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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

```
Class From To : Basic Element Checks.
==========================================================================

Class From To: Check of Additional Element Data
==========================================================================

There were no geometry errors or warnings.
```

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

```
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
```

```
   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
```



```
      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                      GR 1.1
      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
```

```
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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FileName : Tower Analysis ------------------------------
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*D*K)/(2*S*E-0.2*P) Appendix 1-4(c)
 = (100.000*40.2500*0.12)/(2*20000.00*0.85-0.2*100.000)
 = 0.1185 + 0.1250 = 0.2435 in.

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*0.1250)/(1.00*40.2500+0.2*0.1250)
 = 105.525 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*0.2500)/(1.00*40.0000+0.2*0.2500)
 = 212.235 psig

Actual stress at given pressure and thickness, corroded [Sact]:
 = (P*(K*D+0.2*t))/(2*E*t)
 = (100.000*(1.00*40.2500+0.2*0.1250))/(2*0.85*0.1250)
 = 18952.941 psi

Required Thickness of Straight Flange = 0.244 in.

Percent Elongation per UCS-79 (75*tnom/Rf)*(1-Rf/Ro) 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

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*R)/(S*E-0.6*P) per UG-27 (c)(1)
 = (100.000*20.1250)/(20000.00*0.85-0.6*100.000)
 = 0.1188 + 0.1250 = 0.2438 in.
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
```
 = (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
 = (20000.00*0.85*0.6250)/(20.1250+0.6*0.6250)
 = 518.293 psig
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
 = (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
 = (20000.00*0.85*0.7500)/(20.0000+0.6*0.7500)
 = 623.472 psig
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
 = (P*(R+0.6*t))/(E*t)
 = (100.000*(20.1250+0.6*0.6250))/(0.85*0.6250)
 = 3858.823 psi

Percent Elongation per UCS-79  (50*tnom/Rf)*(1-Rf/Ro)  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*R)/(S*E-0.6*P) per UG-27 (c)(1)
 = (100.000*20.1250)/(20000.00*0.85-0.6*100.000)
 = 0.1188 + 0.1250 = 0.2438 in.
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
```
 = (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
 = (20000.00*0.85*0.6250)/(20.1250+0.6*0.6250)
 = 518.293 psig
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
 = (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
 = (20000.00*0.85*0.7500)/(20.0000+0.6*0.7500)
 = 623.472 psig
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
 = (P*(R+0.6*t))/(E*t)
 = (100.000*(20.1250+0.6*0.6250))/(0.85*0.6250)
 = 3858.823 psi

Percent Elongation per UCS-79  (50*tnom/Rf)*(1-Rf/Ro)  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]:

```
 = (P*D)/(2*cos(a)*(S*E-0.6*P)) per Appendix 1-4 (e)
 = (100.000*40.1288)/(2*0.9701*(20000.00*0.85-0.6*100.000))
 = 0.1225 + 0.1250 = 0.2475 in.
```

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

```
 = (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
 = (2*20000.00*0.85*0.625*0.970)/(40.129+1.2*0.625*0.970)
 = 502.998 psig
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
 = (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
 = (2*20000.00*0.85*0.7500*0.9701)/(40.0000+1.2*0.7500*0.9701)
 = 605.254 psig
```

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

```
 = (P*(D+1.2*t*cos(a)))/(2*E*t*cos(a))
 = (100.000*(40.1288+1.2*0.6250*0.9701))/(2*0.85*0.6250*0.9701)
 = 3976.158 psi

Percent Elongation per UCS-79  (75*tnom/Rf)*(1-Rf/Ro)  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*R)/(S*E-0.6*P) per UG-27 (c)(1)
 = (100.000*14.1250)/(20000.00*0.85-0.6*100.000)
 = 0.0834 + 0.1250 = 0.2084 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*E*t)/(R+0.6*t) per UG-27 (c)(1)
 = (20000.00*0.85*0.6250)/(14.1250+0.6*0.6250)
 = 732.759 psig
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
 = (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
 = (20000.00*0.85*0.7500)/(14.0000+0.6*0.7500)
 = 882.353 psig
```

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

```
 = (P*(R+0.6*t))/(E*t)
 = (100.000*(14.1250+0.6*0.6250))/(0.85*0.6250)
 = 2729.412 psi

Percent Elongation per UCS-79  (50*tnom/Rf)*(1-Rf/Ro)  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*D*K)/(2*S*E-0.2*P) Appendix 1-4(c)
 = (100.000*28.2500*0.12)/(2*20000.00*0.85-0.2*100.000)
```

= 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*tnom/Rf)*(1-Rf/Ro) 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.

External Pressure Calculation Results :

ASME Code, Section VIII, Division 1, 2007

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/(K0*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/(K0*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**

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), te = 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), te = 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	$A*Dist^2$

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 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

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.

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 % lb.
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	Nozl	18.1522	0.00000	0.069444	Drain
30	Nozl	206.641	2.33333	3.00000	Manway
40	Ring	80.7499	0.00000	14.3000	Ring:[1 of 1]
40	Nozl	33.9274	1.91667	2.33333	Inlet
60	Nozl	33.9274	1.41667	8.00000	Outlet
70	Nozl	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

		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

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

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.

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

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FileName : Tower Analysis ------------------------------
Wind Load Calculation Step: 8 3:04p Oct 23,2008

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)(10^4)
 L  - Total height of structure ft.
Lc  - Total length of conical section(s) of vessel ft.
tb  - Uncorroded plate thickness at bottom of vessel in.
V30 - Design Wind Speed provided by user mile/hr
Vc  - Critical wind velocity mile/hr
Vw  - Maximum wind speed at top of structure mile/hr
W   - Total corroded weight of structure lb.
Ws  - Cor. vessel weight excl. weight of parts which do not effect stiff. lb.
 Z  - Maximum amplitude of vibration at top of vessel in.
Dl  - Logarithmic decrement ( taken as 0.03 for Welded Structures )
Vp  - Vib. Chance, <= 0.200E+02 (High); 0.200E+02 < 0.250E+02 (Probable)
P30 - wind pressure 30 feet above the base
```

Check other Conditions and Basic Assumptions:

```
#1 - Total Cone Length / Total Length < 0.5
     2.000 / 44.333 = 0.045
```

$\#2 - (D / L^2) * 10^4 < 8.0$ (English Units)
$- (3.21 / 44.33^2) * 10^4 = 16.340$ [Geometry Violation]

Compute the vibration possibility. If Vp > 0.250E+02 no chance. [Vp]:
$= W / (L * Dr^2)$
$= 14442 / (44.33 * 2.850^2)$
$= 40.097$

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

```
PV Elite 2008 Licensee: KEDKEP CONSULTING, INC.
FileName : Tower Analysis     ------------------------------
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 ft.	Earthquake Weight lb.	Element Ope Load lb.	Element Emp Load 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

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

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

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

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

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	

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	

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

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.

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 M = WIMOM + UWIMOM

```
 = (( 4 * M/DC ) - W ) / RN per Jawad & Farr, Eq. 12.3
 = (( 4 * 666022 / 47.500 ) - 17009 ) / 8
 = 4884.6064 lb.
```

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 Basering 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 Basering 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.

Basering 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

<u>Required Thickness of Gusset in Compression, per AISC E2-1:</u>
1. Allowed Compression at Given Thickness:

Factor Kl/r Per E2-1	41.5685
Factor Cc Per E2-1	122.4916

```
   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]:

$= Wmax*e/t^2\ [1.32*Z/(1.43*Cmwth*(Hg+Tta)^2/(R*Tskirt) + (4(Cmwth)(Hg+Tta)^2)^{.333} + 0.031/(R*Tskirt)^{.5}$

$= 4884*2.50/0.50^2\ [1.32*0.16/(1.43*7.00*(9.75)^2/(20.75*0.50) + (4*7.00\ (9.00 + 0.75)^2)^{.333} + 0.031/(20.75*0.50)^{.5}$

= 552.549 psi

Where:

$Z = 1/[(0.177*Wgp*Tba/(R*t)^{.5}*(Tba/t)^2 + 1]$

$Z = 1/[(0.177*7.000*1.500/(20.750*0.500)^{.5}*(1.500/0.500)^2+1]$

Z = 0.161

```
 e = ( Dc - Ds ) / 2
 e = ( 47.500 - 42.500 ) / 2
 e = 2.500 in.

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]

```
 = SkirtStress * ( SkirtThickness - CA )
 = 1241.019 * ( 0.500 - 0.000 )
 = 620.51 lb./in.
```

Results for Computed Minimum Basering Weld Size [BWeld]

```
 = W / [( 0.4 * Yield ) * 2 * 0.707]
 = 620 / [( 0.4 * 34800 ) * 2 * 0.707]
 = 0.032 in.
```

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

Vertical Plate Load [Wv]

```
 = Bolt Load / ( Cmwth + 2 * ( Hg + Tta ) )
 = 57500.0 / ( 5.000 + 2 * ( 9.000 + 1.750 ) )
 = 2169.811 lb./in.
```

Horizontal Plate Load [Wh]

$= Bolt\ Load * e / (Cmwth * (Hg+Tta) + 0.6667 * (Hg+Tta)^2)$

= 57500.0 * 2.500 /(5.000 * (10.750) + 0.6667 * $(10.750)^2$)
= 1099.073 lb./in.

Resultant Weld Load [Wr]
= $(Wv^2 + Wh^2)^{.5}$
= $(2169.81^2 + 1099.07^2)^{.5}$
= 2432.292 lb./in.

Results for Computed Min Gusset and Top Plate to Skirt Weld Size [GsWeld]
= Wr / [(0.4 * Yield) * 2 * 0.707]
= 2432.29 / [(0.4 * 34800) * 2 * 0.707]
= 0.124 in.

Results for Computed Minimum Gusset to Top Plate Weld Size

Weld Load [Wv]
= Bolt Load / (2 * TopWth)
= 57500.0 / (2 * 4.500)
= 6388.889 lb./in.

Weld Load [Wh]
= Bolt Load * e / (2 * Hgt * TopWth)
= 57500.0 * 2.50 / (2 * 10.750 * 4.500)
= 1485.788 lb./in.

Resultant Weld Load [Wr]
= $(Wv^2 + Wh^2)^{.5}$
= $(6388.89^2 + 1485.79^2)^{.5}$
= 6559.380 lb./in.

Results for Computed Min Gusset to Top Plate Weld Size [GtpWeld]
= Wr / [(0.4 * Yield) * 2 * 0.707]
= 6559.38 / [(0.4 * 34800) * 2 * 0.707]
= 0.333 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 Basering 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.

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*Ql*Rl*tan(angle)/(Ss*E1))*(1-0.25*((P*Rl-Ql)/Ql)*(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 sq.in.

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

= $.55*(Dl*ts)^{.5}*$ (ts + tc/Cos(alpha))
= $.55 * (41.500 * 0.625)^{.5}*$ (0.625 + 0.625 / 0.970)
= 3.5552 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]:

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

= 0.000051 * 41.5000 * 41.5000 * 8.48 / 10.9
= 0.07 $in.^4$

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*Qs*Rs/(Ss*E1)*(1-delta/alpha)*tan(alpha)
= 1.00 * 720.9971 * 14.1250 / (20000 * 0.85) *
(1.0 - 6.53 / 14.04) * 0.2500
= 0.0801 sq.in.

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

= $.78*(Rs*Ts)^{.5}$ ((Ts-t)+(Tc-Tr)/Cos(alpha)))
= $.78*(14.125 *0.625)^{.5}$ ((0.625 -0.083)+(0.625 -0.086)/0.97))
= 2.5430 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 * Qs * Rs * tan(alpha) / (Ss * E1)
= (1.0000*191.6300*14.7500*0.2500/(20000*0.85))
= 0.0416 sq.in.

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

= $.55*(Ds*ts)^{.5}$ [(ts-t)+(tc-tr)/cos(alpha))]
= $.55*(29.500*0.625)^{.5}$ [(0.625-0.169)+(0.625-0.084)/0.970]
= 2.3929 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 * Ds^2 * Ats / 10.9
= 0.000037 * 29.5000 * 29.5000 * 46.58 / 10.9
= 0.14 $in.^4$

PV Elite 2008 Licensee: KEDKEP CONSULTING, INC.
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.

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

```
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```

Insert Nozzle No Pad, no Inside projection

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*K1*D))/(2*S*E-0.2*P) per UG-37(a)(3)
 = (100.00*0.90*40.2500)/(2 *20000.00*1.00-0.2*100.00)
 = 0.0906 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*1.58)/(17100*1.00-0.6*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,            Dl     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 * 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:

	Required Thickness	Actual Thickness
Nozzle Weld	0.0875 = 0.7 * TMIN	0.2651 = 0.7 * Wo in.

The Drop for this Nozzle is : 0.0423 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 6.2923 in.

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

```
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```

Insert Nozzle No Pad, no Inside projection

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*(0.7500-0.1250)-0.3151)*(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]:

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

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

$= 0.120$ sq.in.

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

```
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
```

<u>Weld Size Calculations, Description: Manway</u>

```
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

Shear, Outward Nozzle Weld [Sonw]:

```
 = (pi/2) * Dlo * Wo * 0.49 * Snw
 = ( 3.1416 / 2.0 ) * 16.0000 * 0.3750 * 0.49 * 17100
 = 78970. lb.
```

Shear, Nozzle Wall [Snw]:

```
 = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
 = (3.1416 * 7.8125 ) * ( 0.5000 - 0.1250 ) * 0.7 * 17100
 = 110170. lb.
```

Tension, Nozzle Groove Weld [Tngw]:

```
 = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
 = ( 3.1416 / 2.0 ) * 16.0000 * ( 0.7500 - 0.1250 ) * 0.74 * 17100
 = 198769. lb.
```

Strength of Failure Paths:

```
 PATH11 = ( SONW + SNW ) = ( 78970 + 110170 ) = 189140 lb.
 PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
        = ( 78970 + 0 + 198768 + 0 ) = 277738 lb.
 PATH33 = ( Sonw + Tngw + Sinw )
        = ( 78970 + 198768 + 0 ) = 277738 lb.
```

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.

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

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```

Insert Nozzle No Pad, no Inside projection

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]:

$$= Wo^2 * fr2 + (Wi-Can/0.707)^2 * fr2$$
$$= 0.3750^2 * 0.8550 + (0.0000)^2 * 0.8550$$
$$= 0.120 \text{ sq.in.}$$

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

```
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.

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

```
              |  |
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|           \ |  |
|____________\|__|
```

Insert Nozzle No Pad, no Inside projection

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*(0.7500-0.1250)-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]:

 = Wo^2 * fr2 + (Wi-Can/0.707 $)^2$ * fr2
 = 0.3750^2 * 0.8550 + (0.0000 $)^2$ * 0.8550
 = 0.120 sq.in.

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

```
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

Shear, Outward Nozzle Weld [Sonw]:
```
 = (pi/2) * Dlo * Wo * 0.49 * Snw
 = ( 3.1416 / 2.0 ) * 6.6250 * 0.3750 * 0.49 * 17100
 = 32699. lb.
```

Shear, Nozzle Wall [Snw]:
```
 = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
 = (3.1416 * 3.2350 ) * ( 0.2800 - 0.1250 ) * 0.7 * 17100
 = 18856. lb.
```

Tension, Nozzle Groove Weld [Tngw]:
```
 = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
 = ( 3.1416 / 2.0 ) * 6.6250 * ( 0.7500 - 0.1250 ) * 0.74 * 17100
 = 82303. lb.
```

Strength of Failure Paths:

```
 PATH11 = ( SONW + SNW ) = ( 32698 + 18856 ) = 51554 lb.
 PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
        = ( 32698 + 0 + 82302 + 0 ) = 115001 lb.
 PATH33 = ( Sonw + Tngw + Sinw )
        = ( 32698 + 82302 + 0 ) = 115001 lb.
```

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.

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

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*K1*D))/(2*S*E-0.2*P) per UG-37(a)(3)
 = (100.00*0.90*28.2500)/(2 *20000.00*1.00-0.2*100.00)
 = 0.0636 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*1.29)/(17100*1.00-0.6*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,             Dl     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 * 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:

	Required Thickness	Actual Thickness
Nozzle Weld	0.1057 = 0.7 * TMIN	0.2651 = 0.7 * Wo in.

The Drop for this Nozzle is : 0.0406 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 6.4156 in.

Nozzle Schedule:

Description	Nominal Size in.	Flange Sch/Type Cls		Noz. O/Dia in.	Wall Thk in.	Re-Pad ODia in.	Re-Pad Thick in.	Cut Length in.
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

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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($ll^2 + lc^2$) 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 !

PV Elite 2008 c1993-2008 by COADE Engineering Software

PV Elite 2008 Licensee: KEDKEP CONSULTING, INC.
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.	Length ft.	Element Thk in.	R e q d T h k Int.	Ext.	Joint Eff Long	Circ
Skirt	3.00	3.000	0.500	No Calc	-------	0.70	0.70
Ellipse	3.17	0.167	0.250	0.243	-------	0.85	0.70
Cylinder	17.67	14.500	0.750	0.244	-------	0.85	0.70
Cylinder	32.17	14.500	0.750	0.244	-------	0.85	0.70
Conical	34.17	2.000	0.750	0.247	-------	0.85	0.70
Cylinder	44.17	10.000	0.750	0.219	-------	0.85	0.70
Ellipse	44.33	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

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.	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

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

Basering Data : Basering W/Gussets & Chair Cap

Thickness of Basering	1.5000	in.
Inside Diameter of Basering	41.5000	in.
Outside Diameter of Basering	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:

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