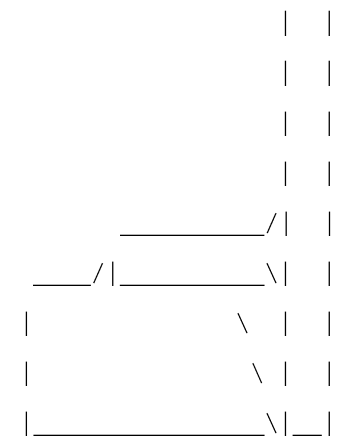
Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	22000.00	psi
Allowable Stress At Ambient	Sna	22000.00	psi
Diameter Basis (for tr calc only)		ID	
Layout Angle		180.00	deg
Diameter		6.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness	tn	80	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	

Corrosion Allowance	can	0.1181	in.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	7.8740	in.
Weld leg size between Nozzle and Pad/Shell	Wo	0.5000	in.
Groove weld depth between Nozzle and Vessel	Wgnv	0.5000	in.
Inside Projection	h	0.0000	in.
Weld leg size, Inside Element to Shell	Wi	0.0000	in.
Pad Material		SA-516 70	
Pad Allowable Stress at Temperature	Sp	20000.00	psi
Pad Allowable Stress At Ambient	Spa	20000.00	psi
Diameter of Pad along vessel surface	Dp	10.6250	in.
Thickness of Pad	te	0.5000	in.
Weld leg size between Pad and Shell	Wp	0.5000	in.
Groove weld depth between Pad and Nozzle	Wgpn	0.5000	in.
Reinforcing Pad Width		2.0000	in.
ASME Code Weld Type per UW-16		None	
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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



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

Reinforcement CALCULATION, Description: N1

ASME Code, Section VIII, Div. 1, 2015, UG-37 to UG-45

Actual Inside Diameter Used in Calculation	5.761	in.
Actual Thickness Used in Calculation	0.432	in.

Nozzle input data check completed without errors.

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

= (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)

= (143.59*55.7051)/(23200*1.00-0.6*143.59)

= 0.3461 in.

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

= (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)

= (143.59*3.00)/(22000*1.00-0.6*143.59)

= 0.0196 in.

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

Parallel to Vessel Wall (Diameter Limit)	Dl	11.9944	in.
Parallel to Vessel Wall, opening length	d	5.9972	in.
Normal to Vessel Wall (Thickness Limit), pad side	Tlwp	0.9547	in.

Weld Strength Reduction Factor [fr1]:

= min(1, Sn/Sv)

= min(1, 22000.0/23200.0)

= 0.948

Weld Strength Reduction Factor [fr2]:

= min(1, Sn/Sv)

= min(1, 22000.0/23200.0)

= 0.948

Weld Strength Reduction Factor [fr4]:

= min(1, Sp/Sv)

= min(1, 20000.0/23200.0)

= 0.862

Weld Strength Reduction Factor [fr3]:

= min(fr2, fr4)

= min(0.948 , 0.862)

= 0.862

Results of Nozzle Reinforcement Area Calculations: (sq.in.)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	2.087	NA	NA
Area in Shell	A1	0.214	NA	NA
Area in Nozzle Wall	A2	0.533	NA	NA
Area in Inward Nozzle	A3	0.000	NA	NA
Area in Welds	A41+A42+A43	0.429	NA	NA
Area in Element	A5	1.293	NA	NA
TOTAL AREA AVAILABLE	Atot	2.469	NA	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Insufficient.

The area available with the given pad is Sufficient.

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness	
Based on given Pad Thickness:	8.7500	0.5000	in.
Based on given Pad Diameter:	10.6250	0.3125	in.
Based on Shell or Nozzle Thickness:	9.0625	0.4375	in.

Area Required [A]:

= (d * tr*F + 2 * tn * tr*F * (1-fr1)) UG-37(c)

= (5.9972*0.3461*1.0+2*0.3139*0.3461*1.0*(1-0.95))

= 2.087 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 )
= 5.997 ( 1.00 * 0.3819 - 1.0 * 0.346 ) - 2 * 0.314
  ( 1.00 * 0.3819 - 1.0 * 0.3461 ) * ( 1 - 0.948 )
= 0.214 sq.in.
```

Area Available in Nozzle Wall Projecting Outward [A2]:

```
= ( 2 * Tlwp ) * ( tn - trn ) * fr2
= ( 2 * 0.955 ) * ( 0.3139 - 0.0196 ) * 0.9483
= 0.533 sq.in.
```

Area Available in Welds [A41 + A42 + A43]:

```
= (Wo² - Ar Lost)*Fr3+((Wi-can/0.707)² - Ar Lost)*fr2 + Wp²*fr4
= (0.2480 ) * 0.86 + (0.0000 ) * 0.95 + 0.2500² * 0.86
= 0.429 sq.in.
```

Area Available in Element [A5]:

```
= (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te))*fr4
= ( 10.6250 - 6.6250 ) * 0.5000 * 0.8621
= 1.293 sq.in.
```

Note: Per user request, A5 multiplied by 0.75, see UG-37(h).

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

```
Wall Thickness for Internal/External pressures      ta = 0.1378 in.
Wall Thickness per UG16(b),                      tr16b = 0.2119 in.
Wall Thickness, shell/head, internal pressure     trb1 = 0.4642 in.
Wall Thickness                 tb1 = max(trb1, tr16b) = 0.4642 in.
Wall Thickness                 tb2 = max(trb2, tr16b) = 0.2119 in.
Wall Thickness per table UG-45                    tb3 = 0.3630 in.
```

Determine Nozzle Thickness candidate [tb]:

```
= min[ tb3, max( tb1,tb2) ]
= min[ 0.363 , max( 0.4642 , 0.2119 ) ]
= 0.3630 in.
```

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

```
= max( ta, tb )
```

= max(0.1378 , 0.3630)

= 0.3630 in.

Available Nozzle Neck Thickness = 0.875 * 0.432 = 0.378 in. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

MDMT of the Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 0.378 , tr = 0.020 , c = 0.1181 in. , E* = 1.00

Stress Ratio = tr * (E*)/(tg - c) = 0.076 , Temp. Reduction = 140 °F

Min Metal Temp. w/o impact per UCS-66, Curve B	-20 °F
Min Metal Temp. at Required thickness (UCS 66.1)	-155 °F

MDMT of Nozzle Neck to Pad Weld for the Nozzle, Curve: B

Govrn. thk, tg = 0.378 , tr = 0.020 , c = 0.1181 in. , E* = 1.00

Stress Ratio = tr * (E*)/(tg - c) = 0.076 , Temp. Reduction = 140 °F

Min Metal Temp. w/o impact per UCS-66, Curve B	-20 °F
Min Metal Temp. at Required thickness (UCS 66.1)	-155 °F

MDMT of Nozzle Neck to Pad Weld for Reinforcement pad, Curve: B

Govrn. thk, tg = 0.378 , tr = 0.020 , c = 0.1181 in. , E* = 1.00

Stress Ratio = tr * (E*)/(tg - c) = 0.076 , Temp. Reduction = 140 °F

Min Metal Temp. w/o impact per UCS-66, Curve B	-20 °F
Min Metal Temp. at Required thickness (UCS 66.1)	-155 °F

MDMT of Shell to Pad Weld at Pad OD for pad, Curve: B

Govrn. thk, tg = 0.500 , tr = 0.346 , c = 0.1181 in. , E* = 1.00

Stress Ratio = tr * (E*)/(tg - c) = 0.906 , Temp. Reduction = 9 °F

Min Metal Temp. w/o impact per UCS-66, Curve B	-6 °F
Min Metal Temp. at Required thickness (UCS 66.1)	-16 °F

Min Metal Temp. w/o impact per UG-20(f) -20 °F

MDMT of Nozzle-Shell/Head Weld for the Nozzle (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 0.378 , tr = 0.020 , c = 0.1181 in. , E* = 1.00

Stress Ratio = tr * (E*)/(tg - c) = 0.076 , Temp. Reduction = 140 °F

Min Metal Temp. w/o impact per UCS-66, Curve B	-20 °F
Min Metal Temp. at Required thickness (UCS 66.1)	-155 °F

Governing MDMT of the Nozzle	:	-155 °F
Governing MDMT of the Reinforcement Pad	:	-20 °F
Governing MDMT of all the sub-joints of this Junction	:	-20 °F

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)	-20 °F
Flange MDMT with Temp reduction per UCS-66(b)(1)(b)	-55 °F
Flange MDMT with Temp reduction per UCS-66(b)(1)(c)	-155 °F

Where the Stress Reduction Ratio per UCS-66(b)(1)(b) is :

Design Pressure/Ambient Rating = 143.59/285.00 = 0.504

Note: Using the minimum value from (b)(1)(b) and (b)(1)(c) above
as the calculated nozzle flange MDMT.

Weld Size Calculations, Description: N1

Intermediate Calc. for nozzle/shell Welds	Tmin	0.3139	in.
Intermediate Calc. for pad/shell Welds	TminPad	0.3819	in.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	0.2197 = 0.7 * tmin.	0.3535 = 0.7 * Wo in.
Pad Weld	0.1909 = 0.5*TminPad	0.3535 = 0.7 * Wp 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
= (2.0866 - 0.2137 + 2 * 0.3139 * 0.9483 *
  (1.00 * 0.3819 - 0.3461 ) ) * 23200
= 43945.63 lb.
```

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

Weld Load [W1]:

```
= (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
= ( 0.5328 + 1.2931 + 0.4293 - 0.0000 * 0.95 ) * 23200
= 52319.48 lb.
```

Weld Load [W2]:

```
= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
= ( 0.5328 + 0.0000 + 0.2371 + ( 0.2273 ) ) * 23200
= 23134.82 lb.
```

Weld Load [W3]:

```
= (A2+A3+A4+A5+(2*tn*t*fr1))*S
= ( 0.5328 + 0.0000 + 0.4293 + 1.2931 + ( 0.2273 ) ) * 23200
= 57593.82 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 ) * 6.6250 * 0.5000 * 0.49 * 20000
= 50992. lb.
```

Shear, Pad Element Weld [Spew]:

```
= (pi/2) * DP * WP * 0.49 * SEW
= ( 3.1416/2.0 ) * 10.6250 * 0.5000 * 0.49 * 20000
= 81780. lb.
```

Shear, Nozzle Wall [Snw]:

```
= (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
= (3.1416 * 3.1556 ) * ( 0.4320 - 0.1181 ) * 0.7 * 22000
```

= 47921. lb.

Tension, Pad Groove Weld [Tpgw]:

= (pi/2) * Dlo * Wgpn * 0.74 * Seg

= (3.1416/2) * 6.6250 * 0.5000 * 0.74 * 22000

= 84709. lb.

Tension, Shell Groove Weld [Tngw]:

= (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng

= (3.1416/2.0) * 6.6250 * (0.5000 - 0.1181) * 0.74 * 23200

= 68228. lb.

Strength of Failure Paths:

PATH11 = (SPEW + SNW) = (81780 + 47921) = 129700 lb.

PATH22 = (Sonw + Tpgw + Tngw + Sinw)

= (50992 + 84709 + 68228 + 0) = 203929 lb.

PATH33 = (Spew + Tngw + Sinw)

= (81780 + 68228 + 0) = 150008 lb.

Summary of Failure Path Calculations:

Path 1-1 = 129700 lb., must exceed W = 43945 lb. or W1 = 52319 lb.

Path 2-2 = 203929 lb., must exceed W = 43945 lb. or W2 = 23134 lb.

Path 3-3 = 150007 lb., must exceed W = 43945 lb. or W3 = 57593 lb.

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case 156.648 psig

The Drop for this Nozzle is : 0.0988 in.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 8.4728 in.