

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2007, Addenda A-08

Analysis Performed by : PRESSURE VESSEL ENGINEERING

Job File : L:\SAMPLES\SAMPLE 14 - VERTICAL W BOLTED COVER\P

Date of Analysis : Jun 19,2009

PV Elite 2009, January 2009

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**PV Elite Vessel Analysis Program: Input Data**

Design Internal Pressure (for Hydrotest)	125.00	psig
Design Internal Temperature	200	F
Type of Hydrotest	UG99-b	
Hydrotest Position	Vertical	
Projection of Nozzle from Vessel Top	0.0000	in
Projection of Nozzle from Vessel Bottom	0.0000	in
Minimum Design Metal Temperature	-20	F
Type of Construction	Welded	
Special Service	Air/Water/Steam	
Degree of Radiography	None	
Miscellaneous Weight Percent	0.	
Use Higher Longitudinal Stresses (Flag)	Y	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Select Location for Stiff. Rings (Flag)	N	
Consider Vortex Shedding	N	
Perform a Corroded Hydrotest	N	
Is this a Heat Exchanger	No	
User Defined Hydro. Press. (Used if > 0)	0.0000	psig
User defined MAWP	0.0000	psig
User defined MAPnc	0.0000	psig

Load Case 1	NP+EW+WI+FW+BW
Load Case 2	NP+EW+EE+FS+BS
Load Case 3	NP+OW+WI+FW+BW
Load Case 4	NP+OW+EQ+FS+BS
Load Case 5	NP+HW+HI
Load Case 6	NP+HW+HE
Load Case 7	IP+OW+WI+FW+BW
Load Case 8	IP+OW+EQ+FS+BS
Load Case 9	EP+OW+WI+FW+BW
Load Case 10	EP+OW+EQ+FS+BS
Load Case 11	HP+HW+HI
Load Case 12	HP+HW+HE
Load Case 13	IP+WE+EW
Load Case 14	IP+WF+CW
Load Case 15	IP+VO+OW
Load Case 16	IP+VE+EW
Load Case 17	NP+VO+OW
Load Case 18	FS+BS+IP+OW
Load Case 19	FS+BS+EP+OW

Wind Design Code	No Wind Loads	
Design Wind Speed	70.000	mile/hr
Exposure Constant	C	
Importance Factor		
Roughness Factor		
Base Elevation	0.0000	in
Percent Wind for Hydrotest	33.	
Using User defined Wind Press. Vs Elev.	N	
Damping Factor (Beta) for Wind (Ope)	0.0100	
Damping Factor (Beta) for Wind (Empty)	0.0000	
Damping Factor (Beta) for Wind (Filled)	0.0000	

Seismic Design Code	NBC 95
NBC Acceleration-Related Seismic Zone	Za 1.000
NBC Velocity-Related Seismic Zone	Zv 0.000
NBC Seismic Importance Factor	I 1.000
NBC Soil Type	1.000
NBC Force Modification Factor	R 1.000
NBC Percent Seismic for Hydrotest	0.000

Design Nozzle for Des. Press. + St. Head	Y
Consider MAP New and Cold in Noz. Design	N
Consider External Loads for Nozzle Des.	Y
Consider Code Case 2168 for Nozzle Des.	N

Material Database Year Current w/Addenda or Code Year

**Complete Listing of Vessel Elements and Details:**

Element From Node	10
Element To Node	20
Element Type	Elliptical
Description	Elliptical Head
Distance "FROM" to "TO"	2.0000 in
Element Outside Diameter	36.000 in
Element Thickness	0.2260 in
Internal Corrosion Allowance	0.06250 in
Nominal Thickness	0.2500 in
External Corrosion Allowance	0.0000 in
Design Internal Pressure	125.00 psig
Design Temperature Internal Pressure	200 F
Design External Pressure	0.0000 psig
Design Temperature External Pressure	70 F
Effective Diameter Multiplier	1.2
Material Name	SA-516 70
Allowable Stress, Ambient	20000. psi
Allowable Stress, Operating	20000. psi
Allowable Stress, Hydrotest	26000. psi
Material Density	0.2830 lbm/in <sup>3</sup>
P Number Thickness	1.2500 in
Yield Stress, Operating	34800. psi
UCS-66 Chart Curve Designation	B
External Pressure Chart Name	CS-2
UNS Number	K02700
Product Form	Plate
Efficiency, Longitudinal Seam	0.85
Efficiency, Circumferential Seam	0.7
Elliptical Head Factor	2.

Element From Node	10
Detail Type	Liquid
Detail ID	Liquid 10
Dist. from "FROM" Node / Offset dist	-9.0000 in
Height/Length of Liquid	11.000 in
Density of Liquid	0.0000 lbm/ft <sup>3</sup>

Element From Node	10
Detail Type	Nozzle
Detail ID	N3
Dist. from "FROM" Node / Offset dist	0.0000 in
Nozzle Diameter	1.75 in.

Nozzle Schedule None  
 Nozzle Class 0  
 Layout Angle 0.  
 Blind Flange (Y/N) N  
 Weight of Nozzle ( Used if > 0 ) 0.0000 lbf  
 Grade of Attached Flange None  
 Nozzle Matl SA-105

Element From Node 10  
 Detail Type Leg  
 Detail ID LEGS  
 Dist. from "FROM" Node / Offset dist 10.000 in  
 Diameter at Leg Centerline 38.003 in  
 Leg Orientation 3  
 Number of Legs 4  
 Section Identifier L3X3X0.2500  
 Length of Legs 31.000 in

Element From Node 20  
 Element To Node 30  
 Element Type Cylinder  
 Description Shell  
 Distance "FROM" to "TO" 41.810 in  
 Element Outside Diameter 36.000 in  
 Element Thickness 0.2500 in  
 Internal Corrosion Allowance 0.06250 in  
 Nominal Thickness 0.2500 in  
 External Corrosion Allowance 0.0000 in  
 Design Internal Pressure 125.00 psig  
 Design Temperature Internal Pressure 200 F  
 Design External Pressure 0.0000 psig  
 Design Temperature External Pressure 70 F  
 Effective Diameter Multiplier 1.2  
 Material Name SA-516 70  
 Efficiency, Longitudinal Seam 0.7  
 Efficiency, Circumferential Seam 0.7

Element From Node 20  
 Detail Type Liquid  
 Detail ID WATER  
 Dist. from "FROM" Node / Offset dist 0.0000 in  
 Height/Length of Liquid 41.810 in  
 Density of Liquid 0.0000 lbm/ft<sup>3</sup>

Element From Node 20  
 Detail Type Nozzle  
 Detail ID N1  
 Dist. from "FROM" Node / Offset dist 24.000 in  
 Nozzle Diameter 18. in.  
 Nozzle Schedule 40  
 Nozzle Class 150  
 Layout Angle 180.  
 Blind Flange (Y/N) N  
 Weight of Nozzle ( Used if > 0 ) 0.0000 lbf  
 Grade of Attached Flange GR 1.1  
 Nozzle Matl SA-106 B

Element From Node 20  
 Detail Type Nozzle

Detail ID	N2	
Dist. from "FROM" Node / Offset dist	24.000	in
Nozzle Diameter	4.	in.
Nozzle Schedule	40	
Nozzle Class	150	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle ( Used if > 0 )	0.0000	lbf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	30	
Element To Node	40	
Element Type	Flange	
Description	36" 150# WN Flange	
Distance "FROM" to "TO"	6.1900	in
Flange Inside Diameter	36.000	in
Element Thickness	3.5600	in
Internal Corrosion Allowance	0.06250	in
Nominal Thickness	0.2500	in
External Corrosion Allowance	0.0000	in
Design Internal Pressure	125.00	psig
Design Temperature Internal Pressure	200	F
Design External Pressure	0.0000	psig
Design Temperature External Pressure	70	F
Effective Diameter Multiplier	1.2	
Material Name	SA-105	
Allowable Stress, Ambient	20000.	psi
Allowable Stress, Operating	20000.	psi
Allowable Stress, Hydrotest	26000.	psi
Material Density	0.2830	lbm/in <sup>3</sup>
P Number Thickness	1.2500	in
Yield Stress, Operating	33000.	psi
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03504	
Product Form	Forgings	
Perform Flange Stress Calculation (Y/N)	N	
Weight of ANSI B16.5/B16.47 Flange	0.0000	lbf
Class of ANSI B16.5/B16.47 Flange	150	
Grade of ANSI B16.5/B16.47 Flange	GR 1.1	
Element From Node	30	
Detail Type	Liquid	
Detail ID	Liquid 30	
Dist. from "FROM" Node / Offset dist	0.0000	in
Height/Length of Liquid	6.1900	in
Density of Liquid	0.0000	lbm/ft <sup>3</sup>
Element From Node	40	
Element To Node	50	
Element Type	Flange	
Description	Blind Cover	
Distance "FROM" to "TO"	3.5600	in
Flange Outside Diameter	46.000	in
Element Thickness	3.5600	in
Internal Corrosion Allowance	0.06250	in
Nominal Thickness	0.2500	in
External Corrosion Allowance	0.0000	in

Design Internal Pressure	125.00	psig
Design Temperature Internal Pressure	200	F
Design External Pressure	0.0000	psig
Design Temperature External Pressure	70	F
Effective Diameter Multiplier	1.2	
Material Name	SA-105	
Perform Flange Stress Calculation (Y/N)	N	
Weight of ANSI B16.5/B16.47 Flange	0.0000	lbf
Class of ANSI B16.5/B16.47 Flange	150	
Grade of ANSI B16.5/B16.47 Flange	GR 1.1	
Element From Node	40	
Detail Type	Liquid	
Detail ID	Liquid 40	
Dist. from "FROM" Node / Offset dist	0.0000	in
Height/Length of Liquid	3.5600	in
Density of Liquid	0.0000	lbm/ft <sup>3</sup>
Element From Node	40	
Detail Type	Nozzle	
Detail ID	N4	
Dist. from "FROM" Node / Offset dist	0.0000	in
Nozzle Diameter	3.	in.
Nozzle Schedule	None	
Nozzle Class	0	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle ( Used if > 0 )	0.0000	lbf
Grade of Attached Flange	None	
Nozzle Matl	SA-105	

**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
Elliptical		126.900	0.25000	0.062500	36.0000	17000.0
Shell		126.900	0.25000	0.062500	36.0000	14000.0
36" 150# W		126.900	0.25000	0.062500	36.0000	20000.0
Blind Cove		126.900	0.25000	0.062500	46.0000	20000.0

**Element Required Thickness and MAWP :**

From	To	Design Pressure psig	M.A.W.P. Corroded psig	M.A.P. New & Cold psig	Actual Thickness in	Required Thickness in
Elliptical		125.000	154.516	215.884	0.22600	0.19535
Shell		125.000	144.544	195.531	0.25000	0.22507
36" 150# W		125.000	258.100	285.000	3.56000	No Calc
Blind Cove		125.000	258.100	285.000	3.56000	No Calc
Minimum			144.544	195.530		

MAWP: 129.553 psig, limited by: Nozzle Reinforcement.

**Internal Pressure Calculation Results :**

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**Elliptical Head From 10 To 20 SA-516 70 , UCS-66 Crv. B at 200 F**

**Elliptical Head**

Thickness Due to Internal Pressure [tr]:

$$\begin{aligned}
 &= (P \cdot D_o \cdot K_{cor}) / (2 \cdot S \cdot E + 2 \cdot P \cdot (K_{cor} - 0.1)) \text{ per Appendix 1-4 (c)} \\
 &= (126.900 \cdot 36.0000 \cdot 0.995) / (2 \cdot 20000.00 \cdot 0.85 + 2 \cdot 126.900 \cdot (1.00 - 0.1)) \\
 &= 0.1329 + 0.0625 = 0.1954 \text{ in}
 \end{aligned}$$

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

Less Operating Hydrostatic Head Pressure of 1.900 psig

$$\begin{aligned}
 &= (2 \cdot S \cdot E \cdot t) / (K_{cor} \cdot D_o - 2 \cdot t \cdot (K_{cor} - 0.1)) \text{ per Appendix 1-4 (c)} \\
 &= (2 \cdot 20000.00 \cdot 0.85 \cdot 0.1635) / (0.995 \cdot 36.0000 - 2 \cdot 0.1635 \cdot (1.00 - 0.1)) \\
 &= 156.416 - 1.900 = 154.516 \text{ psig}
 \end{aligned}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$\begin{aligned}
 &= (2 \cdot S \cdot E \cdot t) / (K \cdot D_o - 2 \cdot t \cdot (K - 0.1)) \text{ per Appendix 1-4 (c)} \\
 &= (2 \cdot 20000.00 \cdot 0.85 \cdot 0.2260) / (1.000 \cdot 36.0000 - 2 \cdot 0.2260 \cdot (1.000 - 0.1)) \\
 &= 215.884 \text{ psig}
 \end{aligned}$$

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

$$\begin{aligned}
 &= (P \cdot (K_{cor} \cdot D_o - 2 \cdot t \cdot (K_{cor} - 0.1))) / (2 \cdot E \cdot t) \\
 &= (126.900 \cdot (0.995 \cdot 36.0000 - 2 \cdot 0.1635 \cdot (0.995 - 0.1))) / (2 \cdot 0.85 \cdot 0.1635) \\
 &= 16225.990 \text{ psi}
 \end{aligned}$$

Required Thickness of Straight Flange:

$$\begin{aligned}
 &= (P \cdot R_o) / (S \cdot E + 0.4 \cdot P) + c \text{ per Appendix 1-1 (a)(1)} \\
 &= (126.900 \cdot 18.0000) / (20000.00 \cdot 0.85 + 0.4 \cdot 126.900) + 0.063 \\
 &= 0.196 \text{ in}
 \end{aligned}$$

Factor K, corroded condition [Kcor]:

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

$$= ( 2 + ( 35.673 / ( 2 * 8.950 ) ) ^ ( 2 ) ) / 6$$

$$= 0.995352$$

Percent Elongation per UCS-79  $(75 * t_{nom} / R_f) * (1 - R_f / R_o)$  3.085 %

**MDMT Calculations in the Knuckle Portion:**

Min Metal Temp. w/o impact per UCS-66 -20 F  
 Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.69] -51 F

**MDMT Calculations in the Straight Flange:**

Min Metal Temp. w/o impact per UCS-66 -20 F  
 Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.61] -55 F

**Cylindrical Shell From 20 To 30 SA-516 70 , UCS-66 Crv. B at 200 F**

**Shell**

**Thickness Due to Internal Pressure [tr]:**

$$= ( P * R_o ) / ( S * E + 0.4 * P ) \text{ per Appendix 1-1 (a)(1)}$$

$$= ( 126.900 * 18.0000 ) / ( 20000.00 * 0.70 + 0.4 * 126.900 )$$

$$= 0.1626 + 0.0625 = 0.2251 \text{ in}$$

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

**Less Operating Hydrostatic Head Pressure of 1.900 psig**

$$= ( S * E * t ) / ( R_o - 0.4 * t ) \text{ per Appendix 1-1 (a)(1)}$$

$$= ( 20000.00 * 0.70 * 0.1875 ) / ( 18.0000 - 0.4 * 0.1875 )$$

$$= 146.444 - 1.900 = 144.544 \text{ psig}$$

**Maximum Allowable Pressure, New and Cold [MAPNC]:**

$$= ( S * E * t ) / ( R_o - 0.4 * t ) \text{ per Appendix 1-1 (a)(1)}$$

$$= ( 20000.00 * 0.70 * 0.2500 ) / ( 18.0000 - 0.4 * 0.2500 )$$

$$= 195.531 \text{ psig}$$

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

$$= ( P * ( R_o - 0.4 * t ) ) / ( E * t )$$

$$= ( 126.900 * ( 18.0000 - 0.4 * 0.1875 ) ) / ( 0.70 * 0.1875 )$$

$$= 17330.914 \text{ psi}$$

Percent Elongation per UCS-79  $(50 * t_{nom} / R_f) * (1 - R_f / R_o)$  0.699 %

Min Metal Temp. w/o impact per UCS-66 -20 F  
 Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.69] -51 F

**Minimum Metal Design Temperature Results :**

Minimum Metal Temp. w/o impact per UCS-66 -20. F  
 Minimum Metal Temp. at Required thickness -51. F

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

Minimum Design Metal Temperature ( Entered by User ) -20. F

**Hydrostatic Test Pressure Results:**

Pressure per UG99b = 1.3 \* M.A.W.P. \* Sa/S 168.419 psig

Pressure per UG99b[34] = 1.3 \* Design Pres \* Sa/S 162.500 psig  
Pressure per UG99c = 1.3 \* M.A.P. - Head(Hyd) 252.328 psig  
Pressure per UG100 = 1.1 \* M.A.W.P. \* Sa/S 142.508 psig

**Vertical Test performed per: UG-99b**

**Stresses on Elements due to Hydrostatic Test Pressure:**

From To	Stress	Allowable	Ratio	Pressure
Elliptical Head	15811.6	26000.0	0.608	170.67
Shell	17417.3	26000.0	0.670	170.28

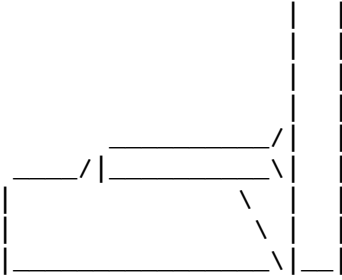
Elements Suitable for Internal Pressure.

**INPUT VALUES, Nozzle Description: N1 From : 20**

Pressure for Nozzle Reinforcement Calculations P		126.900	psig
Temperature for Internal Pressure	Temp	200	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	35.5000	in
Shell Finished (Minimum) Thickness	t	0.2500	in
Shell Internal Corrosion Allowance	cas	0.0625	in
Shell External Corrosion Allowance	caext	0.0000	in
Distance from Bottom/Left Tangent		26.0000	in
User Entered Minimum Design Metal Temperature		-20.00	F
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	17100.00	psi
Nozzle Allowable Stress At Ambient	Sna	17100.00	psi
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		180.00	deg
Nozzle Diameter	Dia	18.0000	in.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	40	
Nozzle Flange Material		SA-105	
Nozzle Flange Type	Weld Neck Flange		
Nozzle Corrosion Allowance	Can	0.0625	in
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	14.5000	in
Weld leg size between Nozzle and Pad/Shell	Wo	0.2500	in
Groove weld depth between Nozzle and Vessel	Wgnv	0.2500	in
Nozzle Inside Projection	h	0.0000	in
Weld leg size, Inside Nozzle 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	22.0000	in
Thickness of Pad	Tp	0.2500	in
Weld leg size between Pad and Shell	Wp	0.2500	in
Groove weld depth between Pad and Nozzle	Wgpn	0.2500	in
Reinforcing Pad Width		2.0000	in
ASME Code Weld Type per UW-16		Q	
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

**Nozzle Sketch**



**Insert Nozzle With Pad, no Inside projection**

**NOZZLE CALCULATION, Description: N1**

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation 18.000 in.  
 Actual Nozzle Thickness Used in Calculation 0.562 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]  
 =  $(P \cdot R) / (S \cdot E - 0.6 \cdot P)$  per UG-27 (c)(1)  
 =  $(126.90 \cdot 17.8125) / (20000 \cdot 1.00 - 0.6 \cdot 126.90)$   
 = 0.1135 in

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]  
 =  $(P \cdot R_o) / (S \cdot E + 0.4 \cdot P)$  per Appendix 1-1 (a)(1)  
 =  $(126.90 \cdot 9.0000) / (17100 \cdot 1.00 + 0.4 \cdot 126.90)$   
 = 0.0666 in

**UG-40, Limits of Reinforcement : [Int. Press]**

Parallel to Vessel Wall (Diameter Limit) D1 34.0020 in  
 Normal to Vessel Wall (Thickness Limit), pad side Tlwp 0.4688 in

**Results of Nozzle Reinforcement Area Calculations:**

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	1.945	NA	NA	in <sup>2</sup>
Area in Shell	A1	1.248	NA	NA	in <sup>2</sup>
Area in Nozzle Wall	A2	0.347	NA	NA	in <sup>2</sup>
Area in Inward Nozzle	A3	0.000	NA	NA	in <sup>2</sup>
Area in Welds	A4	0.115	NA	NA	in <sup>2</sup>
Area in Pad	A5	1.000	NA	NA	in <sup>2</sup>
TOTAL AREA AVAILABLE	Atot	2.710	NA	NA	in <sup>2</sup>

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degr.

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:	19.0000	0.2500	in
Based on given Pad Diameter:	22.0000	0.0625	in
Based on Shell or Nozzle Thickness:	19.0000	0.2500	in

Reinforcement Area Required for Nozzle [Ar]:  
 = ( Dlr \* tr + 2 \* tn \* tr \* (1-fr1) ) UG-37(c)  
 = (17.0010\*0.1135+2\*(0.5620-0.0625)\*0.1135\*(1-0.8550))  
 = 1.945 in<sup>2</sup>

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:  
 = (DL-Dlr)\*(Es\*(t-cas)-tr)-2\*(tn-can)\*(Es\*(t-cas)-tr)\*(1-fr1)  
 = (34.002-17.001)\*(1.00\*(0.2500-0.062)-0.113)-2\*(0.562-0.062)  
 \*(1.00\*(0.2500-0.0625)-0.1135)\*(1-0.8550)  
 = 1.248 in<sup>2</sup>

Area Available in Nozzle Wall, no Pad [A2np]:  
 = ( 2 \* min(Tlnp,ho) ) \* ( tn - can - trn ) \* fr2  
 = ( 2 \* min(0.469 ,14.500 ) ) \* ( 0.5620 - 0.0625 - 0.0666 ) \* 0.8550 )  
 = 0.347 in<sup>2</sup>

Area Available in Nozzle Wall, with Pad [A2wp]:  
 = ( 2 \* min(Tlwp, ho) )\*( tn - can - trn )\* fr2  
 = ( 2 \* min(0.469 ,14.500 ) ) \* ( 0.5620 - 0.0625 - 0.0666 ) \* 0.8550 )  
 = 0.347 in<sup>2</sup>

Area Available in Welds, no Pad [A4np]:  
 = Wo<sup>2</sup> \* fr2 + ( Wi-can/0.707 )<sup>2</sup> \* fr2  
 = 0.2500<sup>2</sup> \* 0.8550 + ( 0.0000 )<sup>2</sup> \* 0.8550  
 = 0.053 in<sup>2</sup>

Area Available in Welds, with Pad [A4wp]:  
 = (Wo<sup>2</sup> - Ar Lost)\*Fr3+((Wi-can/0.707)<sup>2</sup> - Ar Lost)\*Fr2 + Wp<sup>2</sup>\*Fr4  
 = (0.0615 ) \* 0.86 + (0.0000 ) \* 0.86 + 0.0625<sup>2</sup> \* 1.00  
 = 0.115 in<sup>2</sup>

Area Available in Pad [A5]:  
 = (min(Dp,DL)-(Nozzle OD))\*(min(tp,Tlwp,Te))\*fr4  
 = ( 22.0000 - 18.0000 ) \* 0.2500 \* 1.0000  
 = 1.000 in<sup>2</sup>

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

Wall Thickness per UG45(a), tra = 0.1291 in  
 Wall Thickness per UG16(b), tr16b = 0.1562 in  
 Wall Thickness per UG45(b)(1), trb1 = 0.1760 in  
 Wall Thickness per UG45(b)(2), trb2 = 0.0625 in  
 Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.1760 in  
 Std. Wall Pipe per UG45(b)(4), trb4 = 0.3906 in  
 Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 0.1760 in

Final Required Thickness, tr45 = Max(tra, trb) = 0.1760 in  
 Available Nozzle Neck Thickness = .875 \* 0.5620 = 0.4917 in --> OK

**Nozzle Junction MDMT Calculations:**

**Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B**

Nozzle, tg = 0.492 , tr = 0.067 , c = 0.063 in , E\* = 1.00  
 Stress Ratio = tr \* (E\*) / (tg - c) = 0.155

Minimum Temp. w/o impact per UCS-66 -7 F  
 Minimum Temp. at required thickness -147 F  
 Minimum Temp. w/o impact per UG-20(f) -20 F

**Minimum Design Metal Temperature (Nozzle Neck to Pad Weld), Curve: B**

Pad is governing,  $t_g = 0.250$  ,  $t_r = 0.113$  in Temp. Reduction = 35 F  
 Conservately assuming Stress in Pad is same as that in Shell (Div. 1 L-9.3).

Minimum Temp. w/o impact per UCS-66	-20	F
Minimum Temp. at required thickness	-55	F
Minimum Temp. w/o impact per UG-20(f)	-20	F

**Minimum Design Metal Temperature (Shell to Pad Weld at Pad OD), Curve: B**

Pad is governing,  $Thk. = 0.250$  ,  $Req. Thk. = 0.113$  in Reduction = 35 F  
 Conservately assuming Stress in Pad is same as that in Shell (Div. 1 L-9.3).

Minimum Temp. w/o impact per UCS-66	-20	F
Minimum Temp. at required thickness	-55	F
Minimum Temp. w/o impact per UG-20(f)	-20	F

**Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: B**

Shell is governing,  $t_g = 0.250$  ,  $t_r = 0.113$  ,  $c = 0.063$  in ,  $E^* = 1.00$   
 Stress Ratio =  $t_r * (E^*) / (t_g - c) = 0.605$

Minimum Temp. w/o impact per UCS-66	-20	F
Minimum Temp. at required thickness	-55	F

Governing MDMT of the all the sub-joints of this Junction : -55 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 Temperature reduction per UCS-66(b)(1)(b)	-55	F

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

Stress ratio:  $P/Ambient Rating = 126.90/285.00 = 0.445$

Weld Size Calculations, Description: N1

Intermediate Calc. for nozzle/shell Welds	$T_{min}$	0.2500	in
Intermediate Calc. for pad/shell Welds	$T_{minPad}$	0.1875	in

**Results Per UW-16.1:**

	Required Thickness	Actual Thickness
Nozzle Weld	$0.1750 = 0.7 * T_{MIN}$	$0.1768 = 0.7 * W_o$ in
Pad Weld	$0.0938 = 0.5 * T_{minPad}$	$0.1768 = 0.7 * W_p$ in

**Maximum Allowable Pressure for this Nozzle at this Location:**

Converged Max. Allow. Pressure in Operating case	146.443	psig
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Note: The MAWP of this junction was limited by the shell.

The Drop for this Nozzle is : 2.4509 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 17.2009 in

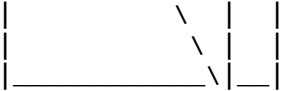
**INPUT VALUES, Nozzle Description: N2 From : 20**

Pressure for Nozzle Reinforcement Calculations P		126.900	psig
Temperature for Internal Pressure	Temp	200	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	35.5000	in
Shell Finished (Minimum) Thickness	t	0.2500	in
Shell Internal Corrosion Allowance	cas	0.0625	in
Shell External Corrosion Allowance	caext	0.0000	in
Distance from Bottom/Left Tangent		26.0000	in
User Entered Minimum Design Metal Temperature		-20.00	F
Nozzle Material		SA-106 B	
Nozzle Material UNS Number		K03006	
Nozzle material Specification used		Smls. pipe	
Nozzle Allowable Stress at Temperature	Sn	17100.00	psi
Nozzle Allowable Stress At Ambient	Sna	17100.00	psi
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	4.0000	in.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	tn	40	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Nozzle Corrosion Allowance	Can	0.0625	in
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	11.0000	in
Weld leg size between Nozzle and Pad/Shell	Wo	0.3750	in
Groove weld depth between Nozzle and Vessel	Wgnv	0.2500	in
Nozzle Inside Projection	h	0.0000	in
Weld leg size, Inside Nozzle to Shell	Wi	0.0000	in
ASME Code Weld Type per UW-16		None	
User Defined Nozzle/Shell Centerline Angle		60.0000	deg.
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head

**Nozzle Sketch**





**Insert Nozzle No Pad, no Inside projection**

**NOZZLE CALCULATION, Description: N2**

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation 4.500 in.  
 Actual Nozzle Thickness Used in Calculation 0.237 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]  
 =  $(P \cdot R) / (S \cdot E - 0.6 \cdot P)$  per UG-27 (c)(1)  
 =  $(126.90 \cdot 17.8125) / (20000 \cdot 1.00 - 0.6 \cdot 126.90)$   
 = 0.1135 in

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]  
 =  $(P \cdot R_o) / (S \cdot E + 0.4 \cdot P)$  per Appendix 1-1 (a)(1)  
 =  $(126.90 \cdot 2.2500) / (17100 \cdot 1.00 + 0.4 \cdot 126.90)$   
 = 0.0166 in

**UG-40, Limits of Reinforcement : [Int. Press]**

Parallel to Vessel Wall (Diameter Limit) D1 9.5863 in  
 Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.4363 in

**Results of Nozzle Reinforcement Area Calculations:**

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.550	NA	NA in <sup>2</sup>
Area in Shell	A1	0.351	NA	NA in <sup>2</sup>
Area in Nozzle Wall	A2	0.118	NA	NA in <sup>2</sup>
Area in Inward Nozzle	A3	0.000	NA	NA in <sup>2</sup>
Area in Welds	A4	0.120	NA	NA in <sup>2</sup>
Area in Pad	A5	0.000	NA	NA in <sup>2</sup>
TOTAL AREA AVAILABLE	Atot	0.589	NA	NA in <sup>2</sup>

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 60.00 Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:  
 =  $(D_{lr} \cdot t_r + 2 \cdot t_n \cdot t_r \cdot (1 - f_{r1}))$  UG-37(c)  
 =  $(4.7932 \cdot 0.1135 + 2 \cdot (0.2370 - 0.0625) \cdot 0.1135 \cdot (1 - 0.8550))$   
 = 0.550 in<sup>2</sup>

Areas per UG-37.1 but with DL = Diameter Limit, DLR = Corroded ID:

Area Available in Shell [A1]:  
 =  $(DL - D_{lr}) \cdot (E_s \cdot (t - c_{as}) - t_r) - 2 \cdot (t_n - c_{an}) \cdot (E_s \cdot (t - c_{as}) - t_r) \cdot (1 - f_{r1})$   
 =  $(9.586 - 4.793) \cdot (1.00 \cdot (0.2500 - 0.062) - 0.113) - 2 \cdot (0.237 - 0.062)$   
 =  $(1.00 \cdot (0.2500 - 0.0625) - 0.1135) \cdot (1 - 0.8550)$   
 = 0.351 in<sup>2</sup>

Area Available in Nozzle Wall, no Pad [A2np]:

$$= ( 2 * \min(Tlnp,ho) ) * ( tn - can - trn ) * fr2$$

$$= ( 2 * \min(0.436 ,11.000 ) ) * ( 0.2370 - 0.0625 - 0.0166 ) * 0.8550 )$$

$$= 0.118 \text{ in}^2$$

**Area Available in Welds, no Pad [A4np]:**

$$= Wo^2 * fr2 + ( Wi-can/0.707 )^2 * fr2$$

$$= 0.3750^2 * 0.8550 + ( 0.0000 )^2 * 0.8550$$

$$= 0.120 \text{ in}^2$$

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

Wall Thickness per UG45(a), tra = 0.0791 in  
 Wall Thickness per UG16(b), tr16b = 0.1562 in  
 Wall Thickness per UG45(b)(1), trb1 = 0.1760 in  
 Wall Thickness per UG45(b)(2), trb2 = 0.0625 in  
 Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.1760 in  
 Std. Wall Pipe per UG45(b)(4), trb4 = 0.2699 in  
 Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 0.1760 in

Final Required Thickness, tr45 = Max(tra, trb) = 0.1760 in  
 Available Nozzle Neck Thickness = .875 \* 0.2370 = 0.2074 in --> OK

**Nozzle Junction MDMT Calculations:**

**Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B**

Nozzle, tg = 0.207 , tr = 0.017 , c = 0.063 in , E\* = 1.00  
 Stress Ratio = tr \* (E\*) / (tg - c) = 0.115

Minimum Temp. w/o impact per UCS-66 -20 F  
 Minimum Temp. at required thickness -155 F

**Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: B**

Nozzle is governing, tg = 0.207 , tr = 0.017 , c = 0.063 in , E\* = 1.00  
 Stress Ratio = tr \* (E\*) / (tg - c) = 0.115

Minimum Temp. w/o impact per UCS-66 -20 F  
 Minimum Temp. at required thickness -155 F

Governing MDMT of the all the sub-joints of this Junction : -155 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 Temperature reduction per UCS-66(b)(1)(b) -55 F

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

$$\text{Stress ratio: } P/\text{Ambient Rating} = 126.90/285.00 = 0.445$$

Weld Size Calculations, Description: N2

Intermediate Calc. for nozzle/shell Welds Tmin 0.1745 in

**Results Per UW-16.1:**

	Required Thickness	Actual Thickness
Nozzle Weld	0.1222 = 0.7 * TMIN	0.2651 = 0.7 * Wo in

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

Weld Load [W]:

$$= (Ar-A1+2*(Thk-can)*Ffr1*(E1(T-Cas)-Tr))*S$$

$$= (0.5495 - 0.3512 + 2 * ( 0.2370 - 0.0625 ) * 0.8550 * (1.00 * ( 0.2500 - 0.0625 ) - 0.1135 ) ) * 20000$$

$$= 4409.12 \text{ lbf}$$

**Weld Load [W1]:**

$$= (A2+A5+A4-(Wi-Can/.707)^2*Ffr2)*S$$

$$= ( 0.1178 + 0.0000 + 0.1202 - 0.0000 * 0.86 ) * 20000$$

$$= 4759.80 \text{ lbf}$$

**Weld Load [W2]:**

$$= ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S$$

$$= ( 0.1178 + 0.0000 + 0.1202 + 0.0559 ) * 20000$$

$$= 5878.78 \text{ lbf}$$

**Weld Load [W3]:**

$$= ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S$$

$$= ( 0.1178 + 0.0000 + 0.1202 + 0.0000 + 0.0559 ) * 20000$$

$$= 5878.78 \text{ lbf}$$

**Strength of Connection Elements for Failure Path Analysis**

**Shear, Outward Nozzle Weld [Sonw]:**

$$= (\pi/2) * Dlo * Wo * 0.49 * Snw$$

$$= ( 3.1416 / 2.0 ) * 5.1962 * 0.3750 * 0.49 * 17100$$

$$= 25646. \text{ lbf}$$

**Shear, Nozzle Wall [Snw]:**

$$= (\pi * ( Dlr + Dlo ) / 4 ) * ( Thk - Can ) * 0.7 * Sn$$

$$= ( 3.1416 * 2.4973 ) * ( 0.2370 - 0.0625 ) * 0.7 * 17100$$

$$= 16388. \text{ lbf}$$

**Tension, Nozzle Groove Weld [Tngw]:**

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

$$= ( 3.1416 / 2.0 ) * 5.1962 * ( 0.2500 - 0.0625 ) * 0.74 * 17100$$

$$= 19366. \text{ lbf}$$

**Strength of Failure Paths:**

$$PATH11 = ( SONW + SNW ) = ( 25646 + 16387 ) = 42033 \text{ lbf}$$

$$PATH22 = ( Sonw + Tpgw + Tngw + Sinw )$$

$$= ( 25646 + 0 + 19365 + 0 ) = 45011 \text{ lbf}$$

$$PATH33 = ( Sonw + Tngw + Sinw )$$

$$= ( 25646 + 19365 + 0 ) = 45011 \text{ lbf}$$

**Summary of Failure Path Calculations:**

Path 1-1 = 42033 lbf, must exceed W = 4409 lbf or W1 = 4759 lbf  
 Path 2-2 = 45011 lbf, must exceed W = 4409 lbf or W2 = 5878 lbf  
 Path 3-3 = 45011 lbf, must exceed W = 4409 lbf or W3 = 5878 lbf

**Maximum Allowable Pressure for this Nozzle at this Location:**

Converged Max. Allow. Pressure in Operating case 131.453 psig

The Drop for this Nozzle is : 0.1432 in

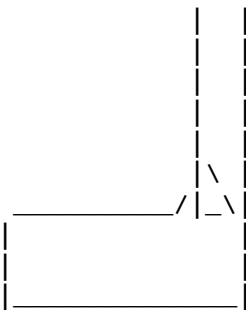
The Cut Length for this Nozzle is, Drop + Ho + H + T : 11.3932 in

**INPUT VALUES, Nozzle Description: N3 From : 10**

Pressure for Nozzle Reinforcement Calculations P		126.900	psig
Temperature for Internal Pressure	Temp	200	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 Elliptical Head	D	35.5480	in
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	0.2260	in
Head Internal Corrosion Allowance	cas	0.0625	in
Head External Corrosion Allowance	caext	0.0000	in
Distance from Head Centerline	L1	0.0000	in
User Entered Minimum Design Metal Temperature		-20.00	F
Nozzle Material		SA-105	
Nozzle Material UNS Number		K03504	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	20000.00	psi
Nozzle Allowable Stress At Ambient	Sna	20000.00	psi
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	1.7500	in.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	0.2175	in
Nozzle Corrosion Allowance	Can	0.0625	in
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	1.1880	in
Weld leg size between Nozzle and Pad/Shell	Wo	0.3750	in
Groove weld depth between Nozzle and Vessel	Wgnv	0.0000	in
ASME Code Weld Type per UW-16		UW-16.2(B-H)	

The Pressure Design option was Design Pressure + static head

**Nozzle Sketch**



**Abutting Nozzle No Pad**

**NOZZLE CALCULATION, Description: N3**

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation 1.750 in.  
 Actual Nozzle Thickness Used in Calculation 0.218 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, Tr [Int. Press]  
 $= (P \cdot K1 \cdot D) / (2 \cdot S \cdot E - 0.2 \cdot P)$  per UG-37(a)(3)  
 $= (126.90 \cdot 0.897 \cdot 35.6730) / (2 \cdot 20000.00 \cdot 1.00 - 0.2 \cdot 126.90)$   
 $= 0.1016$  in

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]  
 $= (P \cdot Ro) / (S \cdot E + 0.4 \cdot P)$  per Appendix 1-1 (a)(1)  
 $= (126.90 \cdot 0.8750) / (20000 \cdot 1.00 + 0.4 \cdot 126.90)$   
 $= 0.0055$  in

**UG-40, Limits of Reinforcement : [Int. Press]**

Parallel to Vessel Wall (Diameter Limit) D1 2.8800 in  
 Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.3875 in

Note: Taking a UG-36(c)(3)(a) exemption for N3  
 This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

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

Wall Thickness per UG45(a), tra = 0.0680 in  
 Wall Thickness per UG16(b), tr16b = 0.1562 in  
 Wall Thickness per UG45(b)(1), trb1 = 0.1752 in  
 Wall Thickness per UG45(b)(2), trb2 = 0.0625 in  
 Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.1752 in  
 Std. Wall Pipe per UG45(b)(4), trb4 = 0.1894 in  
 Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 0.1752 in

Final Required Thickness, tr45 = Max(tra, trb) = 0.1752 in  
 Available Nozzle Neck Thickness = 0.2175 in --> OK

**Nozzle Junction MDMT Calculations:**

**Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B**

Nozzle, tg = 0.218 , tr = 0.006 , c = 0.063 in , E\* = 1.00  
 Stress Ratio = tr \* (E\*) / (tg - c) = 0.036

Minimum Temp. w/o impact per UCS-66 -20 F  
 Minimum Temp. at required thickness -155 F

**Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: B**

Nozzle is governing, tg = 0.218 , tr = 0.006 , c = 0.063 in , E\* = 1.00  
 Stress Ratio = tr \* (E\*) / (tg - c) = 0.036

Minimum Temp. w/o impact per UCS-66 -20 F  
 Minimum Temp. at required thickness -155 F

Governing MDMT of the all the sub-joints of this Junction : -155 F

Weld Size Calculations, Description: N3

**Results Per UW-16.1:**

	Required Thickness	Actual Thickness
Fitting Weld	$0.0663 = UW-16.1(f)5$	$0.2652 = 0.7 * Wo$ in

**Maximum Allowable Pressure for this Nozzle at this Location:**

Converged Max. Allow. Pressure in Operating case 156.416 psig

Note: The MAWP of this junction was limited by the shell.

The Drop for this Nozzle is : 0.0119 in

The Cut Length for this Nozzle is, Drop + Ho + H + T : 1.4259 in

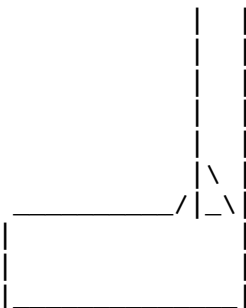
**PV Elite 2009 ©1993-2009 by COADE Engineering Software**

**INPUT VALUES, Nozzle Description: N4 From : 40**

Pressure for Nozzle Reinforcement Calculations P		126.900	psig
Temperature for Internal Pressure	Temp	200	F
Shell Material		SA-105	
Shell Allowable Stress at Temperature	S	20000.00	psi
Shell Allowable Stress At Ambient	Sa	20000.00	psi
Outside Diameter of Bolted Blind Flange	D	35.5000	in
Head Finished (Minimum) Thickness	t	3.5600	in
Head Internal Corrosion Allowance	cas	0.0625	in
Head External Corrosion Allowance	caext	0.0000	in
Distance from Head Centerline	L1	0.0000	in
User Entered Minimum Design Metal Temperature		-20.00	F
Nozzle Material		SA-105	
Nozzle Material UNS Number		K03504	
Nozzle material Specification used		Forgings	
Nozzle Allowable Stress at Temperature	Sn	20000.00	psi
Nozzle Allowable Stress At Ambient	Sna	20000.00	psi
Nozzle Diameter Basis (for tr calc only)	Inbase	OD	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	3.0000	in.
Nozzle Size and Thickness Basis	Idbn	Actual	
Actual Thickness of Nozzle	tn	0.3125	in
Nozzle Corrosion Allowance	Can	0.0625	in
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	ho	3.3750	in
Weld leg size between Nozzle and Pad/Shell	Wo	0.3750	in
Groove weld depth between Nozzle and Vessel	Wgnv	0.3125	in
ASME Code Weld Type per UW-16		B	

The Pressure Design option was Design Pressure + static head

**Nozzle Sketch**



**Abutting Nozzle No Pad**

**NOZZLE CALCULATION, Description: N4**

ASME Code, Section VIII, Division 1, 2007, A-08 UG-37 to UG-45

Actual Nozzle Outside Diameter Used in Calculation 3.000 in.  
 Actual Nozzle Thickness Used in Calculation 0.312 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]  
 =  $(P \cdot Ro) / (S \cdot E + 0.4 \cdot P)$  per Appendix 1-1 (a)(1)  
 =  $(126.90 \cdot 1.5000) / (20000 \cdot 1.00 + 0.4 \cdot 126.90)$   
 = 0.0095 in

**UG-40, Limits of Reinforcement : [Int. Press]**

Parallel to Vessel Wall (Diameter Limit) D1 9.9950 in  
 Normal to Vessel Wall (Thickness Limit), no pad Tlnp 0.6250 in

Note: Taking a UG-36(c)(3)(a) exemption for N4  
 This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

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

Wall Thickness per UG45(a), tra = 0.0720 in  
 Wall Thickness per UG16(b), tr16b = 0.1562 in  
 Wall Thickness per UG45(b)(1), trb1 = 0.0625 in  
 Wall Thickness per UG45(b)(2), trb2 = 0.0625 in  
 Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.1562 in  
 Std. Wall Pipe per UG45(b)(4), trb4 = 0.2515 in  
 Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 0.1562 in  
 Final Required Thickness, tr45 = Max(tra, trb) = 0.1562 in  
 Available Nozzle Neck Thickness = 0.3125 in --> OK

**UG-45 Minimum Nozzle Neck Thickness Requirement: [MAPnc]**

Wall Thickness per UG45(a), tra = 0.0000 in  
 Wall Thickness per UG16(b), tr16b = 0.0938 in  
 Wall Thickness per UG45(b)(1), trb1 = 0.0000 in  
 Check UG16(b) Min. Thickness, trb1 = Max(trb1, tr16b) = 0.0938 in  
 Std. Wall Pipe per UG45(b)(4), trb4 = 0.1890 in  
 Wall Thickness per UG45(b), trb = Min(trb1, trb4) = 0.0938 in  
 Final Required Thickness, tr45 = Max(tra, trb) = 0.0938 in  
 Available Nozzle Neck Thickness = 0.3125 in --> OK

**Nozzle Junction MDMT Calculations:**

**Minimum Design Metal Temperature (Nozzle Neck to Flange Weld), Curve: B**

Nozzle, tg = 0.312 , tr = 0.009 , c = 0.063 in , E\* = 1.00  
 Stress Ratio =  $tr \cdot (E^*) / (tg - c) = 0.038$

Minimum Temp. w/o impact per UCS-66 -20 F  
 Minimum Temp. at required thickness -155 F

**Nozzle MDMT per UCS-66 (a)1(b), (Nozzle to Shell/Head Weld), Curve: B**

Nozzle is governing, tg = 0.312 , tr = 0.009 , c = 0.063 in , E\* = 1.00  
 Stress Ratio =  $tr \cdot (E^*) / (tg - c) = 0.038$

Minimum Temp. w/o impact per UCS-66 -20 F  
Minimum Temp. at required thickness -155 F

Governing MDMT of the all the sub-joints of this Junction : -155 F

Weld Size Calculations, Description: N4

Intermediate Calc. for nozzle/shell Welds Tmin 0.2500 in

**Results Per UW-16.1:**

	Required Thickness	Actual Thickness
Nozzle Weld	$0.1750 = 0.7 * TMIN$	$0.2651 = 0.7 * Wo$ in

**Maximum Allowable Pressure for this Nozzle at this Location:**

Converged Max. Allow. Pressure in Operating case 258.100 psig

Note: The MAWP of this junction was limited by the shell.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 6.9370 in

**Nozzle Calculation Summary**

Description	MAWP psig	Ext	MAPNC psig	UG45 [tr]	Weld Path	Areas
N3	154.52	...	...	OK 0.175	OK	NoCalc[*]
N1	144.54	...	...	OK 0.176	OK	Passed
N2	129.55	...	...	OK 0.176	OK	Passed
N4	258.10	...	...	OK 0.156	OK	NoCalc[*]

Min. - Nozzles 129.55 N2  
 Min. Shell&Flgs 144.54 20 30 195.53

Computed Vessel M.A.W.P. 129.55 psig

[\*] - This was a small opening and the areas were not computed or the MAWP of this connection could not be computed because the longitudinal bending stress was greater than the hoop stress.

Note: MAWPs (Internal Case) shown above are at the High Point.

*Warning: A Nozzle Reinforcement is governing the MAWP of this Vessel.*

Check the Spatial Relationship between the Nozzles

From Node	Nozzle Description	Y Coordinate,	Layout Angle,	Dia. Limit
10	N3	0.000	0.000	2.880
20	N1	26.000	180.000	34.002
20	N2	26.000	0.000	9.586
40	N4	0.000	0.000	9.995

**The nozzle spacing is computed by the following:**

= Sqrt( ll<sup>2</sup> + lc<sup>2</sup> ) where  
 ll - Arc length along the inside vessel surface in the long. direction.  
 lc - Arc length along the inside vessel surface in the circ. direction

If any interferences/violations are found, they will be noted below.  
 No interference violations have been detected !

**Checking Multiple Nozzles on Flat Head per ASME Sec. VIII Div. 1 UG-39**

Comparing Nozzles on Element: Blind Cover

Note: No Nozzle pairs found on this element.

UG-39 Nozzle Diameter and Distance to Edge Checks :

Nozzle Description	Nozzle dia. in	Head Dia. /2 in	Distance from Edge in	Nozzle dia./4 in
N4	2.5000	17.812	16.250	0.6250

No Multiple Nozzle spacing violations have been detected !

**Nozzle Flange MAWP Results :**

Nozzle Description	----- Flange Rating		Temperature F	Class	Grade   Group
	Operating psig	Ambient psig			
N1	260.00	285.00	200	150	GR 1.1
N2	260.00	285.00	200	150	GR 1.1
Minimum Rating	260.000	285.000	psig		

Note: ANSI Ratings are per ANSI/ASME B16.5 2003 Edition

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**Nozzle Schedule:**

Description	Nominal Size in.	Flange Sch/Type Cls	Noz. O/Dia in	Wall Thk in	Re-Pad ODia in	Re-Pad Thick in	Cut Length in
N3	1.750	- None	1.750	0.218	-	-	1.43
N4	3.000	- None	3.000	0.312	-	-	6.94
N2	4.000	40 WNF	4.500	0.237	-	-	11.39
N1	18.000	40 WNF	18.000	0.562	22.00	0.250	17.20

*Note on the Cut Length Calculation:*

The Cut Length is the Outside Projection + Inside Projection + Drop + In Plane Shell Thickness. This value does not include weld gaps, nor does it account for shrinkage.

Please Note: In the case of Oblique Nozzles, the Outside Diameter must be increased. The Re-Pad WIDTH around the nozzle is calculated as follows:  
 Width of Pad = (Pad Outside Dia. (per above) - Nozzle Outside Dia.)/2

**Nozzle Material and Weld Fillet Leg Size Details:**

Nozzle	Material	Shl Grve Weld in	Noz Shl/Pad Weld in	Pad OD Weld in	Pad Grve Weld in	Inside Weld in
N3	SA-105	0.000	0.375	-	-	-
N4	SA-105	0.312	0.375	-	-	-
N2	SA-106 B	0.250	0.375	-	-	-
N1	SA-106 B	0.250	0.250	0.250	0.250	-

Note: The Outside projections below do not include the flange thickness.

**Nozzle Miscellaneous Data:**

Nozzle	Elevation/Distance From Datum in	Layout Angle deg.	Projection Outside in	Projection Inside in	Installed In Component
N3		0.00	1.19	0.00	Elliptical H
N4		0.00	3.38	0.00	Blind Cover
N2	26.000	0.00	11.00	0.00	Shell
N1	26.000	180.00	14.50	0.00	Shell

**Element and Detail Weights**

From	To	Element Metal Wgt. lbf	Element ID Volume ft <sup>3</sup>	Corroded Metal Wgt. lbf	Corroded ID Volume ft <sup>3</sup>	Extra due Misc %
10	20	124.427	4.55150	93.3204	4.59562	0.00000
20	30	332.225	23.9486	249.604	24.1176	0.00000
30	40	0.00000	3.54561	0.00000	3.57062	0.00000
40	50	0.00000	0.00000	0.00000	0.00000	0.00000
Total		456	35	342	35	0

**Weight of Details**

From	Type	Weight of Detail lbf	X Offset, Dtl. Cent. in	Y Offset, Dtl. Cent. in	Description
10	Liqd	0.00000	0.00000	-9.00000	Liquid 10
10	Nozl	0.35206	0.00000	0.74058	N3
10	Legs	60.7205	0.00000	-5.50000	LEGS
20	Liqd	0.00000	0.00000	20.9050	WATER
20	Nozl	226.469	26.1880	24.0000	N1
20	Nozl	21.2083	19.7630	24.0000	N2
30	Liqd	0.00000	0.00000	3.09500	Liquid 30
40	Liqd	0.00000	0.00000	1.78000	Liquid 40
40	Nozl	2.52005	0.00000	0.00000	N4

**Total Weight of Each Detail Type**

Total Weight of Nozzles	250.5
Total Weight of Legs	60.7
-----	
Sum of the Detail Weights	311.3 lbf

**Weight Summary**

Fabricated Wt. - Bare Weight W/O Removable Internals	767.9 lbf
Shop Test Wt. - Fabricated Weight + Water ( Full )	2988.8 lbf
Shipping Wt. - Fab. Wt + Rem.Intls.+ Shipping App.	767.9 lbf
Erected Wt. - Fab. Wt + Rem.Intls.+ Insul. (etc)	767.9 lbf
Ope. Wt. no Liq - Fab. Wt + Intls. + Details + Wghts.	767.9 lbf
Operating Wt. - Empty Wt. + Operating Liquid (No CA)	767.9 lbf
Field Test Wt. - Empty Weight + Water (Full)	2988.8 lbf
Mass of the Upper 1/3 of the Vertical Vessel	50.9 lbf

**Outside Surface Areas of Elements**

From	To	Surface Area in <sup>2</sup>
10	20	1635.09
20	30	4728.60
30	40	989.798
40	50	989.798
Total		8343.285 in <sup>2</sup> [57.9 Square Feet ]

**Element and Detail Weights**

From	To	Total Ele. Empty Wgt.	Total. Ele. Oper. Wgt.	Total. Ele. Hydro. Wgt.	Total Dtl. Offset Mom.	Oper. Wgt. No Liquid
		lbm	lbm	lbm	in-lb	lbm
10	Legs	623.896	623.896	2043.97	0.00000	623.896
Legs	20	-499.117	-499.117	-1635.18	0.00000	-499.117
	20	579.903	579.903	2074.30	6349.91	579.903
	30	0.00000	0.00000	221.247	0.00000	0.00000
	40	2.52005	2.52005	2.52005	0.00000	2.52005

**Cumulative Vessel Weight**

From	To	Cumulative Ope Wgt. No Liquid	Cumulative Oper. Wgt.	Cumulative Hydro. Wgt.
		lbm	lbm	lbm
10	Legs	-623.896	-623.896	-2043.97
Legs	20	83.3058	83.3058	662.893
	20	582.423	582.423	2298.07
	30	2.52005	2.52005	223.767
	40	2.52005	2.52005	2.52005

Note: The cumulative operating weights no liquid in the column above are the cumulative operating weights minus the operating liquid weight minus any weights absent in the empty condition.

**Cumulative Vessel Moment**

From	To	Cumulative Empty Mom.	Cumulative Oper. Mom.	Cumulative Hydro. Mom.
		in-lb	in-lb	in-lb
10	Legs	0.00000	0.00000	0.00000
Legs	20	6349.91	6349.91	6349.91
	20	6349.91	6349.91	6349.91
	30	0.00000	0.00000	0.00000
	40	0.00000	0.00000	0.00000

Note: Loads multiplied by the Scalar multiplier value of 0.6667

**Earthquake Analysis Results**

The NBC Velocity Zone Factor for the Vessel is .... 0.0500  
 The NBC Importance Factor for the Vessel is ..... 1.00  
 The NBC Freq. and Soil Factor (FS) is ..... 3.00  
 The NBC Force Factor (K) for the Vessel is ..... 1.00  
 The NBC Total Weight (W) for the Vessel is ..... 707.2 lbf  
 The NBC Total Shear (V) for the Vessel is ..... 63.6 lbf  
 The NBC Top Shear (Ft) for the Vessel is ..... 0.0 lbf

The Natural Frequency for the Vessel (Ope...) is 44.2420 Hz.

**Earthquake Load Calculation**

From	To	Earthquake Height in	Earthquake Weight lbf	Element Ope Load lbf	Element Emp Load lbf
10	Legs	-8.00000	623.896	-21.3519	-21.3519
Legs	20	-3.00000	-499.117	6.40556	6.40556
20	30	22.9050	579.903	56.8223	56.8223
30	40	46.9050	0.00000	0.00000	0.00000
40	50	51.7800	2.52005	0.55822	0.55822
Top Load		74.56		0	0

The following table is for the Operating Case.

**Wind/Earthquake Shear, Bending**

From	To	Distance to Support in	Cummulative Wind Shear lbf	Earthquake Shear lbf	Wind Bending in-lb	Earthquake Bending in-lb
10	Legs	7.00000	0.00000	0.00000	0.00000	0.00000
Legs	20	4.00000	0.00000	63.7861	0.00000	675.477
20	30	12.9050	0.00000	57.3806	0.00000	1215.66
30	40	36.9050	0.00000	0.55822	0.00000	4.44900
40	50	41.7800	0.00000	0.55822	0.00000	0.99363

**Longitudinal Stress Constants**

From	To	Metal Area	Metal Area	New & Cold	Corroded
		New & Cold	Corroded	Sect. Mod.	Sect. Mod.
		in <sup>2</sup>	in <sup>2</sup>	in <sup>3</sup>	in <sup>3</sup>
10	20	25.3995	18.4074	225.744	164.169
20	30	28.0780	21.0953	249.217	187.890
30	40	28.0780	21.0953	249.217	187.890
40	50	436.850	429.867	3941.99	3890.19

**Longitudinal Allowable Stresses**

From	To	All. Str. Long. Ten. psi	All. Str. Hydr. Ten. psi	All. Str. Long. Com. psi	All. Str. Hyr. Comp. psi
10	Legs	16800.0	21840.0	-15508.4	-21309.0
Legs	20	16800.0	21840.0	-15508.4	-21309.0
20	30	16800.0	21840.0	-16185.9	-21853.3
30	40	24000.0	31200.0	-16185.9	-21853.3
40	50	24000.0	31200.0	-21360.0	-26700.0

**Longitudinal Stress Report**

Note: Longitudinal Operating and Empty Stresses are computed in the corroded condition. Stresses due to loads in the hydrostatic test cases have been computed in the new and cold condition.

**Longitudinal Stresses Due to . . .**

From	To	Long. Str. Int. Pres.	Long. Str. Ext. Pres.	Long. Str. Hyd. Pres.
		psi	psi	psi
10	20	6896.49	0.00000	6589.06
20	30	6002.37	0.00000	5945.19
30	40	0.00000	0.00000	0.00000
40	50	0.00000	0.00000	0.00000

**Longitudinal Stresses Due to . . .**

From	To	Wght. Str. Empty	Wght. Str. Operating	Wght. Str. Hydrotest	Wght. Str. Emp. Mom.	Wght. Str. Opr. Mom.
		psi	psi	psi	psi	psi
10	Legs	33.8937	33.8937	80.4729	0.00000	0.00000
Legs	20	-4.52567	-4.52567	-26.0987	38.6792	38.6792
20	30	-27.6091	-27.6091	-81.8460	33.7958	33.7958
30	40	-0.11946	-0.11946	-7.96949	0.00000	0.00000
40	50	-0.0058624	-0.0058624	-0.0057687	0.00000	0.00000

**Longitudinal Stresses Due to . . .**

From	To	Wght. Str. Hyd. Mom.	Bend. Str. Oper. Wind	Bend. Str. Oper. Equ.	Bend. Str. Hyd. Wind	Bend. Str. Hyd. Equ.
		psi	psi	psi	psi	psi
10	Legs	0.00000	0.00000	0.00000	0.00000	0.00000
Legs	20	28.1289	0.00000	4.11453	0.00000	0.00000
20	30	25.4795	0.00000	6.47004	0.00000	0.00000
30	40	0.00000	0.00000	0.023679	0.00000	0.00000
40	50	0.00000	0.00000	0.00025542	0.00000	0.00000

**Longitudinal Stresses Due to . . .**

From	To	Long. Str. Vortex Ope.	Long. Str. Vortex Emp.	Long. Str. Vortex Tst.	EarthQuake Empty
		psi	psi	psi	psi
10	Legs	0.00000	0.00000	0.00000	0.00000
Legs	20	0.00000	0.00000	0.00000	4.11453
20	30	0.00000	0.00000	0.00000	6.47004
30	40	0.00000	0.00000	0.00000	0.023679
40	50	0.00000	0.00000	0.00000	0.00025542

**Longitudinal Stresses Due to . . .**

From	To	Long. Str. Y Forces W	Long. Str. Y Forces S S
		psi	psi
10	Legs	0.00000	0.00000
Legs	20	0.00000	0.00000
20	30	0.00000	0.00000
30	40	0.00000	0.00000

40 | 50 | 0.00000 | 0.00000 |

**Long. Stresses due to User Forces and Moments**

From	To	Wind For/Mom Corroded psi	Eqk For/Mom Corroded psi	Wnd For/Mom No Corr. psi	Eqk For/Mom No Corr. psi
10	Legs	0.00000	0.00000	0.00000	0.00000
Legs	20	0.00000	0.00000	0.00000	0.00000
20	30	0.00000	0.00000	0.00000	0.00000
30	40	0.00000	0.00000	0.00000	0.00000
40	50	0.00000	0.00000	0.00000	0.00000

**Stress Combination Load Cases for Vertical Vessels:**

**Load Case Definition Key**

- IP = Longitudinal Stress due to Internal Pressure
- EP = Longitudinal Stress due to External Pressure
- HP = Longitudinal Stress due to Hydrotest Pressure
- NP = No Pressure
- EW = Longitudinal Stress due to Weight (No Liquid)
- OW = Longitudinal Stress due to Weight (Operating)
- HW = Longitudinal Stress due to Weight (Hydrotest)
- WI = Bending Stress due to Wind Moment (Operating)
- EQ = Bending Stress due to Earthquake Moment (Operating)
- EE = Bending Stress due to Earthquake Moment (Empty)
- HI = Bending Stress due to Wind Moment (Hydrotest)
- HE = Bending Stress due to Earthquake Moment (Hydrotest)
- WE = Bending Stress due to Wind Moment (Empty) (no CA)
- WF = Bending Stress due to Wind Moment (Filled) (no CA)
- CW = Longitudinal Stress due to Weight (Empty) (no CA)
- VO = Bending Stress due to Vortex Shedding Loads ( Ope )
- VE = Bending Stress due to Vortex Shedding Loads ( Emp )
- VF = Bending Stress due to Vortex Shedding Loads ( Test No CA. )
- FW = Axial Stress due to Vertical Forces for the Wind Case
- FS = Axial Stress due to Vertical Forces for the Seismic Case
- BW = Bending Stress due to Lat. Forces for the Wind Case, Corroded
- BS = Bending Stress due to Lat. Forces for the Seismic Case, Corroded
- BN = Bending Stress due to Lat. Forces for the Wind Case, UnCorroded
- BU = Bending Stress due to Lat. Forces for the Seismic Case, UnCorroded

**General Notes:**

Case types HI and HE are in the Un-Corroded condition.

Case types WE, WF, and CW are in the Un-Corroded condition.

A blank stress and stress ratio indicates that the corresponding stress comprising those components that did not contribute to that type of stress.

An asterisk (\*) in the final column denotes overstress.

**Analysis of Load Case 1 : NP+EW+WI+FW+BW**

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	33.89	16800.00		15508.41	0.0020	
10	34.15	16800.00	-43.20	15508.41	0.0020	0.0028
20	6.19	16800.00	-61.40	16185.92	0.0004	0.0038

**Analysis of Load Case 2 : NP+EW+EE+FS+BS**

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	33.89	14000.00		12923.67	0.0024	
10	38.27	14000.00	-47.32	12923.67	0.0027	0.0037
20	12.66	14000.00	-67.87	13488.27	0.0009	0.0050

**Analysis of Load Case 3 : NP+OW+WI+FW+BW**

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
-----------	----------------	-------------------	--------------	-------------------	-------------	-------------

Node	Stress	Stress	Stress	Stress	Ratio	Ratio
10	33.89	16800.00		15508.41	0.0020	
10	34.15	16800.00	-43.20	15508.41	0.0020	0.0028
20	6.19	16800.00	-61.40	16185.92	0.0004	0.0038

Analysis of Load Case 4 : NP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	33.89	14000.00		12923.67	0.0024	
10	38.27	14000.00	-47.32	12923.67	0.0027	0.0037
20	12.66	14000.00	-67.87	13488.27	0.0009	0.0050

Analysis of Load Case 5 : NP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	80.47	16800.00		15508.41	0.0048	
10	2.03	16800.00	-54.23	15508.41	0.0001	0.0035
20		16800.00	-107.33	16185.92		0.0066

Analysis of Load Case 6 : NP+HW+HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	80.47	16800.00		15508.41	0.0048	
10	2.03	16800.00	-54.23	15508.41	0.0001	0.0035
20		16800.00	-107.33	16185.92		0.0066

Analysis of Load Case 7 : IP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	6930.38	16800.00		15508.41	0.4125	
10	6036.52	16800.00		15508.41	0.3593	
20	6.19	16800.00	-61.40	16185.92	0.0004	0.0038

Analysis of Load Case 8 : IP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	6930.38	14000.00		12923.67	0.4950	
10	6040.64	14000.00		12923.67	0.4315	
20	12.66	14000.00	-67.87	13488.27	0.0009	0.0050

Analysis of Load Case 9 : EP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	33.89	16800.00		15508.41	0.0020	
10	34.15	16800.00	-43.20	15508.41	0.0020	0.0028
20	6.19	16800.00	-61.40	16185.92	0.0004	0.0038

Analysis of Load Case 10 : EP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	33.89	14000.00		12923.67	0.0024	
10	38.27	14000.00	-47.32	12923.67	0.0027	0.0037
20	12.66	14000.00	-67.87	13488.27	0.0009	0.0050

Analysis of Load Case 11 : HP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	6669.53	21840.00		21309.01	0.3054	
10	5947.22	21840.00		21309.01	0.2723	

20 21840.00 -107.33 21853.30 0.0049

**Analysis of Load Case 12 : HP+HW+HE**

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	6669.53	21840.00		21309.01	0.3054	
10	5947.22	21840.00		21309.01	0.2723	
20		21840.00	-107.33	21853.30		0.0049

**Analysis of Load Case 13 : IP+WE+EW**

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	6930.38	16800.00		15508.41	0.4125	
10	6036.52	16800.00		15508.41	0.3593	
20	6.19	16800.00	-61.40	16185.92	0.0004	0.0038

**Analysis of Load Case 14 : IP+WF+CW**

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	6921.05	16800.00		15508.41	0.4120	
10	5999.09	16800.00		15508.41	0.3571	
20		16800.00	-20.74	16185.92		0.0013

**Analysis of Load Case 15 : IP+VO+OW**

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	6930.38	16800.00		15508.41	0.4125	
10	6036.52	16800.00		15508.41	0.3593	
20	6.19	16800.00	-61.40	16185.92	0.0004	0.0038

**Analysis of Load Case 16 : IP+VE+EW**

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	6930.38	16800.00		15508.41	0.4125	
10	6036.52	16800.00		15508.41	0.3593	
20	6.19	16800.00	-61.40	16185.92	0.0004	0.0038

**Analysis of Load Case 17 : NP+VO+OW**

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	33.89	16800.00		15508.41	0.0020	
10	34.15	16800.00	-43.20	15508.41	0.0020	0.0028
20	6.19	16800.00	-61.40	16185.92	0.0004	0.0038

**Analysis of Load Case 18 : FS+BS+IP+OW**

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	6930.38	16800.00		15508.41	0.4125	
10	6036.52	16800.00		15508.41	0.3593	
20	6.19	16800.00	-61.40	16185.92	0.0004	0.0038

**Analysis of Load Case 19 : FS+BS+EP+OW**

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	33.89	16800.00		15508.41	0.0020	
10	34.15	16800.00	-43.20	15508.41	0.0020	0.0028
20	6.19	16800.00	-61.40	16185.92	0.0004	0.0038

Absolute Maximum of the all of the Stress Ratio's 0.4950

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Stress due to Combined Loads : Step: 14 10:38a Jun 19,2009

Governing Element: Elliptical Head

Governing Load Case 8 : IP+OW+EQ+FS+BS

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**Shop/Field Installation Options :**

Note : The CG is computed from the first Element From Node

Center of Gravity of Nozzles	26.2 in
Center of Gravity of Legs	-5.5 in
Center of Gravity of Bare Shell New and Cold	15.9 in
Center of Gravity of Bare Shell Corroded	15.9 in
Vessel CG in the Operating Condition	17.9 in
Vessel CG in the Fabricated (Shop/Empty) Condition	17.6 in

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**RESULTS FOR LEGS : Operating Case Description: LEGS**

**Legs attached to: Elliptical Head**

**Section Properties : Single Angle L3X3X0.2500**

**USA AISC 1989 Steel Table**

Overall Leg Length		31.000	in
Effective Leg Length	Leglen	21.000	in
Distance Leg Up Side of Vessel		10.000	in
Number of Legs	Nleg	4	
Cross Sectional Area for L3X3X0.2500	Aleg	1.440	in <sup>2</sup>
Section Inertia ( strong axis )		1.240	in**4
Section Inertia ( weak axis )		1.240	in**4
Section Modulus ( strong axis )		0.577	in <sup>3</sup>
Section Modulus ( weak axis )		0.577	in <sup>3</sup>
Radius of Gyration ( strong axis )		0.930	in
Radius of Gyration ( weak axis )		0.930	in

**Leg Orientation - Diagonal**

Overturning Moment at top of Legs		675.5	in-lb
Total Weight Load at top of Legs	W	707.2	lbf
Total Shear force at top of Legs		42.4	lbf
Additional force in Leg due to Bracing	Fadd	0.0	lbf
Occasional Load Factor	Occfac	1.333	
Effective Leg End Condition Factor	k	1.000	

**Note: The Legs are Not Cross Braced**  
**The Leg Shear Force includes Wind and Seismic Effects**

Maximum Shear at top of one Leg [Vleg]:  

$$= ( \text{Max}(\text{Wind}, \text{Seismic}) + \text{Fadd} ) * ( \text{Imax} / \text{Itot} )$$

$$= ( 42.4 + 0.0 ) * ( 2.0 / 4.98 )$$

$$= 16.92 \text{ lbf}$$

Axial Compression, Leg futhest from N.A. [Sma]  

$$= ((W/Nleg)+(Mleg/(Nlegm*Rn)))/Aleg)$$

$$= ((707 / 4 ) + (8105 / ( 2 * 19.00 ))) / 1.440 )$$

$$= 135.12 \text{ psi}$$

Axial Compression, Leg closest to N.A. [Sva]  

$$= ( W / Nleg ) / Aleg$$

$$= ( 707 / 4 ) / 1.440$$

$$= 122.78 \text{ psi}$$

Computing Principal Axis and Inertias for Angle.

Leg lengths and thickness:	3.0000	3.0000	0.25000
Distance to geometric centroid:	0.84200	0.84200	
Arm about YY:	0.71700	0.78300	
Arm about ZZ:	0.65800	0.71700	
Leg areas:	0.75000	0.68750	
Geometric inertia components YY:	0.38947	0.85477	
Geometric inertia components ZZ:	0.88722	0.35702	
Geometric inertias Iy & Iz:	1.2442	1.2442	
Product of inertia:	0.73981		
Mohrs Radius:	0.73981		

Average Inertia: 1.2442

QFACT = 1.0000 FBZ = 21.600  
 Principal Axis Inertias (Z&W) = 0.50443 1.9840  
 Angle to Principal Axis = 45.000  
 Distances to extreme fibers CW & CZ = 2.1213 0.93055  
 FOB from Eq 5-5 = 336.31  
 Bending allowables Fby & Fbz = 23.760 21.600

Shear Center Coordinates Wo & Zo: 0.99873 0.0000  
 Values for Elastic Flexural-Torsional Buckling Stress:  
 E, G, J, R0<sup>2</sup>: 29500. 11346. 0.30000E-01 2.7256  
 AREA, LENGTH, Kw, Kz: 1.4400 21.000 1.0000 1.0000  
 H, Few, Fez, Fej: 0.63403 909.65 231.27 86.726  
 Fe computed from C4-1: 83.627

Initial (Kl/r)max, & (Kl/r)equiv = 35.481 59.005  
 Final (Kl/r)max, & Cc = 59.005 127.18  
 Fa based on Eq 4-1 = 17.573

	Actual	Allowable	
Weak Axis Bending :	463.39	28792.80	psi
Strong Axis Bending :	268.57	31672.08	psi
Axial Compression :	135.12	23424.36	psi

UNITY CHECKS ARE: H1-1 0.000  
 H1-2 0.000  
 H1-3 0.030

AISC Unity Check : 0.030 Should be <= to 1

**Bolting Size Requirement for Leg Baseplates :**

Baseplate Material		SA-36
Baseplate Allowable Stress	SBA	16600.00 psi
Baseplate Length	D	6.0000 in
Baseplate Width	B	6.0000 in
Baseplate Thickness	BTHK	0.2500 in
Leg Dimension Along Baseplate Length	d	3.0000 in
Leg Dimension Along Baseplate Width	b	3.0000 in
Dist. from the Leg Edge to Bolt Hole Center	z	2.0000 in
Bolt Material		SA-193 B7
Bolt Allowable Stress	STBA	25000.00 psi
Anchor Bolt Nominal Diameter	BOD	1.0000 in
Number of Anchor Bolts in Tension per Leg	NB	2
Total Number of Anchors Bolt per Leg	NBT	1
Ultimate 28-day Concrete Strength	FCPRIME	3000.000 psi

**LEG BASEPLATE and BOLTING Analysis, including Moments**

Angle Leg

Base Plate Available Area (AA):

$$= B * D$$

$$= 6.00 * 6.00$$

$$= 36.00 \text{ in}^2$$

Clearance Between The Bolt And The Leg Edge (BCL):

$$= z - BOD / 2$$

$$\begin{aligned} &= 2.00 - 1.00 / 2 \\ &= 1.50 \text{ in} \end{aligned}$$

**Moment at Baseplate (MOMENT):**

$$\begin{aligned} &= V_{leg} * L_{leg} \\ &= 16.92 * 31.00 \\ &= 524.40 \text{ in-lb} \end{aligned}$$

**Eccentricity (e):**

$$\begin{aligned} &= \text{MOMENT} * 1.00 / P \\ &= 524.40 * 1.00 / 176.80 \\ &= 2.97 \text{ in} > D/6 \text{ [Plate Uplift Condition]} \end{aligned}$$

$$\begin{aligned} a &= \text{MAX}[\text{ABS}(\text{MAX}[B,D] - \text{MAX}[b,d]) / 2 , \text{ABS}(\text{MIN}[B,D] - \text{MIN}[b,d]) / 2] \\ &= \text{MAX}[1.50 , 1.50 ] \\ &= 1.50 \text{ in} \end{aligned}$$

There is uplift, the total number of bolts should be > 1  
AND  
the total number of bolts in tension should be > 0.

**RESULTS FOR LEGS : HydroTest Case Description: LEGS**

**Legs attached to: Elliptical Head**

**Section Properties : Single Angle L3X3X0.2500**

**USA AISC 1989 Steel Table**

Overall Leg Length		31.000	in
Effective Leg Length	Leglen	21.000	in
Distance Leg Up Side of Vessel		10.000	in
Number of Legs	Nleg	4	
Cross Sectional Area for L3X3X0.2500	Aleg	1.440	in <sup>2</sup>
Section Inertia ( strong axis )		1.240	in**4
Section Inertia ( weak axis )		1.240	in**4
Section Modulus ( strong axis )		0.577	in <sup>3</sup>
Section Modulus ( weak axis )		0.577	in <sup>3</sup>
Radius of Gyration ( strong axis )		0.930	in
Radius of Gyration ( weak axis )		0.930	in

**Leg Orientation - Diagonal**

Overturning Moment at top of Legs		0.0	in-lb
Total Weight Load at top of Legs	W	2928.1	lbf
Total Shear force at top of Legs		0.0	lbf
Additional force in Leg due to Bracing	Fadd	0.0	lbf
Occasional Load Factor	Occfac	1.000	
Effective Leg End Condition Factor	k	1.000	

**Note: The Legs are Not Cross Braced**  
**The Leg Shear Force includes Wind and Seismic Effects**

Maximum Shear at top of one Leg [Vleg]:  
 $= ( \text{Max}(\text{Wind}, \text{Seismic}) + \text{Fadd} ) * ( \text{Imax} / \text{Itot} )$   
 $= ( 0.0 + 0.0 ) * ( 2.0 / 4.98 )$   
 $= 0.00 \text{ lbf}$

Axial Compression, Leg futhest from N.A. [Sma]  
 $= ((\text{W}/\text{Nleg})+(\text{Mleg}/(\text{Nlegm}*\text{Rn}))/\text{Aleg})$   
 $= ((2928 / 4 ) + ( 0 / ( 2 * 19.00 ) ) ) / 1.440 )$   
 $= 508.35 \text{ psi}$

Axial Compression, Leg closest to N.A. [Sva]  
 $= ( \text{W} / \text{Nleg} ) / \text{Aleg}$   
 $= ( 2928 / 4 ) / 1.440$   
 $= 508.35 \text{ psi}$

Computing Principal Axis and Inertias for Angle.

Leg lengths and thickness:	3.0000	3.0000	0.25000
Distance to geometric centroid:	0.84200	0.84200	
Arm about YY:	0.71700	0.78300	
Arm about ZZ:	0.65800	0.71700	
Leg areas:	0.75000	0.68750	
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Geometric inertias Iy & Iz:	1.2442	1.2442	
Product of inertia:	0.73981		
Mohrs Radius:	0.73981		

Average Inertia: 1.2442

QFACT = 1.0000 FBZ = 21.600  
 Principal Axis Inertias (Z&W) = 0.50443 1.9840  
 Angle to Principal Axis = 45.000  
 Distances to extreme fibers CW & CZ = 2.1213 0.93055  
 FOB from Eq 5-5 = 336.31  
 Bending allowables Fby & Fbz = 23.760 21.600

Shear Center Coordinates Wo & Zo: 0.99873 0.0000  
 Values for Elastic Flexural-Torsional Buckling Stress:  
 E, G, J, R0<sup>2</sup>: 29500. 11346. 0.30000E-01 2.7256  
 AREA, LENGTH, Kw, Kz: 1.4400 21.000 1.0000 1.0000  
 H, Few, Fez, Fej: 0.63403 909.65 231.27 86.726  
 Fe computed from C4-1: 83.627

Initial (Kl/r)max, & (Kl/r)equiv = 35.481 59.005  
 Final (Kl/r)max, & Cc = 59.005 127.18  
 Fa based on Eq 4-1 = 17.573

	Actual	Allowable	
Weak Axis Bending :	0.00	21600.00	psi
Strong Axis Bending :	0.00	23760.00	psi
Axial Compression :	508.35	17572.66	psi

UNITY CHECKS ARE: H1-1 0.000  
 H1-2 0.000  
 H1-3 0.029

AISC Unity Check : 0.029 Should be <= to 1

**Bolting Size Requirement for Leg Baseplates :**

Baseplate Material		SA-36
Baseplate Allowable Stress	SBA	16600.00 psi
Baseplate Length	D	6.0000 in
Baseplate Width	B	6.0000 in
Baseplate Thickness	BTHK	0.2500 in
Leg Dimension Along Baseplate Length	d	3.0000 in
Leg Dimension Along Baseplate Width	b	3.0000 in
Dist. from the Leg Edge to Bolt Hole Center	z	2.0000 in
Bolt Material		SA-193 B7
Bolt Allowable Stress	STBA	25000.00 psi
Anchor Bolt Nominal Diameter	BOD	1.0000 in
Number of Anchor Bolts in Tension per Leg	NB	2
Total Number of Anchors Bolt per Leg	NBT	1
Ultimate 28-day Concrete Strength	FCPRIME	3000.000 psi

**LEG BASEPLATE and BOLTING Analysis, including Moments**

Angle Leg

Base Plate Available Area (AA):

$$= B * D$$

$$= 6.00 * 6.00$$

$$= 36.00 \text{ in}^2$$

Clearance Between The Bolt And The Leg Edge (BCL):

$$= z - BOD / 2$$

$$= 2.00 - 1.00 / 2$$

$$= 1.50 \text{ in}$$

**Moment at Baseplate (MOMENT):**

$$= V_{leg} * L_{leg}$$

$$= 0.00 * 31.00$$

$$= 0.00 \text{ in-lb}$$

**Bearing Pressure (FC):**

$$= P / AA$$

$$= 176.80 / 36.00$$

$$= 4.91 \text{ psig}$$

$$m = \text{ABS} (\text{MAX}[B,D] - \text{MAX}[b,d]) / 2$$

$$= \text{ABS}(6.00 - 3.00) / 2$$

$$= 1.50 \text{ in}$$

$$n = \text{ABS} (\text{MIN}[B,D] - \text{MIN}[b,d]) / 2$$

$$= \text{ABS}(6.00 - 3.00) / 2$$

$$= 1.50 \text{ in}$$

**The Baseplate Required Thickness (TREQ):**

$$= (3 * FC * \text{MAX}(m,n)^2 / (1.5 * SBA) )^{1/2}$$

$$= (3 * 4.91 * 1.50^2 / 24900.00)^{1/2}$$

$$= 0.04 \text{ in}$$

**Baseplate Lifting Moment (MBB):**

$$= R_{mleg} + V * \text{Length}$$

$$= 0.00 + 0.00 * 31.00$$

$$= 0.00 \text{ in-lb}$$

**Required Total Bolt Area per Leg (ABREQB): per H. Bednar**

$$= (1 / STBA) * ((4 * MBB / (N_{legm} * OD)) - P)$$

$$= (1 / 25000.00) * ((4 * 0.00 / (2 * 36.00)) - 176.80)$$

$$= -0.0071 \text{ in}^2 \text{ --> (No tension in bolts)}$$

**\*\* No Tensile Bolt Loads. Choose a practical bolt size! \*\***

**Summary of Results:**

		Actual	Required	Pass/Fail
Baseplate Thickness	( in ):	0.250	0.036	Pass
Bolt Root Area (D. Moss)	( in <sup>2</sup> ):	1.10	0.00	Pass

**Design Code: ASME Code Section VIII Division 1, 2007 A-08**

Diameter Spec : 36.000 in OD  
 Vessel Design Length, Tangent to Tangent 53.56 in  
 Distance of Bottom Tangent above Grade 0.00 in  
 Specified Datum Line Distance 0.00 in  
 Shell/Head Matl SA-516 70  
 Shell/Head Matl SA-105  
 Nozzle Material SA-106 B  
 Re-Pad Material SA-516 70  
 Internal Design Temperature 200 F  
 Internal Design Pressure 125.00 psig  
 External Design Temperature 70 F  
 Maximum Allowable Working Pressure 129.55 psig  
 External Max. Allowable Working Pressure 38.84 psig  
 Hydrostatic Test Pressure 168.42 psig  
 Required Minimum Design Metal Temperature -20 F  
 Warmest Computed Minimum Design Metal Temperature -51 F  
 Wind Design Code No Wind Loads  
 Earthquake Design Code NBC

**Element Pressures and MAWP: psig**

Element Desc	Internal	External	M.A.W.P	Corr. All.
Elliptical Head	126.900	0.000	154.516	0.0625
Shell	126.900	0.000	144.544	0.0625
36" 150# WN Flange	126.900	0.000	258.100	0.0625
Blind Cover	126.900	0.000	258.100	0.0625

Liquid Level: 62.56 in Dens.: 0.000 lbm/ft<sup>3</sup> Sp. Gr.: 0.000

Element Type	"To" Elev in	Length in	Element Thk in	R e q d T h k		Joint Eff	
				Int.	Ext.	Long	Circ
Ellipse	2.00	2.000	0.250	0.195	No Calc	0.85	0.70
Cylinder	43.81	41.810	0.250	0.225	No Calc	0.70	0.70
Body Flg	50.00	6.190	3.560	No Calc	3.497	1.00	1.00
Body Flg	53.56	3.560	3.560	No Calc	3.497	1.00	1.00

Element thicknesses are shown as Nominal if specified, otherwise are Minimum

Earthquake Moment on Support 1351. in-lb  
 Earthquake Shear on Support 64. lbf

Note: Wind and Earthquake moments include the effects of user defined forces and moments if any exist in the job and were specified to act (compute loads and stresses) during these cases. Also included are moment effects due to eccentric weights if any are present in the input.

**Weights:**

Fabricated - Bare W/O Removable Internals	767.9	lbm
Shop Test - Fabricated + Water ( Full )	2988.8	lbm
Shipping - Fab. + Rem. Intls.+ Shipping App.	767.9	lbm
Erected - Fab. + Rem. Intls.+ Insul. (etc)	767.9	lbm
Empty - Fab. + Intls. + Details + Wghts.	767.9	lbm
Operating - Empty + Operating Liquid (No CA)	767.9	lbm
Field Test - Empty Weight + Water (Full)	2988.8	lbm