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DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2007

Analysis Performed by : KEDKEP CONSULTING, INC.

Job File : E:\WEB\TOWER ANALYSIS.PVI

Date of Analysis : Oct 23,2008

PV Elite 2008, May 2008

PV Elite 2008 Licensee: KEDKEP CONSULTING, INC.

FileName : Tower Analysis -----

Warnings and Errors Step: 0 3:04p Oct 23,2008

Class From To : Basic Element Checks.

=====

Class From To: Check of Additional Element Data

=====

There were no geometry errors or warnings.

PV Elite 2008 c1993-2008 by COADE Engineering Software

PV Elite Vessel Analysis Program: Input Data

Design Internal Pressure (for Hydrotest)	100.00	psig
Design Internal Temperature	200	F
Type of Hydrotest	UG99-b Note [34]	
Hydrotest Position	Horizontal	
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	RT-4	
Miscellaneous Weight Percent	20.	
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	
Use Hydrotest Allowable Unmodified	Y	
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	NBC-2005	
NBC Design Wind Speed	70.000	mile/hr
NBC Exposure Constant	B	
Importance Factor	1.	
NBC Roughness Factor	1	
NBC Base Elevation	0.0000	ft.
NBC Critical Damping Ratio	0.0080	
NBC Percent Wind for Hydrotest	33.	
Use Wind Profile (Y/N)	N	
Damping Factor (Beta) for Wind (Ope)	0.0080	
Damping Factor (Beta) for Wind (Empty)	0.0000	
Damping Factor (Beta) for Wind (Filled)	0.0000	
Seismic Design Code	NBC-2005	
Importance Factor	1.000	
Overstrength Factor	1.0000	
Ductility Factor	3.0000	

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Height Ratio (hx/hn)	0.0000
Component Amplification factor [Rp]	2.5000
Element or Component factor [Cp]	1.0000
Component Force factor [Ar]	2.5000
Site Class	C
Acceleration Sa(0.2)	0.1500
Acceleration Sa(0.5)	0.0840
Acceleration Sa(1.0)	0.0410
Acceleration Sa(2.0)	0.0230
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	Skirt Sup.
Description	Skirt
Distance "FROM" to "TO"	3.0000 ft.
Skirt Inside Diameter	41.500 in.
Diameter of Skirt at Base	41.500 in.
Skirt Thickness	0.5000 in.
Internal Corrosion Allowance	0.0000 in.
Nominal Thickness	0.5000 in.
External Corrosion Allowance	0.0000 in.
Design Temperature Internal Pressure	200 F
Design Temperature External Pressure	200 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 lb./cu.in.
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	0.7
Efficiency, Head-to-Skirt or Circ. Seam	0.7

Element From Node	20
Element To Node	30
Element Type	Elliptical
Description	Btm Head
Distance "FROM" to "TO"	0.1667 ft.
Inside Diameter	40.000 in.
Element Thickness	0.2500 in.
Internal Corrosion Allowance	0.1250 in.
Nominal Thickness	0.0000 in.
External Corrosion Allowance	0.0000 in.
Design Internal Pressure	100.00 psig
Design Temperature Internal Pressure	200 F
Design External Pressure	15.000 psig
Design Temperature External Pressure	200 F
Effective Diameter Multiplier	1.2
Material Name	SA-516 70
Efficiency, Longitudinal Seam	0.85
Efficiency, Circumferential Seam	0.7

FileName : Tower Analysis

Input Echo

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Elliptical Head Factor	2.	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	Drain	
Dist. from "FROM" Node / Offset dist	0.0000	in.
Nozzle Diameter	3.	in.
Nozzle Schedule	80	
Nozzle Class	150	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.0000	lb.
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	30	
Element To Node	40	
Element Type	Cylinder	
Description	Shell 1	
Distance "FROM" to "TO"	14.500	ft.
Inside Diameter	40.000	in.
Element Thickness	0.7500	in.
Internal Corrosion Allowance	0.1250	in.
Nominal Thickness	0.0000	in.
External Corrosion Allowance	0.0000	in.
Design Internal Pressure	100.00	psig
Design Temperature Internal Pressure	200	F
Design External Pressure	15.000	psig
Design Temperature External Pressure	200	F
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.7	
Element From Node	30	
Detail Type	Nozzle	
Detail ID	Manway	
Dist. from "FROM" Node / Offset dist	3.0000	ft.
Nozzle Diameter	16.	in.
Nozzle Schedule	40	
Nozzle Class	150	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.0000	lb.
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	
Element From Node	40	
Element To Node	50	
Element Type	Cylinder	
Description	shell 2	
Distance "FROM" to "TO"	14.500	ft.
Inside Diameter	40.000	in.
Element Thickness	0.7500	in.
Internal Corrosion Allowance	0.1250	in.
Nominal Thickness	0.0000	in.
External Corrosion Allowance	0.0000	in.
Design Internal Pressure	100.00	psig
Design Temperature Internal Pressure	200	F
Design External Pressure	15.000	psig
Design Temperature External Pressure	200	F
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.7	

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Input Echo

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Element From Node	40	
Detail Type	Ring	
Detail ID	Ring:[1 of 1]	
Dist. from "FROM" Node / Offset dist	14.300	ft.
Inside Diameter of Ring	41.500	in.
Thickness of Ring	1.0000	in.
Outside Diameter of Ring	45.000	in.
Material Name	SA-516 70	
Height of Section Ring	0.0000	in.
Using Custom Stiffener Section	No	
Element From Node	40	
Detail Type	Nozzle	
Detail ID	Inlet	
Dist. from "FROM" Node / Offset dist	2.3333	ft.
Nozzle Diameter	6.	in.
Nozzle Schedule	40	
Nozzle Class	150	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.0000	lb.
Grade of Attached Flange	GR1.1	
Nozzle Matl	SA-106 B	
Element From Node	50	
Element To Node	60	
Element Type	Conical	
Description	Cone	
Distance "FROM" to "TO"	2.0000	ft.
Inside Diameter	40.000	in.
Element Thickness	0.7500	in.
Internal Corrosion Allowance	0.1250	in.
Nominal Thickness	0.0000	in.
External Corrosion Allowance	0.0000	in.
Design Internal Pressure	100.00	psig
Design Temperature Internal Pressure	200	F
Design External Pressure	15.000	psig
Design Temperature External Pressure	200	F
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.7	
Cone Diameter at "To" End	28.000	in.
Design Length of Cone	24.000	in.
Half Apex Angle of Cone	14.036243	
Toriconical (Y/N)	N	
Element From Node	60	
Element To Node	70	
Element Type	Cylinder	
Description	Shell 3	
Distance "FROM" to "TO"	10.000	ft.
Inside Diameter	28.000	in.
Element Thickness	0.7500	in.
Internal Corrosion Allowance	0.1250	in.
Nominal Thickness	0.0000	in.
External Corrosion Allowance	0.0000	in.
Design Internal Pressure	100.00	psig
Design Temperature Internal Pressure	200	F
Design External Pressure	15.000	psig
Design Temperature External Pressure	200	F
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70	
Efficiency, Longitudinal Seam	0.85	

FileName : Tower Analysis -----

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Efficiency, Circumferential Seam	0.7	
Element From Node	60	
Detail Type	Nozzle	
Detail ID	Outlet	
Dist. from "FROM" Node / Offset dist	8.0000	ft.
Nozzle Diameter	6.	in.
Nozzle Schedule	40	
Nozzle Class	150	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.0000	lb.
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	70	
Element To Node	80	
Element Type	Elliptical	
Description	Top Head	
Distance "FROM" to "TO"	0.1667	ft.
Inside Diameter	28.000	in.
Element Thickness	0.3750	in.
Internal Corrosion Allowance	0.1250	in.
Nominal Thickness	0.0000	in.
External Corrosion Allowance	0.0000	in.
Design Internal Pressure	100.00	psig
Design Temperature Internal Pressure	200	F
Design External Pressure	15.000	psig
Design Temperature External Pressure	200	F
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.7	
Elliptical Head Factor	2.	

Element From Node	70	
Detail Type	Nozzle	
Detail ID	Vent	
Dist. from "FROM" Node / Offset dist	0.0000	in.
Nozzle Diameter	2.5	in.
Nozzle Schedule	80	
Nozzle Class	150	
Layout Angle	0.	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.0000	lb.
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

XY Coordinate Calculations

From	To	X (Horiz.) ft.	Y (Vert.) ft.	DX (Horiz.) ft.	DY (Vert.) ft.
	Skirt	0.00000	3.00000	0.00000	3.00000
	Btm Head	0.00000	3.16667	0.00000	0.16667
	Shell 1	0.00000	17.6667	0.00000	14.5000
	shell 2	0.00000	32.1667	0.00000	14.5000
	Cone	0.00000	34.1667	0.00000	2.00000
	Shell 3	0.00000	44.1667	0.00000	10.0000
	Top Head	0.00000	44.3333	0.00000	0.16667

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Internal Pressure Calculations Step: 3 3:04p Oct 23,2008

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	0.00000	0.50000	0.00000	41.5000	0.00000
	Btm Head	100.000	...	0.12500	40.0000	17000.0
	Shell 1	100.000	...	0.12500	40.0000	17000.0
	shell 2	100.000	...	0.12500	40.0000	17000.0
	Cone	100.000	...	0.12500	40.0000	17000.0
	Shell 3	100.000	...	0.12500	28.0000	17000.0
	Top Head	100.000	...	0.12500	28.0000	17000.0

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.
	Skirt	0.00000	No Calc	No Calc	0.50000	No Calc
	Btm Head	100.000	105.525	212.235	0.25000	0.24345
	Shell 1	100.000	518.293	623.472	0.75000	0.24380
	shell 2	100.000	518.293	623.472	0.75000	0.24380
	Cone	100.000	502.998	605.254	0.75000	0.24748
	Shell 3	100.000	732.759	882.353	0.75000	0.21875
	Top Head	100.000	300.353	454.141	0.37500	0.21875
	Minimum		105.525	212.235		

MAWP: 105.525 psig, limited by: Btm Head.

Internal Pressure Calculation Results :

ASME Code, Section VIII, Division 1, 2007

Elliptical Head From 20 To 30 SA-516 70, UCS-66 Crv. B at 200 F

Btm Head

Thickness Due to Internal Pressure [Tr]:

$$= (P \cdot D \cdot K) / (2 \cdot S \cdot E - 0.2 \cdot P) \text{ Appendix 1-4 (c)}$$

$$= (100.000 \cdot 40.2500 \cdot 0.12) / (2 \cdot 20000.00 \cdot 0.85 - 0.2 \cdot 100.000)$$

$$= 0.1185 + 0.1250 = 0.2435 \text{ in.}$$

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

$$= (2 \cdot S \cdot E \cdot t) / (K \cdot D + 0.2 \cdot t) \text{ per Appendix 1-4 (c)}$$

$$= (2 \cdot 20000.00 \cdot 0.85 \cdot 0.1250) / (1.00 \cdot 40.2500 + 0.2 \cdot 0.1250)$$

$$= 105.525 \text{ psig}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$= (2 \cdot S \cdot E \cdot t) / (K \cdot D + 0.2 \cdot t) \text{ per Appendix 1-4 (c)}$$

$$= (2 \cdot 20000.00 \cdot 0.85 \cdot 0.2500) / (1.00 \cdot 40.0000 + 0.2 \cdot 0.2500)$$

$$= 212.235 \text{ psig}$$

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

$$= (P \cdot (K \cdot D + 0.2 \cdot t)) / (2 \cdot E \cdot t)$$

$$= (100.000 \cdot (1.00 \cdot 40.2500 + 0.2 \cdot 0.1250)) / (2 \cdot 0.85 \cdot 0.1250)$$

$$= 18952.941 \text{ psi}$$

Required Thickness of Straight Flange = 0.244 in.

Percent Elongation per UCS-79 $(75 \cdot t_{nom} / R_f) \cdot (1 - R_f / R_o)$ 2.740 %

Min Metal Temp. w/o impact per UCS-66 -20 F

Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.81] -39 F

FileName : Tower Analysis -----

Internal Pressure Calculations Step: 3 3:04p Oct 23,2008

Cylindrical Shell From 30 To 40 SA-516 70 , UCS-66 Crv. B at 200 F

Shell 1

Thickness Due to Internal Pressure [Tr]:

$$= (P \cdot R) / (S \cdot E - 0.6 \cdot P) \text{ per UG-27 (c)(1)}$$

$$= (100.000 \cdot 20.1250) / (20000.00 \cdot 0.85 - 0.6 \cdot 100.000)$$

$$= 0.1188 + 0.1250 = 0.2438 \text{ in.}$$

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

$$= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c)(1)}$$

$$= (20000.00 \cdot 0.85 \cdot 0.6250) / (20.1250 + 0.6 \cdot 0.6250)$$

$$= 518.293 \text{ psig}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c)(1)}$$

$$= (20000.00 \cdot 0.85 \cdot 0.7500) / (20.0000 + 0.6 \cdot 0.7500)$$

$$= 623.472 \text{ psig}$$

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

$$= (P \cdot (R + 0.6 \cdot t)) / (E \cdot t)$$

$$= (100.000 \cdot (20.1250 + 0.6 \cdot 0.6250)) / (0.85 \cdot 0.6250)$$

$$= 3858.823 \text{ psi}$$

Percent Elongation per UCS-79 $(50 \cdot t_{nom} / R_f) \cdot (1 - R_f / R_o)$ 1.840 %

Min Metal Temp. w/o impact per UCS-66	16	F
Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.16]	-124	F
Min Metal Temp. w/o impact per UG-20(f)	-20	F

Cylindrical Shell From 40 To 50 SA-516 70 , UCS-66 Crv. B at 200 F

shell 2

Thickness Due to Internal Pressure [Tr]:

$$= (P \cdot R) / (S \cdot E - 0.6 \cdot P) \text{ per UG-27 (c)(1)}$$

$$= (100.000 \cdot 20.1250) / (20000.00 \cdot 0.85 - 0.6 \cdot 100.000)$$

$$= 0.1188 + 0.1250 = 0.2438 \text{ in.}$$

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

$$= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c)(1)}$$

$$= (20000.00 \cdot 0.85 \cdot 0.6250) / (20.1250 + 0.6 \cdot 0.6250)$$

$$= 518.293 \text{ psig}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c)(1)}$$

$$= (20000.00 \cdot 0.85 \cdot 0.7500) / (20.0000 + 0.6 \cdot 0.7500)$$

$$= 623.472 \text{ psig}$$

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

$$= (P \cdot (R + 0.6 \cdot t)) / (E \cdot t)$$

$$= (100.000 \cdot (20.1250 + 0.6 \cdot 0.6250)) / (0.85 \cdot 0.6250)$$

$$= 3858.823 \text{ psi}$$

Percent Elongation per UCS-79 $(50 \cdot t_{nom} / R_f) \cdot (1 - R_f / R_o)$ 1.840 %

Min Metal Temp. w/o impact per UCS-66	16	F
Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.16]	-124	F
Min Metal Temp. w/o impact per UG-20(f)	-20	F

Conical Section From 50 To 60 SA-516 70 , UCS-66 Crv. B at 200 F

Cone

Thickness Due to Internal Pressure [Tr]:

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Internal Pressure Calculations Step: 3 3:04p Oct 23,2008

$$= (P \cdot D) / (2 \cdot \cos(a) \cdot (S \cdot E - 0.6 \cdot P)) \text{ per Appendix 1-4 (e)}$$

$$= (100.000 \cdot 40.1288) / (2 \cdot 0.9701 \cdot (20000.00 \cdot 0.85 - 0.6 \cdot 100.000))$$

$$= 0.1225 + 0.1250 = 0.2475 \text{ in.}$$

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

$$= (2 \cdot S \cdot E \cdot t \cdot \cos(a)) / (D + 1.2 \cdot t \cdot \cos(a)) \text{ per App 1-4(e)}$$

$$= (2 \cdot 20000.00 \cdot 0.85 \cdot 0.625 \cdot 0.970) / (40.129 + 1.2 \cdot 0.625 \cdot 0.970)$$

$$= 502.998 \text{ psig}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$= (2 \cdot S \cdot E \cdot t \cdot \cos(a)) / (D + 1.2 \cdot t \cdot \cos(a)) \text{ per App 1-4(e)}$$

$$= (2 \cdot 20000.00 \cdot 0.85 \cdot 0.7500 \cdot 0.9701) / (40.0000 + 1.2 \cdot 0.7500 \cdot 0.9701)$$

$$= 605.254 \text{ psig}$$

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

$$= (P \cdot (D + 1.2 \cdot t \cdot \cos(a))) / (2 \cdot E \cdot t \cdot \cos(a))$$

$$= (100.000 \cdot (40.1288 + 1.2 \cdot 0.625 \cdot 0.9701)) / (2 \cdot 0.85 \cdot 0.625 \cdot 0.9701)$$

$$= 3976.158 \text{ psi}$$

Percent Elongation per UCS-79 $(75 \cdot t_{nom} / R_f) \cdot (1 - R_f / R_o)$ 2.607 %

Min Metal Temp. w/o impact per UCS-66	16	F
Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.17]	-124	F
Min Metal Temp. w/o impact per UG-20(f)	-20	F

Cylindrical Shell From 60 To 70 SA-516 70 , UCS-66 Crv. B at 200 F

Shell 3

Thickness Due to Internal Pressure [Tr]:

$$= (P \cdot R) / (S \cdot E - 0.6 \cdot P) \text{ per UG-27 (c)(1)}$$

$$= (100.000 \cdot 14.1250) / (20000.00 \cdot 0.85 - 0.6 \cdot 100.000)$$

$$= 0.0834 + 0.1250 = 0.2084 \text{ in.}$$

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 0.0938 in. will be used.

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

$$= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c)(1)}$$

$$= (20000.00 \cdot 0.85 \cdot 0.6250) / (14.1250 + 0.6 \cdot 0.6250)$$

$$= 732.759 \text{ psig}$$

Maximum Allowable Pressure, New and Cold [MAPNC]:

$$= (S \cdot E \cdot t) / (R + 0.6 \cdot t) \text{ per UG-27 (c)(1)}$$

$$= (20000.00 \cdot 0.85 \cdot 0.7500) / (14.0000 + 0.6 \cdot 0.7500)$$

$$= 882.353 \text{ psig}$$

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

$$= (P \cdot (R + 0.6 \cdot t)) / (E \cdot t)$$

$$= (100.000 \cdot (14.1250 + 0.6 \cdot 0.6250)) / (0.85 \cdot 0.6250)$$

$$= 2729.412 \text{ psi}$$

Percent Elongation per UCS-79 $(50 \cdot t_{nom} / R_f) \cdot (1 - R_f / R_o)$ 2.609 %

Min Metal Temp. w/o impact per UCS-66	16	F
Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.13]	-124	F
Min Metal Temp. w/o impact per UG-20(f)	-20	F

Elliptical Head From 70 To 80 SA-516 70 , UCS-66 Crv. B at 200 F

Top Head

Thickness Due to Internal Pressure [Tr]:

$$= (P \cdot D \cdot K) / (2 \cdot S \cdot E - 0.2 \cdot P) \text{ Appendix 1-4(c)}$$

$$= (100.000 \cdot 28.2500 \cdot 0.12) / (2 \cdot 20000.00 \cdot 0.85 - 0.2 \cdot 100.000)$$

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= 0.0831 + 0.1250 = 0.2081 in.

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 0.0938 in. will be used.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
 = $(2 * S * E * t) / (K * D + 0.2 * t)$ per Appendix 1-4 (c)
 = $(2 * 20000.00 * 0.85 * 0.2500) / (1.00 * 28.2500 + 0.2 * 0.2500)$
 = 300.353 psig

Maximum Allowable Pressure, New and Cold [MAPNC]:
 = $(2 * S * E * t) / (K * D + 0.2 * t)$ per Appendix 1-4 (c)
 = $(2 * 20000.00 * 0.85 * 0.3750) / (1.00 * 28.0000 + 0.2 * 0.3750)$
 = 454.141 psig

Actual stress at given pressure and thickness, corroded [Sact]:
 = $(P * (K * D + 0.2 * t)) / (2 * E * t)$
 = $(100.000 * (1.00 * 28.2500 + 0.2 * 0.2500)) / (2 * 0.85 * 0.2500)$
 = 6658.823 psi

Required Thickness of Straight Flange = 0.208 in.

Percent Elongation per UCS-79 $(75 * t_{nom} / R_f) * (1 - R_f / R_o)$ 5.831 %

Min Metal Temp. w/o impact per UCS-66 -20 F
 Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.32] -155 F

MINIMUM METAL DESIGN TEMPERATURE RESULTS :

Minimum Metal Temp. w/o impact per UCS-66 16. F
 Minimum Metal Temp. at Required thickness -39. 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 137.182 psig
 Pressure per UG99b[34] = 1.3 * Design Pres * Sa/S 130.000 psig
 Pressure per UG99c = 1.3 * M.A.P. - Head(Hyd) 274.461 psig
 Pressure per UG100 = 1.1 * M.A.W.P. * Sa/S 116.077 psig

UG-99(b) Note 34, Test Pressure Calculation:
 = Test Factor * Design Pressure * Stress Ratio
 = 1.3 * 100.000 * 1.000
 = 130.000 psig

Horizontal Hydrotest performed in accordance with: UG-99b (Note 34)

Stresses on Elements due to Hydrostatic Test Pressure:

From To	Stress	Allowable	Ratio	Pressure
Btm Head	12386.7	26000.0	0.476	131.44
Shell 1	4216.5	26000.0	0.162	131.44
shell 2	4216.5	26000.0	0.162	131.44
Cone	4343.4	26000.0	0.167	131.44
Shell 3	2969.6	26000.0	0.114	131.01
Top Head	5769.6	26000.0	0.222	131.01

Elements Suitable for Internal Pressure.

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External Pressure Calculation Results :

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Elliptical Head From 20 to 30 Ext. Chart: CS-2 at 200 F

Btm Head

Elastic Modulus from Chart: CS-2 at 300 F : 0.29000E+08 psi

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	D/t	Factor A	B
0.125	40.50	324.00	0.0004287	6215.71

EMAP = $B / (K_0 * D/t) = 6215.7065 / (0.9000 * 324.0000) = 21.3159$ psig

Results for Required Thickness (Tca):

Tca	OD	D/t	Factor A	B
0.105	40.50	386.22	0.0003596	5214.37

EMAP = $B / (K_0 * D/t) = 5214.3701 / (0.9000 * 386.2190) = 15.0012$ psig

Cylindrical Shell From 30 to 40 Ext. Chart: CS-2 at 200 F

Shell 1

Elastic Modulus from Chart: CS-2 at 300 F : 0.29000E+08 psi

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
0.625	41.50	350.93	66.40	8.4562	0.0002860	4146.94

EMAP = $(4*B) / (3*(D/t)) = (4*4146.9438) / (3*66.4000) = 83.2720$ psig

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
0.315	41.50	350.93	131.70	8.4562	0.0001022	1481.70

EMAP = $(4*B) / (3*(D/t)) = (4*1481.7010) / (3*131.7028) = 15.0004$ psig

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
0.625	41.50	0.53E+25	66.40	.5000E+02	0.0002495	3617.63

EMAP = $(4*B) / (3*(D/t)) = (4*3617.6328) / (3*66.4000) = 72.6432$ psig

Cylindrical Shell From 40 to Ring:[1 of 1] Ext. Chart: CS-2 at 200 F

shell 2

Elastic Modulus from Chart: CS-2 at 300 F : 0.29000E+08 psi

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
0.625	41.50	350.93	66.40	8.4562	0.0002860	4146.94

EMAP = $(4*B) / (3*(D/t)) = (4*4146.9438) / (3*66.4000) = 83.2720$ psig

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
0.315	41.50	350.93	131.70	8.4562	0.0001022	1481.70

EMAP = $(4*B) / (3*(D/t)) = (4*1481.7010) / (3*131.7028) = 15.0004$ psig

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
0.625	41.50	0.53E+25	66.40	.5000E+02	0.0002495	3617.63

EMAP = $(4*B) / (3*(D/t)) = (4*3617.6328) / (3*66.4000) = 72.6432$ psig

Cone From 50 to 60 Ext. Chart: CS-2 at 200 F

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Cone

Elastic Modulus from Chart: CS-2 at 300 F : 0.29000E+08 psi

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
0.606	41.55	20.53	68.52	0.4942	0.0052117	17384.15

EMAP = (4*B)/(3*(D/t)) = (4*17384.1523)/(3*68.5197) = 338.2805 psig

Note: The cone thickness used in the calculation has been modified per UG-33(f), $t_e = t * \cos(\alpha)$.

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
0.100	41.55	20.53	416.90	0.4942	0.0003235	4690.47

EMAP = (4*B)/(3*(D/t)) = (4*4690.4688)/(3*416.9009) = 15.0011 psig

Note: The cone thickness used in the calculation has been modified per UG-33(f), $t_e = t * \cos(\alpha)$.

Cylindrical Shell From 60 to 70 Ext. Chart: CS-2 at 200 F

Shell 3

Elastic Modulus from Chart: CS-2 at 300 F : 0.29000E+08 psi

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
0.625	29.50	124.33	47.20	4.2147	0.0009662	12216.94

EMAP = (4*B)/(3*(D/t)) = (4*12216.9355)/(3*47.2000) = 345.1112 psig

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
0.169	29.50	124.33	174.25	4.2147	0.0001352	1960.33

EMAP = (4*B)/(3*(D/t)) = (4*1960.3263)/(3*174.2460) = 15.0004 psig

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
0.625	29.50	0.24E+30	47.20	.5000E+02	0.0004938	7159.40

EMAP = (4*B)/(3*(D/t)) = (4*7159.4019)/(3*47.2000) = 202.2430 psig

Elliptical Head From 70 to 80 Ext. Chart: CS-2 at 200 F

Top Head

Elastic Modulus from Chart: CS-2 at 300 F : 0.29000E+08 psi

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	D/t	Factor A	B
0.250	28.75	115.00	0.0012077	13182.19

EMAP = B/(K0*D/t) = 13182.1865/(0.9000 *115.0000) = 127.3641 psig

Results for Required Thickness (Tca):

Tca	OD	D/t	Factor A	B
0.074	28.75	386.22	0.0003596	5214.36

EMAP = B/(K0*D/t) = 5214.3579 / (0.9000 *386.2199) = 15.0011 psig

Stiffening Ring Calculations for : Ring:[1 of 1], SA-516 70

Effective Length of Shell			5.60 in.
Area (sq.in.)	Distance (in.)	Area*Dist	
Shell:	3.501	0.3125	1.094
Ring :	1.750	1.5000	2.625
Total:	5.251		3.719
Centroid of Ring plus Shell		=	0.708 in.
Inertia	Distance	A*Dist ²	

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Shell: 0.114 0.3957 0.548
 Ring : 0.447 -0.7918 1.097
 Total: 0.561 1.645
 Available Moment of Inertia, Ring plus Shell 2.206 in**4

Required Stress in Ring plus Shell BREQ 735.35 psi
 Required Strain in Ring plus Shell AREQ 0.0000507

Required Moment of Inertia, Ring plus Shell

$$= (OD^2 * SLEN * (TCA+ARING/SLEN) * AREQ) / 10.9$$

$$= (41.5000^2 * 176.6667 * (0.6250 + 1.7500 / 176.6667) * 0.0000507) / 10.9$$

$$= 0.8988 \text{ in**4}$$

Results for Stiffening Ring Weld Calculations per UG-30

Given Stiffening Ring Fillet Weld Size Wleg 0.500 in.
 Stiffening Ring Attachment Style BOTH
 Location of Stiffening Ring EXTERNAL
 Radial Pressure Load Pext*Slen 2650.00 lb./in.
 The Radial Shear Load V 1099.75 lb.
 The First Moment of the Area (Ring + Shell) Q 1.39 in.³
 Weld Shear Flow due to Rad. Shear Load VQ/I 690.76 lb./in
 The Weld Allowable Stress .55*S 11000.00 psi
 Minimum Weld Leg Size Min(.25,TCA,TRING) Wldmin 0.25 in.
 Maximum Space between Welds 24*TCA 15.00 in.
 The Weld Allowable Load WLeg*.55*S 5500.00 lb./in
 The Combined Weld Load SRSS of VQ/I and Pext*Slen 2738.55 lb./in

External Pressure Calculations

From	To	Section Length ft.	Outside Diameter in.	Corroded Thickness in.	Factor A	Factor B psi
10	20	No Calc	0.00000	0.00000	No Calc	No Calc
20	30	No Calc	40.5000	0.12500	0.00042867	6215.71
30	40	29.2444	41.5000	0.62500	0.00028600	4146.94
40	Ring	29.2444	41.5000	0.62500	0.00028600	4146.94
Ring	50	0.20000	41.5000	0.62500	0.92155	17800.0
50	60	1.71084	41.5462	0.62500	0.0052117	17384.2
60	70	10.3611	29.5000	0.62500	0.00096620	12216.9
70	80	No Calc	28.7500	0.25000	0.0012077	13182.2

External Pressure Calculations

From	To	External Actual T. in.	External Required T. in.	External Des. Press. psig	External M.A.W.P. psig
10	20	0.00000	No Calc	0.00000	No Calc
20	30	0.25000	0.22986	15.0000	21.3159
30	40	0.75000	0.44010	15.0000	83.2720
40	Ring	0.75000	0.44010	15.0000	83.2720
Ring	50	0.75000	0.16469	15.0000	357.430
50	60	0.75000	0.22772	15.0000	338.280
60	70	0.75000	0.29430	15.0000	345.111
70	80	0.37500	0.19944	15.0000	127.364
		Minimum			21.316

External Pressure Calculations

From	To	Actual Len. Bet. Stiff. ft.	Allow. Len. Bet. Stiff. ft.	Ring Inertia Required in**4	Ring Inertia Available in**4
10	20	No Calc	No Calc	No Calc	No Calc
20	30	No Calc	No Calc	No Calc	No Calc
30	40	29.2444	442.4E+21	No Calc	No Calc
40	Ring	29.2444	442.4E+21	No Calc	No Calc

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Ring	50	0.20000	8.656E+21	0.89879	2.20599
50	60	1.71084	1.71084	No Calc	No Calc
60	70	10.3611	19.68E+27	No Calc	No Calc
70	80	No Calc	No Calc	No Calc	No Calc

Elements Suitable for External Pressure.

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Element and Detail Weights

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Element and Detail Weights

From	To	Element Metal Wgt. lb.	Element ID Volume in3	Corroded Metal Wgt. lb.	Corroded ID Volume in3	Extra due Misc %
10	20	1244.54	0.00000	1244.54	0.00000	248.908
20	30	155.075	10890.9	77.5376	11080.4	31.0150
30	40	4727.97	218655.	3952.06	221397.	945.593
40	50	4727.97	218655.	3952.06	221397.	945.593
50	60	573.610	22016.3	479.780	22347.8	114.722
60	70	2300.47	73890.3	1925.39	75215.6	460.094
70	80	121.186	4105.01	80.7908	4204.76	24.2373
Total		13850	548212	11712	555641	2770

Weight of Details

From	Type	Weight of Detail lb.	X Offset, Dtl. Cent. ft.	Y Offset, Dtl. Cent. ft.	Description
20	Noz1	18.1522	0.00000	0.069444	Drain
30	Noz1	206.641	2.33333	3.00000	Manway
40	Ring	80.7499	0.00000	14.3000	Ring:[1 of 1]
40	Noz1	33.9274	1.91667	2.33333	Inlet
60	Noz1	33.9274	1.41667	8.00000	Outlet
70	Noz1	14.8816	0.00000	0.048611	Vent

Total Weight of Each Detail Type

Total Weight of Stiffeners	80.7
Total Weight of Nozzles	307.5

Sum of the Detail Weights	388.3 lb.

Weight Summary

Fabricated Wt. - Bare Weight W/O Removable Internals	17009.3 lb.
Shop Test Wt. - Fabricated Weight + Water (Full)	36805.8 lb.
Shipping Wt. - Fab. Wt + Rem. Intls.+ Shipping App.	17009.3 lb.
Erected Wt. - Fab. Wt + Rem. Intls.+ Insul. (etc)	17009.3 lb.
Ope. Wt. no Liq - Fab. Wt + Intls. + Details + Wghts.	17009.3 lb.
Operating Wt. - Empty Wt. + Operating Liquid (No CA)	17009.3 lb.
Field Test Wt. - Empty Weight + Water (Full)	36805.8 lb.
Mass of the Upper 1/3 of the Vertical Vessel	3966.7 lb.

Outside Surface Areas of Elements

From	To	Surface Area sq.in.
10	20	4806.64
20	30	2032.48
30	40	22685.4
40	50	22685.4
50	60	2762.60
60	70	11121.2
70	80	1076.62
Total		67170.461 sq.in. [466.5 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
------	----	-----------------------	------------------------	-------------------------	------------------------	----------------------

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		lbm	lbm	lbm	ft.lb.	lbm
10	20	1493.45	1493.45	1493.45	0.00000	1493.45
20	30	204.242	204.242	597.523	0.00000	204.242
30	40	5880.20	5880.20	13776.1	482.163	5880.20
40	50	5788.24	5788.24	13684.1	65.0275	5788.24
50	60	688.332	688.332	1483.36	0.00000	688.332
60	70	2794.49	2794.49	5462.75	48.0638	2794.49
70	80	160.305	160.305	308.542	0.00000	160.305

Cumulative Vessel Weight

From	To	Cumulative Ope Wgt. No Liquid lbm	Cumulative Oper. Wgt. lbm	Cumulative Hydro. Wgt. lbm
10	20	17009.3	17009.3	36805.8
20	30	15515.8	15515.8	35312.4
30	40	15311.6	15311.6	34714.8
40	50	9431.37	9431.37	20938.8
50	60	3643.13	3643.13	7254.66
60	70	2954.80	2954.80	5771.29
70	80	160.305	160.305	308.542

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. ft.lb.	Cumulative Oper. Mom. ft.lb.	Cumulative Hydro. Mom. ft.lb.
10	20	595.255	595.255	595.255
20	30	595.255	595.255	595.255
30	40	595.255	595.255	595.255
40	50	113.091	113.091	113.091
50	60	48.0638	48.0638	48.0638
60	70	48.0638	48.0638	48.0638
70	80	0.00000	0.00000	0.00000

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Nozzle Flange MAWP Step: 6 3:04p Oct 23,2008

Nozzle Flange MAWP Results :

Flange Rating	Operating psig	Ambient psig	Temperature F	Class	Grade Group
	260.000	285.000	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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Natural Frequency Calculation Step: 7 3:04p Oct 23,2008

The Natural Frequencies for the vessel have been computed iteratively by solving a system of matrices. These matrices describe the mass and the stiffness of the vessel. This is the generalized eigenvalue/eigenvector problem and is referenced in some mathematical texts.

The Natural Frequency for the Vessel (Empty.) is 4.68398 Hz.

The Natural Frequency for the Vessel (Ope...) is 4.68398 Hz.

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Wind Load Results per National Building Code of Canada 2005

Static Pressure q 13.23 psf
 Gust Factor Cg 3.480
 Pressure Coefficient Cp 0.665
 Exposure Category B
 Importance Factor from Table 4.1.7.1 Iw 1.00

Equation to determine the Wind Pressure at level h [p(h)]:
 = Iw * q * Ce(height,Exp) * Cg * Cp [4.1.7.1](2005)

Intermediate values for each element are shown below:

Element	Ce	Cg	Iw	q
Skirt	0.500	3.480	1.000	13.230
Btm Head	0.500	3.480	1.000	13.230
Shell 1	0.500	3.480	1.000	13.230
shell 2	0.500	3.480	1.000	13.230
Cone	0.500	3.480	1.000	13.230
Shell 3	0.500	3.480	1.000	13.230
Top Head	0.517	3.480	1.000	13.230

Terms involving the calculation of Cg

Note: The figures referenced below are from the NBC 2005 edition

Background Turbulence Factor from Figure I-18 [B]:
 = 1.604

Size Reduction Factor from Figure I-19 [s]:
 = 0.048

Gust Energy ratio from Figure I-20 [F]:
 = 0.025

Peak Factor from Figure I-20 [gP]:
 = 4.265

Value of sigma/mu [sigma/mu]:
 = sqrt(K/CeH * (B + S * F / Beta))
 = sqrt(0.100 / 0.519 * (1.604 + 0.048 * 0.025 / 0.008))
 = 0.581

Value of the Gust Effect Factor [Cg]:
 = 1 + gP(sigma/mu)
 = 1 + 4.265 (0.581)
 = 3.480

Wind Pressure on the first element [p]:
 = Iw * q * Ce * Cg
 = 1.00 * 13.230 * 0.500 * 3.480
 = 23.017 psf

Force on the first element [F]:
 = p * Wind Area * Shape Factor
 = 23.02 * 12.750 * 0.665
 = 195.259 lb.

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/L2)(10⁴)
- 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
 2.000 / 44.333 = 0.045

#2 - (D / L²) * 10⁴ < 8.0 (English Units)
 - (3.21 / 44.33²) * 10⁴ = 16.340 [Geometry Violation]

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

= W / (L * Dr²)
 = 14442 / (44.33 * 2.850²)
 = 40.097

Since Vp is > 0.250E+02 no further vibration analysis is required !

The Natural Frequency for the Vessel (Ope...) is 4.68398 Hz.

Wind Load Calculation

From	To	Wind Height ft.	Wind Diameter ft.	Wind Area sq.in.	Height Factor psf	Element Wind Load lb.
10	20	1.50000	4.25000	1836.00	23.0175	195.259
20	30	3.08333	4.05000	97.2000	23.0175	10.3372
30	40	10.4167	4.15000	8665.20	23.0175	921.545
40	50	24.9167	4.15000	8665.20	23.0175	921.545
50	60	33.1078	3.55000	1022.40	23.0175	108.732
60	70	39.1667	2.95000	4248.00	23.0175	451.775
70	80	44.5058	2.87500	268.835	23.7882	29.5479

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 Earthquake Load Calculation Step: 9 3:04p Oct 23,2008

Seismic Load Calculations per NBC 2005

Input Values :

Importance Factor Ie 1.000
 Site Class C
 Overstrength Factor Ro 1.000
 Ductility Factor Rd 3.000

Fundamental Period of Vibration [T]:

= 1/Fn
 = 1/4.684
 = 0.213 Seconds

Design Spectral Acceleration Candidates per 4.1.8.4.6)

Case #	Fa Fv	Sa()	Value	Applicable Time Period
1	0.150	Sa(0.2)	0.150	T <= 0.2s
2	0.147	Sa(0.5)	0.084	T = 0.5s
3	0.041	Sa(1.0)	0.041	T = 1.0s
4	0.023	Sa(2.0)	0.023	T = 2.0s
5	0.012	Sa(2.0)/2	0.023	T >= 4.0s

Final Selected value of S(Ta) based on the calculated period [S(Ta)]:

= 0.147 Gs

Base Shear per 4.1.8.11 [V]:

= S(Ta) * Ie * W / (Ro * Rd)
 = 0.147 * 1.000 * 17009.3 / (1.000 * 3.000)
 = 833.6 lb.

Minimum Base Shear per 4.1.8.11 [Vmin]:

= S(2.0) * Ie * W / (Ro * Rd)
 = 0.023 * 1.000 * 17009.3 / (1.000 * 3.000)
 = 130.4 lb.

For Rd >= 1.5, V need not be greater than [Vmax]:

= 2/3 * S(0.2) * Ie * W / (Ro * Rd)
 = 2/3 * 0.150 * 1.000 * 17009.3 / (1.000 * 3.000)
 = 567.0 lb.

Sample Force Calculation for the first Element [F]:

= ((V-Ft) * Wx * Hx / (Sum of Wi * hi)) * Scalar
 = ((566.975) * 1493.4 * 1.500 / (347719.7)) * 1.000
 = 3.7 lb.

The Natural Frequency for the Vessel (Ope...) is 4.68398 Hz.

Earthquake Load Calculation

From	To	Earthquake Height	Earthquake Weight	Element Ope Load	Element Emp Load
		ft.	lb.	lb.	lb.
10	20	1.50000	1493.45	3.65272	3.65272
20	30	3.08333	204.242	1.02684	1.02684
30	40	10.4167	5880.20	99.8748	99.8748
40	50	24.9167	5788.24	235.164	235.164
50	60	33.1667	688.332	37.2250	37.2250
60	70	39.1667	2794.49	178.466	178.466
70	80	44.2500	160.305	11.5663	11.5663

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FileName : Tower Analysis -----

Wind/Earthquake Shear, Bending Step: 10 3:04p Oct 23,2008

The following table is for the Operating Case.

Wind/Earthquake Shear, Bending

From	To	Distance to Support ft.	Cummulative Wind Shear lb.	Earthquake Shear lb.	Wind Bending ft.lb.	Earthquake Bending ft.lb.
10	20	1.50000	2638.74	566.975	55501.9	15647.8
20	30	3.08333	2443.48	563.323	47878.6	13952.4
30	40	10.4167	2433.15	562.296	47472.2	13858.6
40	50	24.9167	1511.60	462.421	18872.8	6429.37
50	60	33.1667	590.055	227.257	3635.76	1429.20
60	70	39.1667	481.323	190.032	2564.38	1011.91
70	80	44.2500	29.5479	11.5663	10.0218	3.92298

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Wind Deflection Calculations:

The following table is for the Operating Case.

Wind Deflection

From	To	Cumulative Wind Shear lb.	Centroid Deflection in.	Elem. End Deflection in.	Elem. Ang. Rotation
10	20	2638.74	0.00025070	0.00097905	0.00005
20	30	2443.48	0.0010352	0.0010975	0.00007
30	40	2433.15	0.010709	0.026282	0.00020358
40	50	1511.60	0.045447	0.066462	0.00024730
50	60	590.055	0.069435	0.072420	0.00024913
60	70	481.323	0.087603	0.10299	0.00025681
70	80	29.5479	0.10325	0.10351	0.00025681

Critical Wind Velocity for Tower Vibration

From	To	1st Crit. Wind Speed mile/hr	2nd Crit. Wind Speed mile/hr
10	20	67.6836	423.022
20	30	64.4985	403.115
30	40	66.0910	413.069
40	50	66.0910	413.069
50	60	56.5357	353.348
60	70	46.9804	293.627
70	80	45.7859	286.162

Allowable deflection at the Tower Top (Ope)(6.000"/100ft. Criteria)
 Allowable deflection : 2.660 Actual Deflection : 0.104 in.

Longitudinal Stress Constants

From	To	Metal Area New & Cold sq.in.	Metal Area Corroded sq.in.	New & Cold Sect. Mod. in.3	Corroded Sect. Mod. in.3
10	20	65.9734	65.9734	684.669	684.669
20	30	31.6123	15.8552	316.147	159.546
30	40	96.0149	80.2579	960.800	807.972
40	50	96.0149	80.2579	960.800	807.972
50	60	99.0260	82.7825	990.973	833.571
60	70	67.7406	56.6959	474.830	400.790
70	80	33.4285	22.3838	234.081	158.110

FileName : Tower Analysis -----

Longitudinal Allowable Stresses Step: 13 3:04p Oct 23,2008

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	20	16800.0	21840.0	-19414.6	-24268.3
20	30	16800.0	21840.0	-13388.6	-21215.5
30	40	16800.0	21840.0	-20122.0	-25704.1
40	50	16800.0	21840.0	-20122.0	-25704.1
50	60	16800.0	21840.0	-20197.3	-25784.5
60	70	16800.0	21840.0	-20892.0	-26505.8
70	80	16800.0	21840.0	-18377.1	-24656.9

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. psi	Long. Str. Ext. Pres. psi	Long. Str. Hyd. Pres. psi
10	20	0.00000	0.00000	0.00000
20	30	8030.00	-1218.76	5174.00
30	40	1590.00	-252.807	1707.33
40	50	1590.00	-252.807	1707.33
50	60	1589.69	-253.203	1706.53
60	70	1110.00	-180.831	1187.33
70	80	2805.00	-435.033	2400.67

Longitudinal Stresses Due to . . .

From	To	Wght. Str. Empty psi	Wght. Str. Operating psi	Wght. Str. Hydrotest psi	Wght. Str. Emp. Mom. psi	Wght. Str. Opr. Mom. psi
10	20	-257.820	-257.820	0.00000	10.4329	10.4329
20	30	-978.593	-978.593	0.00000	44.7711	44.7711
30	40	-190.780	-190.780	0.00000	8.84072	8.84072
40	50	-117.513	-117.513	0.00000	1.67963	1.67963
50	60	-44.0085	-44.0085	0.00000	0.69192	0.69192
60	70	-52.1166	-52.1166	0.00000	1.43907	1.43907
70	80	-7.16164	-7.16164	0.00000	0.00000	0.00000

Longitudinal Stresses Due to . . .

From	To	Wght. Str. Hyd. Mom. psi	Bend. Str. Oper. Wind psi	Bend. Str. Oper. Equ. psi	Bend. Str. Hyd. Wind psi	Bend. Str. Hyd. Equ. psi
10	20	0.00000	972.766	274.255	0.00000	0.00000
20	30	0.00000	3601.11	1049.40	0.00000	0.00000
30	40	0.00000	705.056	205.827	0.00000	0.00000
40	50	0.00000	280.298	95.4889	0.00000	0.00000
50	60	0.00000	52.3399	20.5746	0.00000	0.00000
60	70	0.00000	76.7796	30.2976	0.00000	0.00000
70	80	0.00000	0.76062	0.29774	0.00000	0.00000

Longitudinal Stresses Due to . . .

From	To	Long. Str. Vortex Ope. psi	Long. Str. Vortex Emp. psi	Long. Str. Vortex Tst. psi	EarthQuake Empty psi
10	20	0.00000	0.00000	0.00000	274.255
20	30	0.00000	0.00000	0.00000	1049.40
30	40	0.00000	0.00000	0.00000	205.827
40	50	0.00000	0.00000	0.00000	95.4889
50	60	0.00000	0.00000	0.00000	20.5746
60	70	0.00000	0.00000	0.00000	30.2976
70	80	0.00000	0.00000	0.00000	0.29774

Longitudinal Stresses Due to . . .

From	To	Long. Str. Y Forces W psi	Long. Str. Y ForceS S psi
10	20	0.00000	0.00000

FileName : Tower Analysis -----

Longitudinal Stresses Due to . . . Step: 14 3:04p Oct 23,2008

20	30	0.00000	0.00000
30	40	0.00000	0.00000
40	50	0.00000	0.00000
50	60	0.00000	0.00000
60	70	0.00000	0.00000
70	80	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	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
50	60	0.00000	0.00000	0.00000	0.00000
60	70	0.00000	0.00000	0.00000	0.00000
70	80	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	725.38	16800.00	-1241.02	-19414.62	0.0432	0.0639
20	2667.28	16800.00	-4624.47	-13388.63	0.1588	0.3454
30	523.12	16800.00	-904.68	-20122.00	0.0311	0.0450
40	164.46	16800.00	-399.49	-20122.00	0.0098	0.0199
50	9.02	16800.00	-97.04	-20197.31	0.0005	0.0048
60	26.10	16800.00	-130.34	-20892.02	0.0016	0.0062
70		16800.00	-7.92	-18377.09		0.0004

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	26.87	16800.00	-542.51	-19414.62	0.0016	0.0279
20	115.58	16800.00	-2072.77	-13388.63	0.0069	0.1548
30	23.89	16800.00	-405.45	-20122.00	0.0014	0.0201
40		16800.00	-214.68	-20122.00		0.0107
50		16800.00	-65.28	-20197.31		0.0032
60		16800.00	-83.85	-20892.02		0.0040
70		16800.00	-7.46	-18377.09		0.0004

FileName : Tower Analysis

Stress due to Combined Loads Step: 15 3:04p Oct 23,2008

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
10	725.38	16800.00	-1241.02	-19414.62	0.0432	0.0639
20	2667.28	16800.00	-4624.47	-13388.63	0.1588	0.3454
30	523.12	16800.00	-904.68	-20122.00	0.0311	0.0450
40	164.46	16800.00	-399.49	-20122.00	0.0098	0.0199
50	9.02	16800.00	-97.04	-20197.31	0.0005	0.0048
60	26.10	16800.00	-130.34	-20892.02	0.0016	0.0062
70		16800.00	-7.92	-18377.09		0.0004

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	26.87	16800.00	-542.51	-19414.62	0.0016	0.0279
20	115.58	16800.00	-2072.77	-13388.63	0.0069	0.1548
30	23.89	16800.00	-405.45	-20122.00	0.0014	0.0201
40		16800.00	-214.68	-20122.00		0.0107
50		16800.00	-65.28	-20197.31		0.0032
60		16800.00	-83.85	-20892.02		0.0040
70		16800.00	-7.46	-18377.09		0.0004

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	0.00	16800.00	0.00	-19414.62	0.0000	0.0000
20	0.00	16800.00	0.00	-13388.63	0.0000	0.0000
30	0.00	16800.00	0.00	-20122.00	0.0000	0.0000
40	0.00	16800.00	0.00	-20122.00	0.0000	0.0000
50	0.00	16800.00	0.00	-20197.31	0.0000	0.0000
60	0.00	16800.00	0.00	-20892.02	0.0000	0.0000
70	0.00	16800.00	0.00	-18377.09	0.0000	0.0000

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	0.00	16800.00	0.00	-19414.62	0.0000	0.0000
20	0.00	16800.00	0.00	-13388.63	0.0000	0.0000
30	0.00	16800.00	0.00	-20122.00	0.0000	0.0000
40	0.00	16800.00	0.00	-20122.00	0.0000	0.0000
50	0.00	16800.00	0.00	-20197.31	0.0000	0.0000
60	0.00	16800.00	0.00	-20892.02	0.0000	0.0000
70	0.00	16800.00	0.00	-18377.09	0.0000	0.0000

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	725.38	16800.00	-1241.02	-19414.62	0.0432	0.0639
20	10697.29	16800.00		-13388.63	0.6367	
30	2113.12	16800.00		-20122.00	0.1258	
40	1754.46	16800.00		-20122.00	0.1044	
50	1598.72	16800.00		-20197.31	0.0952	
60	1136.10	16800.00		-20892.02	0.0676	
70	2798.60	16800.00		-18377.09	0.1666	

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	26.87	16800.00	-542.51	-19414.62	0.0016	0.0279
20	8145.58	16800.00		-13388.63	0.4849	
30	1613.89	16800.00		-20122.00	0.0961	
40	1569.66	16800.00		-20122.00	0.0934	
50	1566.95	16800.00		-20197.31	0.0933	
60	1089.62	16800.00		-20892.02	0.0649	
70	2798.14	16800.00		-18377.09	0.1666	

FileName : Tower Analysis

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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	725.38	16800.00	-1241.02	-19414.62	0.0432	0.0639
20	1448.52	16800.00	-5843.23	-13388.63	0.0862	0.4364
30	270.31	16800.00	-1157.48	-20122.00	0.0161	0.0575
40		16800.00	-652.30	-20122.00		0.0324
50		16800.00	-350.24	-20197.31		0.0173
60		16800.00	-311.17	-20892.02		0.0149
70		16800.00	-442.96	-18377.09		0.0241

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	26.87	16800.00	-542.51	-19414.62	0.0016	0.0279
20		16800.00	-3291.53	-13388.63		0.2458
30		16800.00	-658.25	-20122.00		0.0327
40		16800.00	-467.49	-20122.00		0.0232
50		16800.00	-318.48	-20197.31		0.0158
60		16800.00	-264.68	-20892.02		0.0127
70		16800.00	-442.49	-18377.09		0.0241

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	0.00	21840.00	0.00	-24268.28	0.0000	0.0000
20	5174.00	21840.00		-21215.53	0.2369	
30	1707.33	21840.00		-25704.14	0.0782	
40	1707.33	21840.00		-25704.14	0.0782	
50	1706.53	21840.00		-25784.51	0.0781	
60	1187.33	21840.00		-26505.81	0.0544	
70	2400.67	21840.00		-24656.91	0.1099	

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	0.00	21840.00	0.00	-24268.28	0.0000	0.0000
20	5174.00	21840.00		-21215.53	0.2369	
30	1707.33	21840.00		-25704.14	0.0782	
40	1707.33	21840.00		-25704.14	0.0782	
50	1706.53	21840.00		-25784.51	0.0781	
60	1187.33	21840.00		-26505.81	0.0544	
70	2400.67	21840.00		-24656.91	0.1099	

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		16800.00	-268.25	-19414.62		0.0138
20	7096.18	16800.00		-13388.63	0.4224	
30	1408.06	16800.00		-20122.00	0.0838	
40	1474.17	16800.00		-20122.00	0.0877	
50	1546.38	16800.00		-20197.31	0.0920	
60	1059.32	16800.00		-20892.02	0.0631	
70	2797.84	16800.00		-18377.09	0.1665	

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		16800.00	-257.82	-19414.62		0.0133
20	7539.18	16800.00		-13388.63	0.4488	
30	1430.53	16800.00		-20122.00	0.0852	
40	1491.77	16800.00		-20122.00	0.0888	
50	1552.90	16800.00		-20197.31	0.0924	
60	1066.38	16800.00		-20892.02	0.0635	

FileName : Tower Analysis

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70 2800.20 16800.00 -18377.09 0.1667

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		16800.00	-268.25	-19414.62		0.0138
20	7096.18	16800.00		-13388.63	0.4224	
30	1408.06	16800.00		-20122.00	0.0838	
40	1474.17	16800.00		-20122.00	0.0877	
50	1546.38	16800.00		-20197.31	0.0920	
60	1059.32	16800.00		-20892.02	0.0631	
70	2797.84	16800.00		-18377.09	0.1665	

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		16800.00	-268.25	-19414.62		0.0138
20	7096.18	16800.00		-13388.63	0.4224	
30	1408.06	16800.00		-20122.00	0.0838	
40	1474.17	16800.00		-20122.00	0.0877	
50	1546.38	16800.00		-20197.31	0.0920	
60	1059.32	16800.00		-20892.02	0.0631	
70	2797.84	16800.00		-18377.09	0.1665	

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		16800.00	-268.25	-19414.62		0.0138
20		16800.00	-1023.36	-13388.63		0.0764
30		16800.00	-199.62	-20122.00		0.0099
40		16800.00	-119.19	-20122.00		0.0059
50		16800.00	-44.70	-20197.31		0.0022
60		16800.00	-53.56	-20892.02		0.0026
70		16800.00	-7.16	-18377.09		0.0004

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		16800.00	-268.25	-19414.62		0.0138
20	7096.18	16800.00		-13388.63	0.4224	
30	1408.06	16800.00		-20122.00	0.0838	
40	1474.17	16800.00		-20122.00	0.0877	
50	1546.38	16800.00		-20197.31	0.0920	
60	1059.32	16800.00		-20892.02	0.0631	
70	2797.84	16800.00		-18377.09	0.1665	

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		16800.00	-268.25	-19414.62		0.0138
20		16800.00	-2242.13	-13388.63		0.1675
30		16800.00	-452.43	-20122.00		0.0225
40		16800.00	-372.00	-20122.00		0.0185
50		16800.00	-297.90	-20197.31		0.0147
60		16800.00	-234.39	-20892.02		0.0112
70		16800.00	-442.19	-18377.09		0.0241

Absolute Maximum of the all of the Stress Ratio's 0.6367

Governing Element: Btm Head

Governing Load Case 7 : IP+OW+WI+FW+BW

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FileName : Tower Analysis -----

Center of Gravity Calculation Step: 16 3:04p Oct 23,2008

Shop/Field Installation Options :

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

Center of Gravity of Stiffening Rings	32.0 ft.
Center of Gravity of Nozzles	13.3 ft.
Center of Gravity of Bare Shell New and Cold	20.5 ft.
Center of Gravity of Bare Shell Corroded	20.2 ft.
Vessel CG in the Operating Condition	20.1 ft.
Vessel CG in the Fabricated (Shop/Empty) Condition	20.4 ft.

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Basering Calculations Step: 17 3:04p Oct 23,2008

Skirt Data :

Skirt Outside Diameter at Base	SOD	42.5000	in.
Skirt Thickness	STHK	0.5000	in.
Skirt Internal Corrosion Allowance	SCA	0.0000	in.
Skirt External Corrosion Allowance		0.0000	in.
Skirt Material		SA-516 70	

Basering Input: Type of Geometry: Basering W/Gussets & Chair Cap

Thickness of Basering	TBA	1.5000	in.
Design Temperature of the Basering		100.00	F
Basering Matl		SA-516 70	
Basering Operating All. Stress	BASOPE	20000.00	psi
Basering Yield Stress		38000.00	psi
Inside Diameter of Basering	DI	41.5000	in.
Outside Diameter of Basering	DOU	51.5000	in.

Nominal Diameter of Bolts	BND	2.0000	in.
Bolt Corrosion Allowance	BCA	0.0000	in.
Bolt Material		SA-193 B7	
Bolt Operating Allowable Stress	SA	25000.00	psi
Number of Bolts	NGIV	8	
Diameter of Bolt Circle	DC	47.5000	in.

Ultimate Comp. Strength of Concrete	FPC	3000.0	psi
Allowable Comp. Strength of Concrete	FC	1200.0	psi
Modular ratio Steel/Concrete		9.833	

Thickness of Gusset Plates	TGA	0.7500	in.
Width of Gussets at Top Plate	TWDT	4.5000	in.
Width of Gussets at Base Plate	BWDT	4.5000	in.
Gusset Plate Elastic Modulus	E	28884600.0	psi
Gusset Plate Yield Stress	SY	38000.0	psi
Height of Gussets	HG	9.0000	in.
Distance between Gussets	RG	3.5000	in.
Dist. from Bolt Center to Gusset (Rg/2)	CG	1.7500	in.
Number of Gussets per bolt	NG	2	

Thickness of Top Plate or Ring	TTA	1.7500	in.
Radial Width of the Top Plate	TOPWTH	4.5000	in.
Circum. Width of the Top Plate	CMWTH	7.0000	in.
Anchor Bolt Hole Dia. in Top Plate	BHOLE	2.1250	in.

External Corrosion Allowance	CA	0.0000	in.
------------------------------	----	--------	-----

Dead Weight of Vessel	DW	17009.3	lb.
Operating Weight of Vessel	ROW	17009.3	lb.
Earthquake Moment on Basering	EQMOM	15647.8	ft.lb.
Wind Moment on Basering	WIMOM	55501.9	ft.lb.
Percent Bolt Preload	ppl	100.0	

Use AISC A5.2 Increase in Fc and Bolt Stress		No
Use Allowable Weld Stress per AISC J2.5		No

Factor for Increase of Allowables	Fact	1.0000
-----------------------------------	------	--------

Results for Basering Analysis : Analyze Option

Calculation of Load per Bolt [W/Bolt], Wind + Dead Weight Condition:

$$W = ROW \quad M = WIMOM + UWIMOM$$

$$= ((4 * M/DC) - W) / RN \text{ per Jawad \& Farr, Eq. 12.3}$$

$$= ((4 * 666022 / 47.500) - 17009) / 8$$

$$= 4884.6064 \text{ lb.}$$

FileName : Tower Analysis -----

Basing Calculations Step: 17 3:04p Oct 23,2008

Required Area for Each Bolt, Based on Max Load 0.1954 sq.in.
 Area Available in a Single Bolt (Corr) 2.3000 sq.in.
 Area Available in all the Bolts (Corr) 18.4000 sq.in.
 Bolt Stress Based on Approximate Analysis 2123.7 psi
 Allowable Bolt Stress 25000.0 [Fact] 25000.000 psi

Concrete Contact Area of Base Ring CCA 730.42 sq.in.
 Concrete Contact Section Modulus of Base Ring 7755.40 in.³

Calculation of Concrete Load, Wind in Operating Condition [Sc]:
 = ((ppl/100*(Abt*Sa)+W)/Cca) + M/CZ per Jawad & Farr Eq. 12.1
 = (1.000 (18.4000 *25000 +17009)/730.42) + 666022 /7755.40
 = 738.94 psi

Determine Maximum Bending Width of Basing Section [Rw1,Rw2]:
 Rw1 = (Dou - SkirtOD)/2, Rw2 = (SkirtID - Di + 2*Sca)/2
 Rw1 = (51.500 -42.500)/2, Rw2 = (41.500 -41.500 + 2*0.000)/2
 Rw1 = 4.500 , Rw2 = 0.000 in.

Calculation of required Basing Thickness, (Simplified) [Tb]:
 Allowable Bending Stress 1.5 Basope = 30000.000 psi
 = Max(Rw1,Rw2) * (3 * Sc / S)^{.5}+ CA per Jawad & Farr Eq. 12.12
 = Max(4.5000 ,0.0000) * (3 * 738.940 / 30000.000)^{.5}+ 0.0000
 = 1.2233 in.

Basing Stress at given Thickness [Sb]
 = 3 * Sc * (Max[Rw1, Rw2]/(Tb - Ca))²
 = 3 * 738.940 * (Max[4.500 , 0.000]/(1.500 - 0.000))²
 = 19951.379 , must be less than 30000.000 psi

Required Thickness of Top Plate in Tension:
 (Calculated as a fixed beam per Megyesy)
 Ft = (Sa*Abss), Bolt Allowable Stress * Area
 Rm = (Ft * 2 * Cg)/8, Bending Moment
 Sb Allowable Bending Stress
 Wt = (Topwth - Bnd), Width of Section

 T = (6 * Rm / (Sb * Wt))^{.5}+ CA
 T = (6 * 25156 / (30000 * 2.5000))^{.5}+ 0.0000
 T = 1.4186 in.

Required Thickness of Top Chair Cap Plate per Moss:
 P = (Sa*Abss) Bolt Allowable Stress * Area
 e = (Topwth-Bhole)/2 Distance to Edge of Hole
 Sb Allowable Bending Stress
 b = Cg Gusset Plate Dimension
 db = Bhole Bolt Hole Diameter

Top Chair Cap Plate Required Thickness [Tc]
 Allowable Bending Stress 1.5 Basope = 30000.000 psi
 = (P / (Sb * e) * (0.375 * b - 0.22 * db))^{.5}+ CA
 = (57500/(30000*0.938)*(0.375*3.50-0.22*2.125))^{.5}+0.000
 = 1.3144 in.

Stress in the Top Plate at given Thickness [Stpl]
 = P * (0.375 * b - 0.22 * db) / e / (Tta - Ca)²
 = 57500 * (0.375*3.500 - 0.22*2.125)/0.938 / (1.750 -0.000)²
 = 16922.994 psi , must be less than 30000.000 psi

Required Thickness of Gusset in Compression, per AISC E2-1:

1. Allowed Compression at Given Thickness:
 Factor Kl/r Per E2-1 41.5685
 Factor Cc Per E2-1 122.4916

FileName : Tower Analysis -----

Basering Calculations Step: 17 3:04p Oct 23,2008

Allowable Buckling Str. per E2-1	20017.37	psi
Actual Buckling Str. at Given Thickness	8518.52	psi
Required Gusset thickness, + CA	0.3977	in.

2. Allowed Compression at Calculated Thickness:

Factor Kl/r Per E2-1	78.3862	
Factor Cc Per E2-1	122.4916	
Allowable Buckling Str. per E2-1	16126.55	psi
Act. Buckling Str. at Calculated Thickness	16063.46	psi

Summary of Basering Thickness Calculations:

Required Basering Thickness (simplified)	1.2233	in.
Actual Basering Thickness as entered by user	1.5000	in.
Required Top Ring/Plate Thickness as a Fixed Beam	1.4186	in.
Required Thickness of Chair Cap per Moss/AISI	1.3144	in.
Actual Top Ring Thickness as entered by user	1.7500	in.
Required Gusset thickness, + CA	0.3977	in.
Actual Gusset Thickness as entered by user	0.7500	in.

Local Stress at the Top Plate per AISI, including axial Stress [S]:

$$\begin{aligned}
 &= W_{max} * e / t^2 [1.32 * Z / (1.43 * C_{m_{wth}} * (H_g + T_{ta})^2 / (R * T_{skirt}) \\
 &\quad + (4 * (C_{m_{wth}} * (H_g + T_{ta})^2)^{.333} + 0.031 / (R * T_{skirt})^{.5} \\
 &= 4884 * 2.50 / 0.50^2 [1.32 * 0.16 / (1.43 * 7.00 * (9.75)^2 / (20.75 * 0.50) \\
 &\quad + (4 * 7.00 * (9.00 + 0.75)^2)^{.333} + 0.031 / (20.75 * 0.50)^{.5} \\
 &= 552.549 \text{ psi}
 \end{aligned}$$

Where:

$$\begin{aligned}
 Z &= 1 / [(0.177 * W_{gp} * T_{ba} / (R * t)^{.5} * (T_{ba} / t)^2 + 1] \\
 Z &= 1 / [(0.177 * 7.000 * 1.500 / (20.750 * 0.500)^{.5} * (1.500 / 0.500)^2 + 1] \\
 Z &= 0.161
 \end{aligned}$$

$$\begin{aligned}
 e &= (D_c - D_s) / 2 \\
 e &= (47.500 - 42.500) / 2 \\
 e &= 2.500 \text{ in.}
 \end{aligned}$$

Local Stress in the Skirt due to the Gussets	552	psi
Weight plus Bending Stress in the Skirt (Highest)	1241	psi
Comb. loc. + bending stress Worst Load Case	1793	psi
Allowed membrane+bending stress(1.5* Skirt All.)	30000	psi

Weld Size Calculations per Steel Plate Engineering Data - Vol. 2

Compute the Weld load at the Skirt/Base Junction [W]

$$\begin{aligned}
 &= SkirtStress * (SkirtThickness - CA) \\
 &= 1241.019 * (0.500 - 0.000) \\
 &= 620.51 \text{ lb./in.}
 \end{aligned}$$

Results for Computed Minimum Basering Weld Size [BWeld]

$$\begin{aligned}
 &= W / [(0.4 * Yield) * 2 * 0.707] \\
 &= 620 / [(0.4 * 34800) * 2 * 0.707] \\
 &= 0.032 \text{ in.}
 \end{aligned}$$

Results for Computed Minimum Gusset and Top Plate to Skirt Weld Size

Vertical Plate Load [Wv]

$$\begin{aligned}
 &= Bolt Load / (C_{m_{wth}} + 2 * (H_g + T_{ta})) \\
 &= 57500.0 / (5.000 + 2 * (9.000 + 1.750)) \\
 &= 2169.811 \text{ lb./in.}
 \end{aligned}$$

Horizontal Plate Load [Wh]

$$= Bolt Load * e / (C_{m_{wth}} * (H_g + T_{ta}) + 0.6667 * (H_g + T_{ta})^2)$$

FileName : Tower Analysis -----

Basing Calculations Step: 17 3:04p Oct 23,2008

$$= 57500.0 * 2.500 / (5.000 * (10.750) + 0.6667 * (10.750)^2)$$

$$= 1099.073 \text{ lb./in.}$$

Resultant Weld Load [Wr]

$$= (W_v^2 + W_h^2)^{.5}$$

$$= (2169.81^2 + 1099.07^2)^{.5}$$

$$= 2432.292 \text{ lb./in.}$$

Results for Computed Min Gusset and Top Plate to Skirt Weld Size [GsWeld]

$$= W_r / [(0.4 * \text{Yield}) * 2 * 0.707]$$

$$= 2432.29 / [(0.4 * 34800) * 2 * 0.707]$$

$$= 0.124 \text{ in.}$$

Results for Computed Minimum Gusset to Top Plate Weld Size

Weld Load [Wv]

$$= \text{Bolt Load} / (2 * \text{TopWth})$$

$$= 57500.0 / (2 * 4.500)$$

$$= 6388.889 \text{ lb./in.}$$

Weld Load [Wh]

$$= \text{Bolt Load} * e / (2 * \text{Hgt} * \text{TopWth})$$

$$= 57500.0 * 2.50 / (2 * 10.750 * 4.500)$$

$$= 1485.788 \text{ lb./in.}$$

Resultant Weld Load [Wr]

$$= (W_v^2 + W_h^2)^{.5}$$

$$= (6388.89^2 + 1485.79^2)^{.5}$$

$$= 6559.380 \text{ lb./in.}$$

Results for Computed Min Gusset to Top Plate Weld Size [GtpWeld]

$$= W_r / [(0.4 * \text{Yield}) * 2 * 0.707]$$

$$= 6559.38 / [(0.4 * 34800) * 2 * 0.707]$$

$$= 0.333 \text{ in.}$$

Note: The calculated weld sizes need not exceed the component thickness framing into the weld. At the same time, the weld must meet a minimum size specification which is 3/16 in. (4.76 mm) or 1/4 in. (6.35 mm), depending on the component thickness.

Summary of Required Weld Sizes:

Required Basing to Skirt Double Fillet Weld Size	0.1875	in.
Required Gusset to Skirt Double Fillet Weld Size	0.2500	in.
Required Top Plate to Skirt Weld Size	0.3333	in.
Required Gusset to Top Plate Double Fillet Weld Size	0.3333	in.

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FileName : Tower Analysis -----
 Conical Section

Conical Reinforcement Calculations, ASME VIII Div. 1, App. 1

Conical Section From 50 To 60 SA-516 70

Cone

Elastic Modulus Data from Table TM-1 at 200.00 F

Elastic Modulus for Cone Material	28500000.00	psi
Elastic Modulus for Small Cylinder Material	28500000.00	psi
Elastic Modulus for Large Cylinder Material	28500000.00	psi
Elastic Modulus for Large End Reinforcement	28500000.00	psi
Elastic Modulus for Small End Reinforcement	28500000.00	psi
Axial Force on Small End of Cone	2954.80	lb.
Axial Force on Large End of Cone	3643.13	lb.
Moment on Small End of Cone	2612.44	ft.lb.
Moment on Large End of Cone	3683.82	ft.lb.

Note: Both ends of the Cone are Lines of Support

Maximum Centroid Reinforcement Distance Large End	0.9003	in.
Maximum Centroid Reinforcement Distance Small End	0.7591	in.

Note: No ring was found close enough to the large end to be considered.

Note: No ring was found close enough to the small end to be considered.

Reinforcement Calculations for Cone / Large Cylinder:

Required Area of Reinforcement for Large End Under Internal Pressure

Large end ratio of pressure to allowable stress	0.00588	
Large end max. half apex angle w/o reinforcement	24.765	degrees
Large end actual half apex angle	14.036	degrees

Required Area of Reinforcement for Large End Under External Pressure

Large end ratio of pressure to allowable stress	0.00088	
Large end max. half apex angle w/o reinforcement	2.206	degrees
Large end actual half apex angle	14.036	degrees

Area of Reinforcement Required in Large End Shell [Arl]:

$$= (k*Q1*R1*tan(angle)/(Ss*E1))*(1-0.25*((P*R1-Q1)/Q1))*(delta/alpha)$$

$$= (1.0000*217.9774*20.7500*0.250/(20000*0.85))*$$

$$(1-.25*((15.00*20.750-217.977)/217.977))*(2.206/14.036)$$

$$= 0.0654 \text{ sq.in.}$$

Area of Reinforcement Available in Large End Shell [Ael]:

$$= .55*(D1*ts)^{.5} * (ts + tc/Cos(alpha))$$

$$= .55 * (41.500 * 0.625)^{.5} * (0.625 + 0.625 / 0.970)$$

$$= 3.5552 \text{ sq.in.}$$

Summary of Reinforcement Area, Large End, External Pressure:

Area of reinforcement required per App. 1-8(1)	0.0654	sq.in.
Area of reinforcement in shell per App. 1-8(2)	3.5552	sq.in.
Area of reinforcement in stiffening ring	0.0000	sq.in.

Intermediate Results, Large End, External Pressure:

Area Available in Cone, Shell, and Reinforcement	8.48	sq.in.
Force per Unit Length on Shell / Cone Junction	199.55	lb./in.
Actual Buckling Stress associated with this Force	732.36	psi
Material Strain associated with this stress	0.000051	

Required Moment of Inertia, Large End, External Pressure [I's]:

$$= A * D1^2 * Atl / 10.9$$

FileName : Tower Analysis -----
 Conical Section

$$= 0.000051 * 41.5000 * 41.5000 * 8.48 / 10.9$$

$$= 0.07 \text{ in.}^4$$

Available Moment of Inertia, Large End, External Pressure:

	Area	Centroid	Ar*Ce	Dist	I	Ar*Di ²
Shl	1.500	0.0000	0.000	-0.1912	0.049	0.055
Con	1.805	-0.3501	-0.632	0.1589	0.136	0.046
Sec	0.000	0.3125	0.000	-0.5037	0.000	0.000
TOT	3.305		-0.632		0.185	0.100
Centroid of Section			-0.1912	Moment of Inertia		0.29

Summary of Large End Inertia Calculations

Available Moment of Inertia (Large End)	0.285	in**4
Required Moment of Inertia (Large End)	0.068	in**4

Reinforcement Calculations for Cone / Small Cylinder:

Required Area of Reinforcement for Small End under Internal Pressure

Small end ratio of pressure to allowable stress	0.00588	
Small end max. half apex angle w/o reinforcement	6.529	degrees
Small end actual half apex angle	14.036	degrees

Required Area of Reinforcement, Small End, Internal [Ars]:

$$= k * Q_s * R_s / (S_s * E_1) * (1 - \Delta / \alpha) * \tan(\alpha)$$

$$= 1.00 * 720.9971 * 14.1250 / (20000 * 0.85) * (1.0 - 6.53 / 14.04) * 0.2500$$

$$= 0.0801 \text{ sq.in.}$$

Area of Reinforcement Available in Small End Shell [Aes]:

$$= .78 * (R_s * T_s)^{.5} * ((T_s - t) + (T_c - T_r) / \cos(\alpha))$$

$$= .78 * (14.125 * 0.625)^{.5} * ((0.625 - 0.083) + (0.625 - 0.086) / 0.97)$$

$$= 2.5430 \text{ sq.in.}$$

Summary of Reinforcement Area, Small End, Internal Pressure:

Area of reinforcement required per App. 1-5(3)	0.0801	sq.in.
Area of reinforcement in shell per App. 1-5(4)	2.5430	sq.in.
Area of reinforcement in stiffening ring	0.0000	sq.in.

Required Area of Reinforcement for Small End Under External Pressure

Area of Reinforcement Required in Small End Shell [Ars]:

$$= k * Q_s * R_s * \tan(\alpha) / (S_s * E_1)$$

$$= (1.0000 * 191.6300 * 14.7500 * 0.2500 / (20000 * 0.85))$$

$$= 0.0416 \text{ sq.in.}$$

Area of Reinforcement Available in Small End Shell [Aes]:

$$= .55 * (D_s * t_s)^{.5} * [(t_s - t) + (t_c - t_r) / \cos(\alpha)]$$

$$= .55 * (29.500 * 0.625)^{.5} * [(0.625 - 0.169) + (0.625 - 0.084) / 0.970]$$

$$= 2.3929 \text{ sq.in.}$$

Summary of Reinforcement Area, Small End, External Pressure:

Area of reinforcement required per App. 1-8(1)	0.0416	sq.in.
Area of reinforcement in shell per App. 1-8(2)	2.3929	sq.in.
Area of reinforcement in stiffening ring	0.0000	sq.in.

Intermediate Results, Small End, External Pressure:

Area Available in Cone, Shell, and Reinforcement	46.58	sq.in.
Force per Unit Length on Shell / Cone Junction	1124.00	lb./in.
Actual Buckling Stress associated with this Force	533.83	psi
Material Strain associated with this stress	0.000037	

Required Moment of Inertia, Small End, External Pressure [I's]:

$$= A * D_s^2 * A_t_s / 10.9$$

$$= 0.000037 * 29.5000 * 29.5000 * 46.58 / 10.9$$

$$= 0.14 \text{ in.}^4$$

FileName : Tower Analysis -----
 Conical Section

Available Moment of Inertia, Small End, External Pressure:

	Area	Centroid	Ar*Ce	Dist	I	Ar*Di ²
Shl	1.476	0.0000	0.000	0.1498	0.048	0.033
Con	1.521	0.2952	0.449	-0.1454	0.097	0.032
Sec	0.000	0.3125	0.000	-0.1627	0.000	0.000
TOT	2.997		0.449		0.145	0.065
Centroid of Section			0.1498	Moment of Inertia		0.21

Summary of Small End Inertia Calculations

Available Moment of Inertia (Small End)	0.210	in**4
Required Moment of Inertia (Small End)	0.137	in**4

Note: The following calculations are only required per 1-5(g)(1) and do include external loads due to wind or seismic. These discontinuity stresses are computed at the shell/cone junction and do not include effects of local stiffening from a junction ring.

Results for Discontinuity Stresses per Bednar p. 236 2nd Edition

Stress Type	Stress	Allowable	Location
Tensile Stress	2821.19	60000.00	Small Cyl. Long.
Compres. Stress	-462.23	-60000.00	Small Cyl. Long.
Membrane Stress	3213.66	30000.00	Small End Tang.
Tensile Stress	2857.49	60000.00	Cone Longitudinal
Compres. Stress	-425.93	-60000.00	Cone Longitudinal
Tensile Stress	3284.76	30000.00	Cone Tangential
Tensile Stress	4365.24	60000.00	Large Cyl. Long.
Compres. Stress	-1078.23	-60000.00	Large Cyl. Long.
Membrane Stress	1870.12	-30000.00	Large End Tang.
Tensile Stress	4415.82	60000.00	Cone Longitudinal
Compres. Stress	-1027.65	-60000.00	Cone Longitudinal
Compres. Stress	1970.76	-30000.00	Cone Tangential

Note: An asterisk (*) denotes that this stress was not applicable for this combination of loads.

FileName : Tower Analysis

Nozzle Calcs. Drain

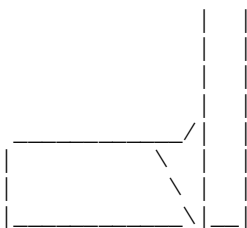
Nozl: 1 3:04p Oct 23,2008

INPUT VALUES, Nozzle Description: Drain From : 20

Pressure for Nozzle Reinforcement Calculations P		100.000	psig
Temperature for Internal Pressure	Temp	200	F
Design External Pressure	Pext	15.00	psig
Temperature for External Pressure	Tempex	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	40.0000	in.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Actual Thickness	T	0.2500	in.
Head Internal Corrosion Allowance	Cas	0.1250	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-106 B	
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	ID	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	3.0000	in.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	Thknom	80	
Nozzle Flange Material		SA-105	
Nozzle Flange Type	Weld Neck	Flange	
Nozzle Corrosion Allowance	Can	0.1250	in.
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	Ho	6.0000	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		C	
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

FileName : Tower Analysis -----
 Nozzle Calcs. Drain Nozl: 1 3:04p Oct 23,2008

NOZZLE CALCULATION, Description: Drain

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

Actual Nozzle Inside Diameter Used in Calculation 2.900 in.
 Actual Nozzle Thickness Used in Calculation 0.300 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)
 = $(100.00 \cdot 0.90 \cdot 40.2500) / (2 \cdot 20000.00 \cdot 1.00 - 0.2 \cdot 100.00)$
 = 0.0906 in.

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
 = $(P \cdot R) / (S \cdot E - 0.6 \cdot P)$ per UG-27 (c)(1)
 = $(100.00 \cdot 1.58) / (17100 \cdot 1.00 - 0.6 \cdot 100.00)$
 = 0.0092 in.

Required Nozzle thickness under External Pressure per UG-28 : 0.0140 in.

UG-40, Thickness and Diameter Limit Results : [Int. Press]

Effective material diameter limit, D1 6.3000 in.
 Effective material thickness limit, no pad Tlnp 0.3125 in.

Note: Taking a UG-36(c)(3)(a) exemption for Drain .
 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 = 0.1390 in.
 Wall Thickness per UG16(b), tr16b = 0.2188 in.
 Wall Thickness per UG45(b)(1), trb1 = 0.2257 in.
 Wall Thickness per UG45(b)(2), trb2 = 0.1401 in.
 Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.2257 in.
 Std. Wall Pipe per UG45(b)(4), trb4 = 0.3140 in.
 Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 0.2257 in.

Final Required Thickness, tr45 = Max(tra, trb) = 0.2257 in.
 Available Nozzle Neck Thickness = $.875 \cdot 0.3000 = 0.2625$ in. --> OK

Minimum Design Metal Temperature (Nozzle Neck), Curve: B

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

Nozzle MDMT Thickness Calc. per UCS-66 (a)1(b), MIN(tn,t,te), Curve: B

Minimum Temp. w/o impact per UCS-66 -20 F
 Minimum Temp. at required thickness -155 F
 Minimum Temp. w/o impact per UG-20(f) -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 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 = $100.00 / 285.00 = 0.351$

Weld Size Calculations, Description: Drain

Intermediate Calc. for nozzle/shell Welds Tmin 0.1250 in.

Results Per UW-16.1:

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FileName : Tower Analysis -----

Nozzle Calcs. Drain Nozl: 1 3:04p Oct 23,2008

	Required Thickness	Actual Thickness
Nozzle Weld	$0.0875 = 0.7 * TMIN$	$0.2651 = 0.7 * Wo \text{ in.}$

The Drop for this Nozzle is : 0.0423 in.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 6.2923 in.

PV Elite 2008 c1993-2008 by COADE Engineering Software

FileName : Tower Analysis

Nozzle Calcs. Manway

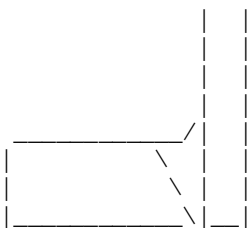
Nozl: 2 3:04p Oct 23,2008

INPUT VALUES, Nozzle Description: Manway From : 30

Pressure for Nozzle Reinforcement Calculations P		100.000	psig
Temperature for Internal Pressure	Temp	200	F
Design External Pressure	Pext	15.00	psig
Temperature for External Pressure	Tempex	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	40.0000	in.
Design Length of Section	L	350.9333	in.
Shell Actual Thickness	T	0.7500	in.
Shell Internal Corrosion Allowance	Cas	0.1250	in.
Shell External Corrosion Allowance	Caext	0.0000	in.
Distance from Bottom/Left Tangent		3.1667	ft.
User Entered Minimum Design Metal Temperature		-20.00	F
Nozzle Material		SA-106 B	
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	ID	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	16.0000	in.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	Thknom	40	
Nozzle Flange Material		SA-105	
Nozzle Flange Type	Weld Neck	Flange	
Nozzle Corrosion Allowance	Can	0.1250	in.
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	Ho	6.0000	in.
Weld leg size between Nozzle and Pad/Shell	Wo	0.3750	in.
Groove weld depth between Nozzle and Vessel	Wgnv	0.7500	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	
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

FileName : Tower Analysis

Nozzle Calcs. Manway

Noz1: 2 3:04p Oct 23,2008

NOZZLE CALCULATION, Description: Manway

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

Actual Nozzle Inside Diameter Used in Calculation 15.000 in.
 Actual Nozzle Thickness Used in Calculation 0.500 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
 = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
 = (100.00*20.1250)/(20000*1.00-0.6*100.00)
 = 0.1009 in.

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
 = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
 = (100.00*7.62)/(17100*1.00-0.6*100.00)
 = 0.0447 in.

Required Nozzle thickness under External Pressure per UG-28 : 0.0342 in.

UG-40, Thickness and Diameter Limit Results : [Int. Press]

Effective material diameter limit, Dl 30.5000 in.
 Effective material thickness limit, no pad Tlnp 0.9375 in.

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5	Design	External	Mapnc
Area Required Ar	1.550	2.420	NA sq.in.
Area in Shell A1	7.935	4.692	NA sq.in.
Area in Nozzle Wall A2	0.529	0.546	NA sq.in.
Area in Inward Nozzle A3	0.000	0.000	NA sq.in.
Area in Welds A4	0.120	0.120	NA sq.in.
Area in Pad A5	0.000	0.000	NA sq.in.
TOTAL AREA AVAILABLE Atot	8.585	5.359	NA sq.in.

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
 = 0.5 * (DLR*Tr+2*Thk*Tr*(1-fr1)) per UG-37(d) or UG-39
 = 0.5*(15.2500*0.3151+2*(0.5000-0.1250)*0.3151*(1-0.8550))
 = 2.420 sq.in.

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*(Thk-Can)*(ES*(T-Cas)-Tr)*(1-fr1)
 = (30.500-15.250)*(1.00*(0.7500-0.125)-0.315)-2*(0.500-0.125)
 (1.00(0.7500-0.125)-0.315)*(1-0.8550)
 = 4.692 sq.in.

Area Available in Nozzle Wall, no Pad [A2np]:
 = (2 * min(Tlnp,ho)) * (Thk - Can - Trn) * fr2
 = (2 * min(0.938 ,6.000)) * (0.5000 - 0.1250 - 0.0342) * 0.8550)
 = 0.546 sq.in.

Area Available in Welds, no Pad [A4np]:
 = Wo² * fr2 + (Wl-Can/0.707)² * fr2
 = 0.3750² * 0.8550 + (0.0000)² * 0.8550
 = 0.120 sq.in.

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

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FileName : Tower Analysis -----

Nozzle Calcs. Manway Nozl: 2 3:04p Oct 23,2008

Wall Thickness per UG45(a), tra = 0.1697 in.
 Wall Thickness per UG16(b), tr16b = 0.2188 in.
 Wall Thickness per UG45(b)(1), trb1 = 0.2259 in.
 Wall Thickness per UG45(b)(2), trb2 = 0.1401 in.
 Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.2259 in.
 Std. Wall Pipe per UG45(b)(4), trb4 = 0.4531 in.
 Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 0.2259 in.

Final Required Thickness, tr45 = Max(tra, trb) = 0.2259 in.
 Available Nozzle Neck Thickness = .875 * 0.5000 = 0.4375 in. --> OK

M.A.W.P. Results for this Nozzle (Based on Areas and UG-45) at this Location

Approximate M.A.W.P. for given geometry 307.692 psig
 Nozzle is O.K. for the External Pressure 15.000 psig

Note: The MAWP of this junction was limited by UG-45 considerations.

Minimum Design Metal Temperature (Nozzle Neck), Curve: B

Minimum Temp. w/o impact per UCS-66 -14 F
 Minimum Temp. at required thickness -154 F
 Minimum Temp. w/o impact per UG-20(f) -20 F

Nozzle MDMT Thickness Calc. per UCS-66 (a)1(b), MIN(tn,t,te), Curve: B

Minimum Temp. w/o impact per UCS-66 -14 F
 Minimum Temp. at required thickness -154 F
 Minimum Temp. w/o impact per UG-20(f) -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 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 = 100.00 / 285.00 = 0.351

Weld Size Calculations, Description: Manway

Intermediate Calc. for nozzle/shell Welds Tmin 0.3750 in.

Results Per UW-16.1:

Required Thickness Actual Thickness
 Nozzle Weld 0.2500 = Min per Code 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
 = (2.4198 - 4.6922 + 2 * (0.5000 - 0.1250) * 0.8550 *
 (1.00 * (0.7500 - 0.1250) - 0.3151)) * 20000
 = 0.00 lb.

Weld Load [W1]:

= (A2+A5+A4-(Wi-Can/.707)^2*Ffr2)*S
 = (0.5463 + 0.0000 + 0.1202 - 0.0000 * 0.86) * 20000
 = 13331.24 lb.

Weld Load [W2]:

= ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S
 = (0.5463 + 0.0000 + 0.1202 + 0.4008) * 20000
 = 21346.87 lb.

Weld Load [W3]:

= ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S
 = (0.5463 + 0.0000 + 0.1202 + 0.0000 + 0.4008) * 20000
 = 21346.87 lb.

Strength of Connection Elements for Failure Path Analysis

FileName : Tower Analysis

Nozzle Calcs. Manway Nozl: 2 3:04p Oct 23,2008

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned} &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\ &= (3.1416 / 2.0) * 16.0000 * 0.3750 * 0.49 * 17100 \\ &= 78970. \text{ lb.} \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned} &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\ &= (3.1416 * 7.8125) * (0.5000 - 0.1250) * 0.7 * 17100 \\ &= 110170. \text{ lb.} \end{aligned}$$

Tension, Nozzle Groove Weld [Tngw]:

$$\begin{aligned} &= (\pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng \\ &= (3.1416 / 2.0) * 16.0000 * (0.7500 - 0.1250) * 0.74 * 17100 \\ &= 198769. \text{ lb.} \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned} \text{PATH11} &= (\text{SONW} + \text{SNW}) = (78970 + 110170) = 189140 \text{ lb.} \\ \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\ &= (78970 + 0 + 198768 + 0) = 277738 \text{ lb.} \\ \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\ &= (78970 + 198768 + 0) = 277738 \text{ lb.} \end{aligned}$$

Summary of Failure Path Calculations:

Path 1-1 = 189140 lb., must exceed W = 0 lb. or W1 = 13331 lb.
Path 2-2 = 277738 lb., must exceed W = 0 lb. or W2 = 21346 lb.
Path 3-3 = 277738 lb., must exceed W = 0 lb. or W3 = 21346 lb.

The Drop for this Nozzle is : 1.6697 in.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 8.4197 in.

FileName : Tower Analysis

Nozzle Calcs. Inlet

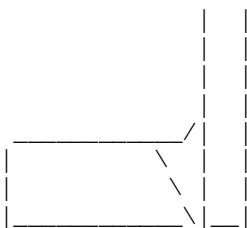
Nozl: 3 3:04p Oct 23,2008

INPUT VALUES, Nozzle Description: Inlet From : 40

Pressure for Nozzle Reinforcement Calculations P		100.000	psig
Temperature for Internal Pressure	Temp	200	F
Design External Pressure	Pext	15.00	psig
Temperature for External Pressure	Tempex	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	40.0000	in.
Design Length of Section	L	350.9333	in.
Shell Actual Thickness	T	0.7500	in.
Shell Internal Corrosion Allowance	Cas	0.1250	in.
Shell External Corrosion Allowance	Caext	0.0000	in.
Distance from Bottom/Left Tangent		17.0000	ft.
User Entered Minimum Design Metal Temperature		-20.00	F
Nozzle Material		SA-106 B	
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	ID	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	6.0000	in.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	Thknom	40	
Nozzle Flange Material		SA-105	
Nozzle Flange Type		Weld Neck Flange	
Nozzle Corrosion Allowance	Can	0.1250	in.
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	Ho	6.0000	in.
Weld leg size between Nozzle and Pad/Shell	Wo	0.3750	in.
Groove weld depth between Nozzle and Vessel	Wgnv	0.7500	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		C	
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

FileName : Tower Analysis

Nozzle Calcs. Inlet

Noz1: 3 3:04p Oct 23,2008

NOZZLE CALCULATION, Description: Inlet

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

Actual Nozzle Inside Diameter Used in Calculation 6.065 in.
 Actual Nozzle Thickness Used in Calculation 0.280 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
 = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
 = (100.00*20.1250)/(20000*1.00-0.6*100.00)
 = 0.1009 in.

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
 = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
 = (100.00*3.16)/(17100*1.00-0.6*100.00)
 = 0.0185 in.

Required Nozzle thickness under External Pressure per UG-28 : 0.0204 in.

UG-40, Thickness and Diameter Limit Results : [Int. Press]

Effective material diameter limit, Dl 12.6300 in.
 Effective material thickness limit, no pad Tlnp 0.3875 in.

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5	Design	External	Mapnc
Area Required Ar	0.642	1.002	NA sq.in.
Area in Shell A1	3.286	1.943	NA sq.in.
Area in Nozzle Wall A2	0.090	0.089	NA sq.in.
Area in Inward Nozzle A3	0.000	0.000	NA sq.in.
Area in Welds A4	0.120	0.120	NA sq.in.
Area in Pad A5	0.000	0.000	NA sq.in.
TOTAL AREA AVAILABLE Atot	3.497	2.152	NA sq.in.

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
 = 0.5 * (DLR*Tr+2*Thk*Tr*(1-fr1)) per UG-37(d) or UG-39
 = 0.5*(6.3150*0.3151+2*(0.2800-0.1250)*0.3151*(1-0.8550))
 = 1.002 sq.in.

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*(Thk-Can)*(ES*(T-Cas)-Tr)*(1-fr1)
 = (12.630-6.315)*(1.00*(0.7500-0.125)-0.315)-2*(0.280-0.125)
 (1.00(0.7500-0.1250)-0.3151)*(1-0.8550)
 = 1.943 sq.in.

Area Available in Nozzle Wall, no Pad [A2np]:
 = (2 * min(Tlnp,ho)) * (Thk - Can - Trn) * fr2
 = (2 * min(0.387 ,6.000)) * (0.2800 - 0.1250 - 0.0204) * 0.8550)
 = 0.089 sq.in.

Area Available in Welds, no Pad [A4np]:
 = Wo² * fr2 + (Wl-Can/0.707)² * fr2
 = 0.3750² * 0.8550 + (0.0000)² * 0.8550
 = 0.120 sq.in.

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

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FileName : Tower Analysis -----

Nozzle Calcs. Inlet Nozl: 3 3:04p Oct 23,2008

Wall Thickness per UG45(a), tra = 0.1454 in.
 Wall Thickness per UG16(b), tr16b = 0.2188 in.
 Wall Thickness per UG45(b)(1), trb1 = 0.2259 in.
 Wall Thickness per UG45(b)(2), trb2 = 0.1401 in.
 Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.2259 in.
 Std. Wall Pipe per UG45(b)(4), trb4 = 0.3700 in.
 Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 0.2259 in.

Final Required Thickness, tr45 = Max(tra, trb) = 0.2259 in.
 Available Nozzle Neck Thickness = .875 * 0.2800 = 0.2450 in. --> OK

M.A.W.P. Results for this Nozzle (Based on Areas and UG-45) at this Location

Approximate M.A.W.P. for given geometry 118.830 psig
 Nozzle is O.K. for the External Pressure 15.000 psig

Note: The MAWP of this junction was limited by UG-45 considerations.

Minimum Design Metal Temperature (Nozzle Neck), Curve: B

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

Nozzle MDMT Thickness Calc. per UCS-66 (a)1(b), MIN(tn,t,te), Curve: B

Minimum Temp. w/o impact per UCS-66 -20 F
 Minimum Temp. at required thickness -155 F
 Minimum Temp. w/o impact per UG-20(f) -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 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 = 100.00 / 285.00 = 0.351

Weld Size Calculations, Description: Inlet

Intermediate Calc. for nozzle/shell Welds Tmin 0.1550 in.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	0.1085 = 0.7 * TMIN	0.2651 = 0.7 * Wo in.

The Drop for this Nozzle is : 0.2762 in.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 7.0262 in.

PV Elite 2008 c1993-2008 by COADE Engineering Software

FileName : Tower Analysis -----

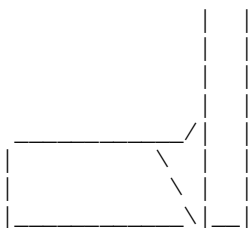
Nozzle Calcs. Outlet Nozl: 4 3:04p Oct 23,2008

INPUT VALUES, Nozzle Description: Outlet From : 60

Pressure for Nozzle Reinforcement Calculations P		100.000	psig
Temperature for Internal Pressure	Temp	200	F
Design External Pressure	Pext	15.00	psig
Temperature for External Pressure	Tempex	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	28.0000	in.
Design Length of Section	L	124.3333	in.
Shell Actual Thickness	T	0.7500	in.
Shell Internal Corrosion Allowance	Cas	0.1250	in.
Shell External Corrosion Allowance	Caext	0.0000	in.
Distance from Bottom/Left Tangent		39.1667	ft.
User Entered Minimum Design Metal Temperature		-20.00	F
Nozzle Material		SA-106 B	
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	ID	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	6.0000	in.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	Thknom	40	
Nozzle Flange Material		SA-105	
Nozzle Flange Type	Weld Neck	Flange	
Nozzle Corrosion Allowance	Can	0.1250	in.
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	Ho	6.0000	in.
Weld leg size between Nozzle and Pad/Shell	Wo	0.3750	in.
Groove weld depth between Nozzle and Vessel	Wgnv	0.7500	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	
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

FileName : Tower Analysis

Nozzle Calcs. Outlet

Noz1: 4 3:04p Oct 23,2008

NOZZLE CALCULATION, Description: Outlet

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

Actual Nozzle Inside Diameter Used in Calculation 6.065 in.
 Actual Nozzle Thickness Used in Calculation 0.280 in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]
 = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
 = (100.00*14.1250)/(20000*1.00-0.6*100.00)
 = 0.0708 in.

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
 = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
 = (100.00*3.16)/(17100*1.00-0.6*100.00)
 = 0.0185 in.

Required Nozzle thickness under External Pressure per UG-28 : 0.0204 in.

UG-40, Thickness and Diameter Limit Results : [Int. Press]

Effective material diameter limit, Dl 12.6300 in.
 Effective material thickness limit, no pad Tlnp 0.3875 in.

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		Design	External	Mapnc	
Area Required	Ar	0.451	0.538	NA	sq.in.
Area in Shell	A1	3.475	2.857	NA	sq.in.
Area in Nozzle Wall	A2	0.090	0.089	NA	sq.in.
Area in Inward Nozzle	A3	0.000	0.000	NA	sq.in.
Area in Welds	A4	0.120	0.120	NA	sq.in.
Area in Pad	A5	0.000	0.000	NA	sq.in.
TOTAL AREA AVAILABLE	Atot	3.685	3.067	NA	sq.in.

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Reinforcement Area Required for Nozzle [Ar]:
 = 0.5 * (DLR*Tr+2*Thk*Tr*(1-fr1)) per UG-37(d) or UG-39
 = 0.5*(6.3150*0.1693+2*(0.2800-0.1250)*0.1693*(1-0.8550))
 = 0.538 sq.in.

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*(Thk-Can)*(ES*(T-Cas)-Tr)*(1-fr1)
 = (12.630-6.315)*(1.00*(0.7500-0.125)-0.169)-2*(0.280-0.125)
 (1.00(0.7500-0.125)-0.1693)*(1-0.8550)
 = 2.857 sq.in.

Area Available in Nozzle Wall, no Pad [A2np]:
 = (2 * min(Tlnp,ho)) * (Thk - Can - Trn) * fr2
 = (2 * min(0.387 ,6.000)) * (0.2800 - 0.1250 - 0.0204) * 0.8550)
 = 0.089 sq.in.

Area Available in Welds, no Pad [A4np]:
 = Wo² * fr2 + (Wl-Can/0.707)² * fr2
 = 0.3750² * 0.8550 + (0.0000)² * 0.8550
 = 0.120 sq.in.

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

FileName : Tower Analysis -----

Nozzle Calcs. Outlet Nozl: 4 3:04p Oct 23,2008

Wall Thickness per UG45(a), tra = 0.1454 in.
 Wall Thickness per UG16(b), tr16b = 0.2188 in.
 Wall Thickness per UG45(b)(1), trb1 = 0.1958 in.
 Wall Thickness per UG45(b)(2), trb2 = 0.1356 in.
 Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.2188 in.
 Std. Wall Pipe per UG45(b)(4), trb4 = 0.3700 in.
 Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 0.2188 in.

Final Required Thickness, tr45 = Max(tra, trb) = 0.2188 in.
 Available Nozzle Neck Thickness = .875 * 0.2800 = 0.2450 in. --> OK

M.A.W.P. Results for this Nozzle (Based on Areas and UG-45) at this Location

Approximate M.A.W.P. for given geometry 169.050 psig
 Nozzle is O.K. for the External Pressure 15.000 psig

Note: The MAWP of this junction was limited by UG-45 considerations.

Minimum Design Metal Temperature (Nozzle Neck), Curve: B

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

Nozzle MDMT Thickness Calc. per UCS-66 (a)1(b), MIN(tn,t,te), Curve: B

Minimum Temp. w/o impact per UCS-66 -20 F
 Minimum Temp. at required thickness -155 F
 Minimum Temp. w/o impact per UG-20(f) -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 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 = 100.00 / 285.00 = 0.351

Weld Size Calculations, Description: Outlet

Intermediate Calc. for nozzle/shell Welds Tmin 0.1550 in.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	0.1085 = 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
 = (0.5384 - 2.8573 + 2 * (0.2800 - 0.1250) * 0.8550 *
 (1.00 * (0.7500 - 0.1250) - 0.1693)) * 20000
 = 0.00 lb.

Weld Load [W1]:

= (A2+A5+A4-(Wi-Can/.707)^2*Ffr2)*S
 = (0.0892 + 0.0000 + 0.1202 - 0.0000 * 0.86) * 20000
 = 4188.58 lb.

Weld Load [W2]:

= ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S
 = (0.0892 + 0.0000 + 0.1202 + 0.1657) * 20000
 = 7501.71 lb.

Weld Load [W3]:

= ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S
 = (0.0892 + 0.0000 + 0.1202 + 0.0000 + 0.1657) * 20000
 = 7501.71 lb.

Strength of Connection Elements for Failure Path Analysis

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FileName : Tower Analysis -----

Nozzle Calcs. Outlet Nozl: 4 3:04p Oct 23,2008

Shear, Outward Nozzle Weld [Sonw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * Wo * 0.49 * Snw \\
 &= (3.1416 / 2.0) * 6.6250 * 0.3750 * 0.49 * 17100 \\
 &= 32699. \text{ lb.}
 \end{aligned}$$

Shear, Nozzle Wall [Snw]:

$$\begin{aligned}
 &= (\pi * (Dlr + Dlo) / 4) * (Thk - Can) * 0.7 * Sn \\
 &= (3.1416 * 3.2350) * (0.2800 - 0.1250) * 0.7 * 17100 \\
 &= 18856. \text{ lb.}
 \end{aligned}$$

Tension, Nozzle Groove Weld [Tngw]:

$$\begin{aligned}
 &= (\pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng \\
 &= (3.1416 / 2.0) * 6.6250 * (0.7500 - 0.1250) * 0.74 * 17100 \\
 &= 82303. \text{ lb.}
 \end{aligned}$$

Strength of Failure Paths:

$$\begin{aligned}
 \text{PATH11} &= (\text{SONW} + \text{SNW}) = (32698 + 18856) = 51554 \text{ lb.} \\
 \text{PATH22} &= (\text{Sonw} + \text{Tpgw} + \text{Tngw} + \text{Sinw}) \\
 &= (32698 + 0 + 82302 + 0) = 115001 \text{ lb.} \\
 \text{PATH33} &= (\text{Sonw} + \text{Tngw} + \text{Sinw}) \\
 &= (32698 + 82302 + 0) = 115001 \text{ lb.}
 \end{aligned}$$

Summary of Failure Path Calculations:

Path 1-1 = 51554 lb., must exceed W = 0 lb. or W1 = 4188 lb.
 Path 2-2 = 115001 lb., must exceed W = 0 lb. or W2 = 7501 lb.
 Path 3-3 = 115001 lb., must exceed W = 0 lb. or W3 = 7501 lb.

The Drop for this Nozzle is : 0.3975 in.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 7.1475 in.

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FileName : Tower Analysis

Nozzle Calcs. Vent

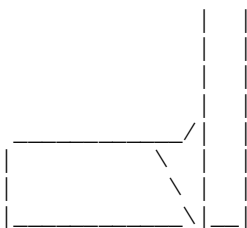
Nozl: 5 3:04p Oct 23,2008

INPUT VALUES, Nozzle Description: Vent From : 70

Pressure for Nozzle Reinforcement Calculations P		100.000	psig
Temperature for Internal Pressure	Temp	200	F
Design External Pressure	Pext	15.00	psig
Temperature for External Pressure	Tempex	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	28.0000	in.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Actual Thickness	T	0.3750	in.
Head Internal Corrosion Allowance	Cas	0.1250	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-106 B	
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	ID	
Layout Angle		0.00	deg
Nozzle Diameter	Dia	2.5000	in.
Nozzle Size and Thickness Basis	Idbn	Nominal	
Nominal Thickness of Nozzle	Thknom	80	
Nozzle Flange Material		SA-105	
Nozzle Flange Type	Weld Neck	Flange	
Nozzle Corrosion Allowance	Can	0.1250	in.
Joint Efficiency of Shell Seam at Nozzle	Es	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Nozzle Outside Projection	Ho	6.0000	in.
Weld leg size between Nozzle and Pad/Shell	Wo	0.3750	in.
Groove weld depth between Nozzle and Vessel	Wgnv	0.3750	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		C	
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

FileName : Tower Analysis -----
 Nozzle Calcs. Vent Nozl: 5 3:04p Oct 23,2008

NOZZLE CALCULATION, Description: Vent

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

Actual Nozzle Inside Diameter Used in Calculation 2.323 in.
 Actual Nozzle Thickness Used in Calculation 0.276 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)
 = $(100.00 \cdot 0.90 \cdot 28.2500) / (2 \cdot 20000.00 \cdot 1.00 - 0.2 \cdot 100.00)$
 = 0.0636 in.

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]
 = $(P \cdot R) / (S \cdot E - 0.6 \cdot P)$ per UG-27 (c)(1)
 = $(100.00 \cdot 1.29) / (17100 \cdot 1.00 - 0.6 \cdot 100.00)$
 = 0.0075 in.

Required Nozzle thickness under External Pressure per UG-28 : 0.0124 in.

UG-40, Thickness and Diameter Limit Results : [Int. Press]

Effective material diameter limit, D1 5.1460 in.
 Effective material thickness limit, no pad Tlnp 0.3775 in.

Note: Taking a UG-36(c)(3)(a) exemption for Vent .
 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 = 0.1374 in.
 Wall Thickness per UG16(b), tr16b = 0.2188 in.
 Wall Thickness per UG45(b)(1), trb1 = 0.1957 in.
 Wall Thickness per UG45(b)(2), trb2 = 0.1356 in.
 Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.2188 in.
 Std. Wall Pipe per UG45(b)(4), trb4 = 0.3026 in.
 Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 0.2188 in.

Final Required Thickness, tr45 = Max(tra, trb) = 0.2188 in.
 Available Nozzle Neck Thickness = $.875 \cdot 0.2760 = 0.2415$ in. --> OK

Minimum Design Metal Temperature (Nozzle Neck), Curve: B

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

Nozzle MDMT Thickness Calc. per UCS-66 (a)1(b), MIN(tn,t,te), Curve: B

Minimum Temp. w/o impact per UCS-66 -20 F
 Minimum Temp. at required thickness -155 F
 Minimum Temp. w/o impact per UG-20(f) -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 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 = $100.00 / 285.00 = 0.351$

Weld Size Calculations, Description: Vent

Intermediate Calc. for nozzle/shell Welds Tmin 0.1510 in.

Results Per UW-16.1:

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FileName : Tower Analysis -----

Nozzle Calcs. Vent Nozl: 5 3:04p Oct 23,2008

	Required Thickness	Actual Thickness
Nozzle Weld	$0.1057 = 0.7 * TMIN$	$0.2651 = 0.7 * Wo \text{ in.}$

The Drop for this Nozzle is : 0.0406 in.

The Cut Length for this Nozzle is, Drop + Ho + H + T : 6.4156 in.

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FileName : Tower Analysis

Nozzle Schedule

Step: 24 3:04p Oct 23,2008

Nozzle Schedule:

Description	Nominal Size in.	Flange Sch/Type Cls	Flange Type	Noz. O/Dia in.	Wall Thk in.	Re-Pad ODia in.	Re-Pad Thick in.	Cut Length in.
Vent	2.500	80	WNF	2.875	0.276	-	-	6.42
Drain	3.000	80	WNF	3.500	0.300	-	-	6.29
Inlet	6.000	40	WNF	6.625	0.280	-	-	7.03
Outlet	6.000	40	WNF	6.625	0.280	-	-	7.15
Manway	16.000	40	WNF	16.000	0.500	-	-	8.42

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.
Vent	SA-106 B	0.375	0.375	-	-	-
Drain	SA-106 B	0.250	0.375	-	-	-
Inlet	SA-106 B	0.750	0.375	-	-	-
Outlet	SA-106 B	0.750	0.375	-	-	-
Manway	SA-106 B	0.750	0.375	-	-	-

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

Nozzle Miscellaneous Data:

Nozzle	Elevation/Distance From Datum ft.	Layout Angle deg.	Projection Outside in.	Projection Inside in.	Installed In Component
Vent		0.00	6.00	0.00	Top Head
Drain		0.00	6.00	0.00	Btm Head
Inlet	20.000	0.00	6.00	0.00	shell 2
Outlet	42.167	0.00	6.00	0.00	Shell 3
Manway	6.167	0.00	6.00	0.00	Shell 1

FileName : Tower Analysis -----

Nozzle Summary Step: 25 3:04p Oct 23,2008

Nozzle Calculation Summary

Description	Internal psig	Ext	MAPNC psig	UG45 [tr]	Weld Path	Areas
Drain	136.55	OK 0.226	OK	Passed
Manway	307.69	OK	...	OK 0.226	OK	Passed
Inlet	118.83	OK	...	OK 0.226	OK	Passed
Outlet	169.05	OK	...	OK 0.219	OK	Passed
Vent	164.82	OK 0.219	OK	Passed

Min. - Nozzles	118.83	Inlet				
Min. Shell&Flgs	105.52	20	30	212.23		

Computed Vessel M.A.W.P.	105.52	psig				

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

Check the Spatial Relationship between the Nozzles

From Node	Nozzle Description	Y Coordinate,	Layout Angle,	Dia. Limit
20	Drain	0.000	0.000	6.300
30	Manway	38.000	0.000	30.500
40	Inlet	204.000	0.000	12.630
60	Outlet	470.000	0.000	12.630
70	Vent	0.000	0.000	5.146

The nozzle spacing is computed by the following:

= Sqrt(ll² + lc²) 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 !

FileName : Tower Analysis

Vessel Design Summary Step: 26 3:04p Oct 23,2008

Design Code: ASME Code Section VIII Division 1, 2007

Diameter Spec : 40.000 x 28.000 in. ID
 Vessel Design Length, Tangent to Tangent 41.33 ft.
 Distance of Bottom Tangent above Grade 3.00 ft.
 Distance of Base above Grade 0.00 ft.
 Specified Datum Line Distance 0.00 ft.
 Skirt Material SA-516 70
 Shell/Head Matl SA-516 70
 Stiff Ring Matl SA-516 70
 Nozzle Material SA-106 B
 Internal Design Temperature 200 F
 Internal Design Pressure 100.00 psig
 External Design Temperature 200 F
 External Design Pressure 15.00 psig
 Maximum Allowable Working Pressure 105.52 psig
 External Max. Allowable Working Pressure 21.32 psig
 Hydrostatic Test Pressure 130.00 psig
 Required Minimum Design Metal Temperature -20 F
 Warmest Computed Minimum Design Metal Temperature -39 F
 Wind Design Code NBC-2005
 Earthquake Design Code NBC 2005

Element Pressures and MAWP: psig

Element Desc	Internal	External	M. A. W. P	Corr. All.
Btm Head	100.000	15.000	105.525	0.1250
Shell 1	100.000	15.000	518.293	0.1250
shell 2	100.000	15.000	518.293	0.1250
Cone	100.000	15.000	502.998	0.1250
Shell 3	100.000	15.000	732.759	0.1250
Top Head	100.000	15.000	300.353	0.1250

Stiffener Ring Specifications:

Elevation ft. Selected Type User Description
 31.97 Bar 1.75 x 1.00 Ring:[1 of 1]

Element Type	"To" Elev ft.	Elev ft.	Length ft.	Element Thk in.	Req'd Thk Int.	Ext.	Joint Eff Long	Circ
Skirt	3.00	3.000	3.000	0.500	No Calc	-----	0.70	0.70
Ellipse	3.17	0.167	0.167	0.250	0.243	-----	0.85	0.70
Cylinder	17.67	14.500	14.500	0.750	0.244	-----	0.85	0.70
Cylinder	32.17	14.500	14.500	0.750	0.244	-----	0.85	0.70
Conical	34.17	2.000	2.000	0.750	0.247	-----	0.85	0.70
Cylinder	44.17	10.000	10.000	0.750	0.219	-----	0.85	0.70
Ellipse	44.33	0.167	0.167	0.375	0.219	-----	0.85	0.70

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

External Pressure Calculations

From	To	External Actual T. in.	External Required T. in.	External Des. Press. psig	External M.A.W.P. psig
10	20	0.00000	No Calc	0.00000	No Calc
20	30	0.25000	0.22986	15.0000	21.3159
30	40	0.75000	0.44010	15.0000	83.2720
40	Ring	0.75000	0.44010	15.0000	83.2720

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FileName : Tower Analysis -----

Vessel Design Summary Step: 26 3:04p Oct 23,2008

Ring	50	0.75000	0.16469	15.0000	357.430	
	50	60	0.75000	0.22772	15.0000	338.280
	60	70	0.75000	0.29430	15.0000	345.111
	70	80	0.37500	0.19944	15.0000	127.364

External Pressure Calculations

From	To	Actual Len. Bet. Stiff. ft.	Allow. Len. Bet. Stiff. ft.	Ring Inertia Required in**4	Ring Inertia Available in**4
10	20	No Calc	No Calc	No Calc	No Calc
20	30	No Calc	No Calc	No Calc	No Calc
30	40	29.2444	442.4E+21	No Calc	No Calc
40	Ring	29.2444	442.4E+21	No Calc	No Calc
Ring	50	0.20000	8.656E+21	0.89879	2.20599
50	60	1.71084	1.71084	No Calc	No Calc
60	70	10.3611	19.68E+27	No Calc	No Calc
70	80	No Calc	No Calc	No Calc	No Calc

Wind/Earthquake Shear, Bending

From	To	Distance to Support ft.	Cumulative Wind Shear lb.	Earthquake Shear lb.	Wind Bending ft.lb.	Earthquake Bending ft.lb.
10	20	1.50000	2638.74	566.975	55501.9	15647.8
20	30	3.08333	2443.48	563.323	47878.6	13952.4
30	40	10.4167	2433.15	562.296	47472.2	13858.6
40	50	24.9167	1511.60	462.421	18872.8	6429.37
50	60	33.1667	590.055	227.257	3635.76	1429.20
60	70	39.1667	481.323	190.032	2564.38	1011.91
70	80	44.2500	29.5479	11.5663	10.0218	3.92298

Abs Max of the all of the Stress Ratio's : 0.6367

Basing Data : Basing W/Gussets & Chair Cap

Thickness of Basing	1.5000 in.
Inside Diameter of Basing	41.5000 in.
Outside Diameter of Basing	51.5000 in.
Nominal Diameter of Bolts	2.0000 in.
Diameter of Bolt Circle	47.5000 in.
Number of Bolts	8
Thickness of Gusset Plates	0.7500 in.
Average Width of Gusset Plates	4.5000 in.
Height of Gussets	9.0000 in.
Distance between Gussets	3.5000 in.
Thickness of Top Plate or Ring	1.7500 in.
Circumferential Width of the Top Plate	7.0000 in.
Radial Width of the Top Plate	4.5000 in.
Wind Moment on Support	55502. ft.lb.
Wind Shear on Support	2639. lb.
Earthquake Moment on Support	15648. ft.lb.
Earthquake Shear on Support	567. lb.

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:

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FileName : Tower Analysis -----

Vessel Design Summary Step: 26 3:04p Oct 23,2008

Fabricated - Bare W/O Removable Internals	17009.3	lbm
Shop Test - Fabricated + Water (Full)	36805.8	lbm
Shipping - Fab. + Rem. Intls.+ Shipping App.	17009.3	lbm
Erected - Fab. + Rem. Intls.+ Insul. (etc)	17009.3	lbm
Empty - Fab. + Intls. + Details + Wghts.	17009.3	lbm
Operating - Empty + Operating Liquid (No CA)	17009.3	lbm
Field Test - Empty Weight + Water (Full)	36805.8	lbm

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