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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\HORIZONTAL TANK.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) | 0.0000 | psig |
| Design Internal Temperature | 0 | 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-3 | |
| Miscellaneous Weight Percent | 0. | |
| Use Higher Longitudinal Stresses (Flag) | Y | |
| Select t for Internal Pressure (Flag) | N | |
| Select t for External Pressure (Flag) | N | |
| Select t for Axial Stress (Flag) | N | |
| Select Location for Stiff. Rings (Flag) | N | |
| 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 | IBC-2006 | |
| Design Wind Speed | 70.000 | mile/hr |
| Exposure Constant | C | |
| Importance Factor | 1. | |
| Roughness Factor | 1 | |
| Base Elevation | 0.0000 | ft. |
| Percent Wind for Hydrotest | 33. | |
| Use Wind Profile (Y/N) | N | |
| Damping Factor (Beta) for Wind (Ope) | 0.0100 | |
| Damping Factor (Beta) for Wind (Empty) | 0.0000 | |
| Damping Factor (Beta) for Wind (Filled) | 0.0000 | |

| | |
|---|---|
| Seismic Design Code | IBC 2006 |
| Importance Factor | 1.000 |
| Table Value Fa | 1.000 |
| Table Value Fv | 1.400 |
| Short Period Acceleration value Ss | 1.000 |

| | | |
|---|---|---|
| Long Period Acceleration Value Sl | | 0.400 |
| Moment Reduction Factor Tau | | 1.000 |
| Force Modification Factor R | | 3.000 |
| Site Class | | C |
| Component Elevation Ratio | z/h | 0.000 |
| Amplification Factor | Ap | 0.000 |
| Force Factor | | 0.000 |
| Consider Vertical Acceleration | | No |
| Minimum Acceleration Multiplier | | 0.000 |
| User Value of Sds (used if > 0 ) | | 0.000 |
| User Value of Sd1 (used if > 0 ) | | 0.000 |

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

Material Database Year Current w/Addenda or Code Year

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

| | | |
|---|---|---|
| Element From Node | 10 | |
| Element To Node | 20 | |
| Element Type | Elliptical | |
| Description | LF Head | |
| Distance "FROM" to "TO" | 0.1667 | ft. |
| Inside Diameter | 60.000 | in. |
| Element Thickness | 0.6250 | 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 | |
| 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 | 1. | |
| Efficiency, Circumferential Seam | 1. | |
| Elliptical Head Factor | 2. | |

| | | |
|---|---|---|
| Element From Node | 10 | |
| Detail Type | Nozzle | |
| Detail ID | Inspection | |
| Dist. from "FROM" Node / Offset dist | 0.0000 | in. |
| Nozzle Diameter | 6. | 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 10

| | | |
|---|---|---|
| Detail Type | Nozzle | |
| Detail ID | Outlet | |
| Dist. from "FROM" Node / Offset dist | 15.000 | in. |
| Nozzle Diameter | 6. | 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 | 20 | |
| Element To Node | 30 | |
| Element Type | Cylinder | |
| Description | Shell | |
| Distance "FROM" to "TO" | 10.000 | ft. |
| Inside Diameter | 60.000 | in. |
| Element Thickness | 0.6250 | in. |
| Internal Corrosion Allowance | 0.1250 | in. |
| Nominal Thickness | 0.0000 | in. |
| External Corrosion Allowance | 0.0000 | in. |
| Design Internal Pressure | 150.00 | 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 | 0.85 | |

| | | |
|---|---|---|
| Element From Node | 20 | |
| Detail Type | Saddle | |
| Detail ID | Lft Sdl | |
| Dist. from "FROM" Node / Offset dist | 1.2500 | ft. |
| Width of Saddle | 8.0000 | in. |
| Height of Saddle at Bottom | 45.000 | in. |
| Saddle Contact Angle | 120. | |
| Height of Composite Ring Stiffener | 0.0000 | in. |
| Width of Wear Plate | 12.000 | in. |
| Thickness of Wear Plate | 0.3750 | in. |
| Contact Angle, Wear Plate (degrees) | 132. | |

| | | |
|---|---|---|
| Element From Node | 20 | |
| Detail Type | Saddle | |
| Detail ID | Sdl 2 Fr20 | |
| Dist. from "FROM" Node / Offset dist | 9.0000 | ft. |
| Width of Saddle | 8.0000 | in. |
| Height of Saddle at Bottom | 45.000 | in. |
| Saddle Contact Angle | 120. | |
| Height of Composite Ring Stiffener | 0.0000 | in. |
| Width of Wear Plate | 12.000 | in. |
| Thickness of Wear Plate | 0.3750 | in. |
| Contact Angle, Wear Plate (degrees) | 132. | |

| | | |
|---|---|---|
| Element From Node | 20 | |
| Detail Type | Nozzle | |
| Detail ID | Manhole | |
| Dist. from "FROM" Node / Offset dist | 5.0000 | ft. |
| Nozzle Diameter | 16. | in. |
| Nozzle Schedule | None | |
| 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-516 70 | |
| Element From Node | 20 | |
| Detail Type | Nozzle | |
| Detail ID | Drain | |
| Dist. from "FROM" Node / Offset dist | 5.0000 | ft. |
| Nozzle Diameter | 2. | in. |
| Nozzle Schedule | 160 | |
| Nozzle Class | 150 | |
| Layout Angle | 180. | |
| 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 | Elliptical | |
| Description | RT Head | |
| Distance "FROM" to "TO" | 0.1667 | ft. |
| Inside Diameter | 60.000 | in. |
| Element Thickness | 0.6250 | in. |
| Internal Corrosion Allowance | 0.1250 | in. |
| Nominal Thickness | 0.0000 | in. |
| External Corrosion Allowance | 0.0000 | in. |
| Design Internal Pressure | 150.00 | 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 | 1. | |
| Efficiency, Circumferential Seam | 0.85 | |
| Elliptical Head Factor | 2. | |
| Element From Node | 30 | |
| Detail Type | Nozzle | |
| Detail ID | Inlet | |
| Dist. from "FROM" Node / Offset dist | 0.0000 | in. |
| Nozzle Diameter | 4. | in. |
| Nozzle Schedule | 120 | |
| 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. |
|---|---|---|---|---|---|
| LF Head | | 0.16667 | 0.00000 | 0.16667 | 0.00000 |
| | Shell | 10.1667 | 0.00000 | 10.0000 | 0.00000 |
| | RT Head | 10.3333 | 0.00000 | 0.16667 | 0.00000 |

**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 |
|---|---|---|---|---|---|---|
| LF Head | | 100.000 | ... | 0.12500 | 60.0000 | 20000.0 |
| Shell | | 150.000 | ... | 0.12500 | 60.0000 | 17000.0 |
| RT Head | | 150.000 | ... | 0.12500 | 60.0000 | 20000.0 |

**Element Required Thickness and MAWP :**

| From | To | Design Pressure psig | M.A.W.P. Corroded psig | M.A.P. New & Cold psig | Actual Thickness in. | Required Thickness in. |
|---|---|---|---|---|---|---|
| LF Head | | 100.000 | 331.400 | 415.800 | 0.62500 | 0.27570 |
| Shell | | 150.000 | 279.376 | 349.794 | 0.62500 | 0.39222 |
| RT Head | | 150.000 | 331.400 | 415.800 | 0.62500 | 0.35111 |
| Minimum | | | 260.000 | 285.000 | | |

*Note : The M.A.W.P is Governed by an ANSI Flange !*

*Note : The M.A.P.(NC) is Governed by a Flange !*

**Internal Pressure Calculation Results :**

**ASME Code, Section VIII, Division 1, 2007**

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

LF Head

Thickness Due to Internal Pressure [Tr]:
= (P*D*K)/(2*S*E-0.2*P) Appendix 1-4(c)
= (100.000*60.2500*0.12)/(2*20000.00*1.00-0.2*100.000)
= 0.1507 + 0.1250 = 0.2757 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*1.00*0.5000)/(1.00*60.2500+0.2*0.5000)
= 331.400 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*1.00*0.6250)/(1.00*60.0000+0.2*0.6250)
= 415.800 psig

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(K*D+0.2*t))/(2*E*t)
= (100.000*(1.00*60.2500+0.2*0.5000))/(2*1.00*0.5000)
= 6035.000 psi

Required Thickness of Straight Flange = 0.276 in.

Percent Elongation per UCS-79 (75*tnom/Rf)*(1-Rf/Ro) 4.548 %

Min Metal Temp. w/o impact per UCS-66 6 F
Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.30] -134 F
Min Metal Temp. w/o impact per UG-20(f) -20 F

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

Shell

Thickness Due to Internal Pressure [Tr]:

```
 = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
 = (150.000*30.1250)/(20000.00*0.85-0.6*150.000)
 = 0.2672 + 0.1250 = 0.3922 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*0.5000)/(30.1250+0.6*0.5000)
 = 279.376 psig
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
 = (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
 = (20000.00*0.85*0.6250)/(30.0000+0.6*0.6250)
 = 349.794 psig
```

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

```
 = (P*(R+0.6*t))/(E*t)
 = (150.000*(30.1250+0.6*0.5000))/(0.85*0.5000)
 = 10738.235 psi
```

```
Percent Elongation per UCS-79  (50*tnom/Rf)*(1-Rf/Ro)  1.031 %

Min Metal Temp. w/o impact per UCS-66                    6  F
Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.45]  -55  F
Min Metal Temp. w/o impact per UG-20(f)                -20  F
```

**Elliptical Head From 30 To 40 SA-516 70 , UCS-66 Crv. B at 200 F**

RT Head

Thickness Due to Internal Pressure [Tr]:

```
 = (P*D*K)/(2*S*E-0.2*P) Appendix 1-4(c)
 = (150.000*60.2500*0.12)/(2*20000.00*1.00-0.2*150.000)
 = 0.2261 + 0.1250 = 0.3511 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*1.00*0.5000)/(1.00*60.2500+0.2*0.5000)
 = 331.400 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*1.00*0.6250)/(1.00*60.0000+0.2*0.6250)
 = 415.800 psig
```

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

```
 = (P*(K*D+0.2*t))/(2*E*t)
 = (150.000*(1.00*60.2500+0.2*0.5000))/(2*1.00*0.5000)
 = 9052.500 psi
```

Required Thickness of Straight Flange = 0.352 in.

```
Percent Elongation per UCS-79  (75*tnom/Rf)*(1-Rf/Ro)  4.548 %

Min Metal Temp. w/o impact per UCS-66                    6  F
Min Metal Temp. at Rqd thickness (UCS 66.1)[rat 0.45]  -55  F
Min Metal Temp. w/o impact per UG-20(f)                -20  F
```

**MINIMUM METAL DESIGN TEMPERATURE RESULTS :**

```
Minimum Metal Temp. w/o impact per UCS-66                 6.  F
Minimum Metal Temp. at Required thickness               -55.  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         338.000  psig
Pressure per UG99b[34] = 1.3 * Design Pres * Sa/S         0.000  psig
Pressure per UG99c     = 1.3 * M.A.P. - Head(Hyd)      370.500  psig
Pressure per UG100     = 1.1 * M.A.W.P. * Sa/S         286.000  psig
```

UG-99(b) Note 34, Test Pressure Calculation:

```
 = Test Factor * Design Pressure * Stress Ratio
 = 1.3 * 0.000 * 1.000
 = 0.000 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 |
|---|---|---|---|---|

Elements Suitable for Internal Pressure.

**External Pressure Calculation Results :**

**ASME Code, Section VIII, Division 1, 2007**

**Elliptical Head From 10 to 20 Ext. Chart: CS-2 at 200 F**

LF 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 |
|---|---|---|---|---|
| 0.500 | 61.25 | 122.50 | 0.0011338 | 12917.58 |

EMAP = B/(K0*D/t) = 12917.5791/(0.9000 *122.5000 ) = 117.1663 psig

Results for Required Thickness (Tca):

| Tca | OD | D/t | Factor A | B |
|---|---|---|---|---|
| 0.159 | 61.25 | 386.22 | 0.0003596 | 5214.34 |

EMAP = B/(K0*D/t) = 5214.3438 /(0.9000 *386.2210 ) = 15.0010 psig

**Cylindrical** Shell **From 20 to 30 Ext. Chart: CS-2 at 200 F**

Shell

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 |
|---|---|---|---|---|---|---|
| 0.500 | 61.25 | 134.00 | 122.50 | 2.1878 | 0.0004466 | 6475.23 |

EMAP = (4*B)/(3*(D/t)) = (4*6475.2334 )/(3*122.5000 ) = 70.4787 psig

Results for Required Thickness (Tca):

| Tca | OD | SLEN | D/t | L/D | Factor A | B |
|---|---|---|---|---|---|---|
| 0.270 | 61.25 | 134.00 | 227.01 | 2.1878 | 0.0001761 | 2554.01 |

EMAP = (4*B)/(3*(D/t)) = (4*2554.0081 )/(3*227.0074 ) = 15.0010 psig

Results for Maximum Stiffened Length (Slen):

| Tca | OD | SLEN | D/t | L/D | Factor A | B |
|---|---|---|---|---|---|---|
| 0.500 | 61.25 | 620.37 | 122.50 | 10.1284 | 0.0000950 | 1378.20 |

EMAP = (4*B)/(3*(D/t)) = (4*1378.1968 )/(3*122.5000 ) = 15.0008 psig

**Elliptical Head From 30 to 40 Ext. Chart: CS-2 at 200 F**

RT 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 |
|---|---|---|---|---|
| 0.500 | 61.25 | 122.50 | 0.0011338 | 12917.58 |

EMAP = B/(K0*D/t) = 12917.5791/(0.9000 *122.5000 ) = 117.1663 psig

Results for Required Thickness (Tca):

| Tca | OD | D/t | Factor A | B |
|---|---|---|---|---|
| 0.159 | 61.25 | 386.22 | 0.0003596 | 5214.34 |

EMAP = B/(K0*D/t) = 5214.3438 /(0.9000 *386.2210 ) = 15.0010 psig

**External Pressure Calculations**

| From | To | Section Length ft. | Outside Diameter in. | Corroded Thickness in. | Factor A | Factor B psi |
|---|---|---|---|---|---|---|
| 10 | 20 | No Calc | 61.2500 | 0.50000 | 0.0011338 | 12917.6 |
| 20 | 30 | 11.1667 | 61.2500 | 0.50000 | 0.00044657 | 6475.23 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 30 | 40 | No Calc | 61.2500 | 0.50000 | 0.0011338 | 12917.6 |

**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 | 0.62500 | 0.28359 | 15.0000 | 117.166 |
| 20 | 30 | 0.62500 | 0.39481 | 15.0000 | 70.4787 |
| 30 | 40 | 0.62500 | 0.28359 | 15.0000 | 117.166 |
| Minimum | | | | | 70.479 |

**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 | 11.1667 | 51.6973 | No Calc | No Calc |
| 30 | 40 | 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 | 845.430 | 33929.2 | 676.344 | 34331.3 | 0.00000 |
| 20 | 30 | 4042.49 | 339292. | 3240.66 | 342125. | 0.00000 |
| 30 | 40 | 845.430 | 33929.2 | 676.344 | 34331.3 | 0.00000 |
| Total | | 5733 | 407150 | 4593 | 410788 | 0 |

**Weight of Details**

| From | Type | Weight of Detail lb. | X Offset, Dtl. Cent. ft. | Y Offset, Dtl. Cent. ft. | Description |
|---|---|---|---|---|---|
| 10 | Nozl | 23.8335 | -0.10417 | 0.00000 | Inspection |
| 10 | Nozl | 23.8335 | -0.10417 | 1.25000 | Outlet |
| 20 | Sadl | 88.0180 | 1.25000 | 3.08333 | Lft Sdl |
| 20 | Sadl | 88.0180 | 9.00000 | 3.08333 | Sdl 2 Fr20 |
| 20 | Nozl | 139.364 | 5.00000 | 3.16667 | Manhole |
| 20 | Nozl | 6.76820 | 5.00000 | 2.58333 | Drain |
| 30 | Nozl | 15.1776 | 0.27083 | 0.00000 | Inlet |

**Total Weight of Each Detail Type**

| | |
|---|---|
| Total Weight of Saddles | 176.0 |
| Total Weight of Nozzles | 209.0 |
| Sum of the Detail Weights | 385.0 lb. |

**Weight Summary**

| | | |
|---|---|---|
| Fabricated Wt. | - Bare Weight W/O Removable Internals | 6118.4 lb. |
| Shop Test Wt. | - Fabricated Weight + Water ( Full ) | 20821.0 lb. |
| Shipping Wt. | - Fab. Wt + Rem. Intls.+ Shipping App. | 6118.4 lb. |
| Erected Wt. | - Fab. Wt + Rem. Intls.+ Insul. (etc) | 6118.4 lb. |
| Ope. Wt. no Liq | - Fab. Wt + Intls. + Details + Wghts. | 6118.4 lb. |
| Operating Wt. | - Empty Wt. + Operating Liquid (No CA) | 6118.4 lb. |
| Oper. Wt. + CA | - Corr Wt. + Operating Liquid | 4978.4 lb. |
| Field Test Wt. | - Empty Weight + Water (Full) | 20821.0 lb. |

Note: The Corroded Weight and thickness are used in the Horizontal Vessel Analysis (Ope Case) and Earthquake Load Calculations.

**Outside Surface Areas of Elements**

| From | To | Surface Area sq.in. |
|---|---|---|
| 10 | 20 | 4451.48 |
| 20 | 30 | 23090.7 |
| 30 | 40 | 4451.48 |
| Total | | 31993.676 sq.in. [222.2 Square Feet ] |

**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

## Wind Analysis Results

Wind Load Results per IBC 2006:

Note: Per Section 1609 of IBC 2003/06 these results are also applicable for the determination of Wind Loads on structures (1609.1.1).

```
User Entered Importance Factor is                    1.000
Gust Effect Factor (Ope)(G or Gf)                    0.850
User entered Beta Value ( Operating Case )          0.0100
Shape Factor (Cf)                                    0.522
User Entered Basic Wind Speed                         70.0    mile/hr
```

## Sample Calculation for the First Element

The ASCE code performs all calculations in Imperial Units only. The wind pressure is therefore computed in these units.

Value of [Alpha] and [Zg]
Exposure Category = 3 (C) thus from Table C6-2:
Alpha = 9.500 : Zg = 900.000 ft.

Effective Height [z]
= Centroid Hgt. + Vessel Base Elevation
= 3.750 + 0.000 = 3.750 ft.

Compute [Kz]
Because z (3.750 ft.) < 15 ft.
$= 2.01 * ( 15 / Zg )^{2 / Alpha}$
$= 2.01 * ( 15 / 900.000 )^{2 / 9.500}$
= 0.849

Type of Hill: No Hill

Directionality Factor for round structures [Kd]:
= 0.95 per [6-6 ASCE-7 98][6-4 ASCE-7 02/05]

As there is No Hill Present: [Kzt]
K1 = 0, K2 = 0, K3 = 0

Topographical Factor [Kzt]
$= ( 1 + K1 * K2 * K3 )^2$
$= ( 1 + 0.000 * 0.000 * 0.000 )^2$
= 1.0000

Basic Wind Pressure, Imperial Units [qz]:
$= 0.00256 * Kz * Kzt * Kd * I * Vr(mph)^2$
$= 0.00256 * 0.849 * 1.000 * 0.950 * 1.000 * 70.000$
= 10.116 psf

Force on the first element [F]:
= qz * Gh * Cf * WindArea
= 10.116 * 0.850 * 0.522 * 898.651
= 28.025 lb.

| Element | Hgt (z) ft. | K1 | K2 | K3 | Kz | Kzt | qz psf |
|---|---|---|---|---|---|---|---|
| LF Head | 3.8 | 0.000 | 0.000 | 0.000 | 0.849 | 1.000 | 10.116 |
| Shell | 3.8 | 0.000 | 0.000 | 0.000 | 0.849 | 1.000 | 10.116 |
| RT Head | 3.8 | 0.000 | 0.000 | 0.000 | 0.849 | 1.000 | 10.116 |

## Wind Load Calculation

| From | To | Wind Height ft. | Wind Diameter ft. | Wind Area sq.in. | Height Factor psf | Element Wind Load lb. |
|---|---|---|---|---|---|---|
| 10 | 20 | 3.75000 | 6.12500 | 898.651 | 10.1160 | 28.0249 |
| 20 | 30 | 3.75000 | 6.12500 | 8820.00 | 10.1160 | 275.056 |
| 30 | 40 | 3.75000 | 6.12500 | 898.651 | 10.1160 | 28.0249 |

**Earthquake Analysis Results per ASCE 7-2002/IBC 2003/06**

```
User Entered Table Value 9.4.1.2.4a                Fa: 1.000
User Entered Table Value 9.4.1.2.4b                Fv: 1.400
Max. Mapped Acceleration Value for Short Periods   Ss: 1.000
Max. Mapped Acceleration Value for 1 Sec. Period   S1: 0.400
Force Modification Factor                           R: 3.000
Importance Factor                                   I: 1.000
Site Class                                              C

 Sms = Fa * Ss = 1.000 * 1.000 = 1.000
 Sm1 = Fv * S1 = 1.400 * 0.400 = 0.560
 Sds = 2/3 * Sms = 2/3 * 1.000 = 0.667
 Sd1 = 2/3 * Sm1 = 2/3 * 0.560 = 0.373
```

Check the Period (1/Frequency) from 9.5.5.3.2-1 [T]:
$= Ct * hn^{x}$ where Ct = 0.020, x = 0.75 and hn = total Vessel Height
$= 0.020 * ( 5.0000 ^{0.75}) = 0.067$ seconds

The Coefficient Cu from Table 9.5.5.3.1 is : 1.400

Check the Min. Value of T which is the Smaller of Cu*Ta and T [T]:
= Minimum Value of (1.400 * 0.067 , 1/33.000 ) = 0.0303 per 9.5.5.3

As the time period is < 0.06 second, use section 9.14.5.2.

Compute the Base Shear per 9.14.5.2, [V]:
= 0.3 * Sds * W * I
= 0.3 * 0.667 * 4978 * 1.00 = 995.67 lb.

Note: Loads multiplied by the Scalar multiplier value of 0.7000

Final Base Shear, V = 696.97 lb.

**Earthquake Load Calculation**

| From | To | Earthquake Height ft. | Earthquake Weight lb. | Element Ope Load lb. |
|---|---|---|---|---|
| 10 | 20 | 2.50000 | 995.672 | 139.394 |
| 20 | Sadl | 2.50000 | 995.672 | 139.394 |
| Sadl | 30 | 2.50000 | 995.672 | 139.394 |
| 20 | 30 | 2.50000 | 995.672 | 139.394 |
| 30 | 40 | 2.50000 | 995.672 | 139.394 |

**Shop/Field Installation Options :**

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

| | |
|---|---|
| Center of Gravity of Saddles | 5.3 ft. |
| Center of Gravity of Nozzles | 4.3 ft. |
| Center of Gravity of Bare Shell New and Cold | 5.2 ft. |
| Center of Gravity of Bare Shell Corroded | 5.2 ft. |
| Vessel CG in the Operating Condition | 5.1 ft. |
| Vessel CG in the Fabricated (Shop/Empty) Condition | 5.1 ft. |

**Zick Analysis: Stresses for the Left Saddle**

Horizontal Vessel Stress Calculations : Operating Case

| | | | |
|---|---|---|---|
| Shell Allowable Stress used in Calculation | | 20000.00 | psi |
| Shell Comp. Yield Stress used in Calculation | | 34800.00 | psi |
| Head Allowable Stress used in Calculation | | 20000.00 | psi |
| Saddle Force Q, Operating Case | | 3384.02 | lb. |
| Stress Results for Zick Stresses: | Actual | Allowable | |
| Long. Stress at Top of Saddles | 4533.24 | 17000.00 | psi |
| Long. Stress at Bottom of Saddles | 4444.26 | 17000.00 | psi |
| Long. Stress at Top of Midspan | 4460.11 | 17000.00 | psi |
| Long. Stress at Bottom of Midspan | 4517.39 | 17000.00 | psi |
| Tangential Shear in Shell | 141.91 | 16000.00 | psi |
| Circ. Stress at Horn of Saddle | -836.44 | -30000.00 | psi |
| Circ. Stress at Tip of Wear Plate | -727.06 | -30000.00 | psi |
| Circ. Compressive Stress in Shell | -245.02 | -17400.00 | psi |

Note: The Longitudinal Stress from the Zick Analysis is combined with the Longitudinal Pressure Stress to get the total stress.

**Intermediate Results: Saddle Reaction Q due to Wind or Seismic**

Saddle Reaction Force due to Wind Ft [Fwt]:
= Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E
= 3.00 * ( 331.1 /2 + 0 ) * 45.0000 / 53.2606
= 419.6 lb.

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:
= Max( Fl, Friction Load, Sum of X Forces) * B / Ls
= Max( 248.39 , 0.00 , 0 ) * 45.0000 / 93.0000
= 120.2 lb.

Saddle Reaction Force due to Earthquake Fl or Friction [Fsl]:
= Max( Fl, Friction Force, Sum of X Forces ) * B / Ls
= Max( 696.97 , 0.00 , 0 ) * 45.0000 / 93.0000
= 337.2 lb.

Saddle Reaction Force due to Earthquake Ft [Fst]:
= Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E
= 3.00 * ( 696 /2 + 0 ) * 45.0000 / 53.2606
= 883.3 lb.

Load Combination Results for Q + Wind or Seismic [Q]:
= Saddle Load + Max( Fwl, Fwt, Fsl, Fst )
= 2500 + Max( 120 , 419 , 337 , 883 )
= 3384.0 lb.

**Summary of Loads on this Saddle Support:**

| | | |
|---|---|---|
| Vertical Load on this Saddle | 3384.02 | lb. |
| Transverse Shear Load on this Saddle | 348.49 | lb. |
| Longitudinal Shear Load on this Saddle | 696.97 | lb. |

**Formulas and Substitutions for Zick Analysis Results:**

Longitudinal Bending (+-) at Midspan
= ( 3 * Q * L * K.2 / ( pi * $R^2$ * ( Ts - Ca )))
= ( 3 * 3384 * 10.33 * 0.3892 ) /
( 3.141 * 30.1250 * 30.1250 * ( 0.6250 - 0.1250 )))
= 28.64 psi

Compute the area ratio [K]:
```
 = Pi * (Sin(Delta)/Delta - Cos(Delta) ) / (Delta + Sin(Delta) * Cos(Delta) -
   (Delta + Sin(Delta) * Cos(Delta) - 2 * Sin(Delta) * Sin(Delta)/Delta)
 = Pi * (Sin(1.396 ) / 1.396 - Cos(1.396 )) / ( 1.396 + Sin(1.396 ) *
   Cos(1.396 ) - 2 * Sin(1.396 ) * Sin(1.396 )/ 1.396 )
 = 9.3799
```

Compute the moment fraction [X]:
```
 = 1 - (1 - A/L + ( R^2 - H^2 )/(2 * A*L ) )/(1 + (4*H )/( 3 * L ) )
 = 1 - (1 - 1.417 /10.333 + (30.125^2 - 1.250^2)/( 2 * 1.417 * 10.333 ) )
   (1 + (4 * 1.250 )/(3 * 10.333 ) )
 = 0.1175
```

Intermediate Product [K.1]:
```
 = K * X  * 4 * A / L
 = 9.380 * 0.118 * 4 * 1.417 / 10.333 = 0.6046
```

Longitudinal Bending (+-) at Saddle
```
 = ( 3 * Q * L * K.1 / ( pi * R^2 * ( Ts - Ca )))
 = ( 3 * 3384 * 10.33 * 0.6046 ) /
   ( 3.141 * 30.1250 * 30.1250 * ( 0.6250 - 0.1250 )))
 = 44.49 psi
```

Tangential Shear in Shell near Saddle
```
 = Q * K.4 * (( L-H-2A )/( L+H ))/( R*(Ts-Ca))
 = 3384 * 1.1707 * (( 10.33 - 1.25 - 2 * 1.42 )/
   ( 10.33 + 1.25 ))/( 30.1250 * ( 0.6250 - 0.1250 ))
 = 141.91 psi
```

Circumferential Stress at Tip of the Wear Plate
```
 = -Q/(4*(TS-CA)*(SADWTH+1.56*Sqrt(R*(TS-CA))))-12*Q*R*K13/(L*(TS-CA)^2)
 = -3384 /( 4 * 0.5000 * (8.00 + 1.56 * Sqrt(30.1250 *0.5000 )))
   -12.0 * 3384 * 2.51 * 0.0154 / ( 10.3333 * 0.5000^2 )
 = -727.06 psi
```

Note: Wear Plate thk. could Not be considered in this formula because:

Saddle-Tangent Distance A (1.42 ) is > R/2 (1.26 ft.)

Circumferential Stress at Horn of Saddle
```
 = -Q/(4*TEM*(SADWTH+1.56*sqrt(R*TCA)))-12*Q*R*K.7/(L*TEB)
 = -3384 /( 4 * 0.5000 * (8.00 + 1.56 * sqrt(30.1250 *0.5000 )))
   -12.0 * 3384 * 2.51 * 0.0181 / ( 10.3333 * 0.2500 )
 = -836.44 psi
```

Circumferential Compression at Bottom of Shell
```
 = (Q*( K.9/( TEM9 * WPDWTH ) ) )
 = ( 3384 *( 0.7603 /( 0.8750 * 12.000 ) ) )
 = -245.02 psi
```

Free Un-Restrained Thermal Expansion between the Saddles [Exp]:
```
 = Alpha * Ls * ( Design Temperature - Ambient Temperature )
 = 0.589E-05 * 93.000 * ( 200.0 - 70.0 )
 = 0.071 in.
```

**Input Data for Base Plate Bolting Calculations:**

| | | | |
|---|---|---|---|
| Total Number of Bolts per BasePlate | Nbolts | 8 | |
| Total Number of Bolts in Tension/Baseplate | Nbt | 4 | |
| Bolt Material Specification | | SA-193 B7 | |
| Bolt Allowable Stress | Stba | 25000.00 | psi |
| Bolt Corrosion Allowance | Bca | 0.0000 | in. |
| Distance from Bolts to Edge | Edgedis | 2.0000 | in. |
| Nominal Bolt Diameter | Bnd | 1.3750 | in. |
| Thread Series | Series | TEMA | |

| | | | |
|---|---|---|---|
| BasePlate Allowable Stress | S | 13800.00 | psi |
| Area Available in a Single Bolt | BltArea | 1.1550 | sq.in. |
| Saddle Load QO (Weight) | QO | 2500.7 | lb. |
| Saddle Load QL (Wind/Seismic contribution) | QL | 337.2 | lb. |
| Maximum Transverse Force | Ft | 348.5 | lb. |
| Maximum Longitudinal Force | Fl | 697.0 | lb. |

**Bolt Area Calculation per Dennis R. Moss**

Bolt Area Requirement Due to Longitudinal Load [Bltarearl]:
= 0.0 (QO > QL --> No Uplift in Longitudinal direction)

Bolt Area due to Shear Load [Bltarears]:
= Fl / (Stba * Nbolts)
= 696.97 / (25000.00 * 8.00 )
= 0.0035 sq.in.

Bolt Area due to Transverse Load

Moment on Baseplate Due to Transverse Load [Rmom]:
= B * Ft + Sum of X Moments
= 3.75 * 348.49 + 0.00
= 1306.82 ft.lb.

Eccentricity (e):
= Rmom / QO
= 15681.83 / 2500.72
= 6.27 in. < Bplen/6 --> No Uplift in Transverse direction

Bolt Area due to Transverse Load [Bltareart]:
= 0 (No Uplift)

Required of a Single Bolt [Bltarear]
= max[Bltarearl, Bltarears, Bltareart]
= max[0.0000 , 0.0035 , 0.0000 ]
= 0.0035 sq.in.

**Zick Analysis: Stresses for the Right Saddle**

| | | | |
|---|---|---|---|
| Shell Allowable Stress used in Calculation | | 20000.00 | psi |
| Shell Comp. Yield Stress used in Calculation | | 34800.00 | psi |
| Head Allowable Stress used in Calculation | | 20000.00 | psi |
| Saddle Force Q, Operating Case | | 3184.92 | lb. |

| Stress Results for Zick Stresses: | Actual | Allowable | |
|---|---|---|---|
| Long. Stress at Top of Saddles | 4530.63 | 17000.00 | psi |
| Long. Stress at Bottom of Saddles | 4446.87 | 17000.00 | psi |
| Long. Stress at Top of Midspan | 4461.80 | 17000.00 | psi |
| Long. Stress at Bottom of Midspan | 4515.70 | 17000.00 | psi |
| Tangential Shear in Shell | 133.56 | 16000.00 | psi |
| Circ. Stress at Horn of Saddle | -787.22 | -30000.00 | psi |
| Circ. Stress at Tip of Wear Plate | -684.28 | -30000.00 | psi |
| Circ. Compressive Stress in Shell | -230.61 | -17400.00 | psi |

Note: The Longitudinal Stress from the Zick Analysis is combined with the Longitudinal Pressure Stress to get the total stress.

**Intermediate Results: Saddle Reaction Q due to Wind or Seismic**

Saddle Reaction Force due to Wind Ft [Fwt]:
= Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E

```
 = 3.00 * ( 331.1 /2 + 0 ) * 45.0000 / 53.2606
 = 419.6 lb.
```

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:

```
 = Max( Fl, Friction Load, Sum of X Forces) * B / Ls
 = Max( 248.39 , 0.00 , 0 ) * 45.0000 / 93.0000
 = 120.2 lb.
```

Saddle Reaction Force due to Earthquake Fl or Friction [Fsl]:

```
 = Max( Fl, Friction Force, Sum of X Forces ) * B / Ls
 = Max( 696.97 , 0.00 , 0 ) * 45.0000 / 93.0000
 = 337.2 lb.
```

Saddle Reaction Force due to Earthquake Ft [Fst]:

```
 = Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E
 = 3.00 * ( 696 /2 + 0 ) * 45.0000 / 53.2606
 = 883.3 lb.
```

Load Combination Results for Q + Wind or Seismic [Q]:

```
 = Saddle Load + Max( Fwl, Fwt, Fsl, Fst )
 = 2301 + Max( 120 , 419 , 337 , 883 )
 = 3184.9 lb.
```

**Summary of Loads on this Saddle Support:**

| | | |
|---|---|---|
| Vertical Load on this Saddle | 3184.92 | lb. |
| Transverse Shear Load on this Saddle | 348.49 | lb. |
| Longitudinal Shear Load on this Saddle | 696.97 | lb. |

**Formulas and Substitutions for Zick Analysis Results:**

Longitudinal Bending (+-) at Midspan

```
 = ( 3 * Q * L * K.2 / ( pi * R^2 * ( Ts - Ca )))
 = ( 3 * 3184 * 10.33 * 0.3892 ) /
   ( 3.141 * 30.1250 * 30.1250 * ( 0.6250 - 0.1250 )))
 = 26.95 psi
```

Compute the area ratio [K]:

```
 = Pi * (Sin(Delta)/Delta - Cos(Delta) ) / (Delta + Sin(Delta) * Cos(Delta) -
   (Delta + Sin(Delta) * Cos(Delta) - 2 * Sin(Delta) * Sin(Delta)/Delta)
 = Pi * (Sin(1.396 ) / 1.396 - Cos(1.396 )) / ( 1.396 + Sin(1.396 ) *
   Cos(1.396 ) - 2 * Sin(1.396 ) * Sin(1.396 )/ 1.396 )
 = 9.3799
```

Compute the moment fraction [X]:

```
 = 1 - (1 - A/L + ( R^2 - H^2 )/(2 * A*L ) )/(1 + (4*H )/( 3 * L ) )
 = 1 - (1 - 1.417 /10.333 + (30.125^2 - 1.250^2)/( 2 * 1.417 * 10.333 ) )
   (1 + (4 * 1.250 )/(3 * 10.333 ) )
 = 0.1175
```

Intermediate Product [K.1]:

```
 = K * X  * 4 * A / L
 = 9.380 * 0.118 * 4 * 1.417 / 10.333 = 0.6046
```

Longitudinal Bending (+-) at Saddle

```
 = ( 3 * Q * L * K.1 / ( pi * R^2 * ( Ts - Ca )))
 = ( 3 * 3184 * 10.33 * 0.6046 ) /
   ( 3.141 * 30.1250 * 30.1250 * ( 0.6250 - 0.1250 )))
 = 41.88 psi
```

Tangential Shear in Shell near Saddle

```
 = Q * K.4 * (( L-H-2A )/( L+H ))/( R*(Ts-Ca))
 = 3184 * 1.1707 * (( 10.33 - 1.25 - 2 * 1.42 )/
   ( 10.33 + 1.25 ))/( 30.1250 * ( 0.6250 - 0.1250 ))
 = 133.56 psi
```

Circumferential Stress at Tip of the Wear Plate
= -Q/(4*(TS-CA)*(SADWTH+1.56*Sqrt(R*(TS-CA))))-12*Q*R*K13/(L*(TS-CA)$^2$)
= -3184 /( 4 * 0.5000 * (8.00 + 1.56 * Sqrt(30.1250 *0.5000 )))
-12.0 * 3184 * 2.51 * 0.0154 / ( 10.3333 * 0.5000$^2$ )
= -684.28 psi

Note: Wear Plate thk. could Not be considered in this formula because:

Saddle-Tangent Distance A (1.42 ) is > R/2 (1.26 ft.)

Circumferential Stress at Horn of Saddle
= -Q/(4*TEM*(SADWTH+1.56*sqrt(R*TCA)))-12*Q*R*K.7/(L*TEB)
= -3184 /( 4 * 0.5000 * (8.00 + 1.56 * sqrt(30.1250 *0.5000 )))
-12.0 * 3184 * 2.51 * 0.0181 / ( 10.3333 * 0.2500 )
= -787.22 psi

Circumferential Compression at Bottom of Shell
= (Q*( K.9/( TEM9 * WPDWTH ) ) )
= ( 3184 *( 0.7603 /( 0.8750 * 12.000 ) ) )
= -230.61 psi

**Zick Analysis: Stresses for the Left Saddle**

Horizontal Vessel Stress Calculations : Test Case

| | | |
|---|---|---|
| Shell Allowable Stress used in Calculation | 20000.00 | psi |
| Shell Comp. Yield Stress used in Calculation | 38000.00 | psi |
| Head Allowable Stress used in Calculation | 20000.00 | psi |
| Saddle Force Q, Test Case, no Ext. Forces | 10816.61 | lb. |

| Stress Results for Zick Stresses: | Actual | Allowable | |
|---|---|---|---|
| Long. Stress at Top of Saddles | 116.22 | 17000.00 | psi |
| Long. Stress at Bottom of Saddles | -116.22 | 15113.64 | psi |
| Long. Stress at Top of Midspan | -73.69 | -15113.64 | psi |
| Long. Stress at Bottom of Midspan | 73.69 | 17000.00 | psi |
| Tangential Shear in Shell | 364.40 | 16000.00 | psi |
| Circ. Stress at Horn of Saddle | -1767.08 | -30000.00 | psi |
| Circ. Stress at Tip of Wear Plate | -1496.97 | -30000.00 | psi |
| Circ. Compressive Stress in Shell | -685.28 | -19000.00 | psi |

| | | |
|---|---|---|
| Hydrostatic Test Pressure at top of Vessel | 0.000 | psig |

Note: The Longitudinal Stress from the Zick Analysis is combined with the Longitudinal Pressure Stress to get the total stress.

**Intermediate Results: Saddle Reaction Q due to Wind or Seismic**

Saddle Reaction Force due to Wind Ft [Fwt]:
```
 = Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E
 = 3.00 * ( 109.3 /2 + 0 ) * 45.0000 / 53.0441
 = 139.0 lb.
```

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:
```
 = Max( Fl, Friction Load, Sum of X Forces) * B / Ls
 = Max( 81.97 , 0.00 , 0 ) * 45.0000 / 93.0000
 = 39.7 lb.
```

Load Combination Results for Q + Wind or Seismic [Q]:
```
 = Saddle Load + Max( Fwl, Fwt, Fsl, Fst )
 = 10677 + Max( 39 , 139 , 0 , 0 )
 = 10816.6 lb.
```

**Summary of Loads on this Saddle Support:**

| | | |
|---|---|---|
| Vertical Load on this Saddle | 10816.61 | lb. |
| Transverse Shear Load on this Saddle | 54.63 | lb. |
| Longitudinal Shear Load on this Saddle | 81.97 | lb. |

**Formulas and Substitutions for Zick Analysis Results:**

Longitudinal Bending (+-) at Midspan
```
 = ( 3 * Q * L * K.2 / ( pi * R^2 * ( Ts - Ca )))
 = ( 3 * 10816 * 10.33 * 0.3883 ) /
   ( 3.141 * 30.0000 * 30.0000 * ( 0.6250 - 0.0000 )))
 = 73.69 psi
```

Compute the area ratio [K]:
```
 = Pi * (Sin(Delta)/Delta - Cos(Delta) ) / (Delta + Sin(Delta) * Cos(Delta) -
   (Delta + Sin(Delta) * Cos(Delta) - 2 * Sin(Delta) * Sin(Delta)/Delta)
 = Pi * (Sin(1.396 ) / 1.396 - Cos(1.396 )) / ( 1.396 + Sin(1.396 ) *
   Cos(1.396 ) - 2 * Sin(1.396 ) * Sin(1.396 )/ 1.396 )
 = 9.3799
```

Compute the moment fraction [X]:

```
 = 1 - (1 - A/L + ( R^2 - H^2 )/(2 * A*L ) )/(1 + (4*H )/( 3 * L ) )
 = 1 - (1 - 1.417 /10.333 + (30.000^2 - 1.250^2)/( 2 * 1.417 * 10.333 ) )
   (1 + (4 * 1.250 )/(3 * 10.333 ) )
 = 0.1191
```

Intermediate Product [K.1]:

```
 = K * X  * 4 * A / L
 = 9.380 * 0.119 * 4 * 1.417 / 10.333 = 0.6125
```

Longitudinal Bending (+-) at Saddle

```
 = ( 3 * Q * L * K.1 / ( pi * R^2 * ( Ts - Ca )))
 = ( 3 * 10816 * 10.33 * 0.6125 ) /
   ( 3.141 * 30.0000 * 30.0000 * ( 0.6250 - 0.0000 )))
 = 116.22 psi
```

Tangential Shear in Shell near Saddle

```
 = Q * K.4 * (( L-H-2A )/( L+H ))/( R*(Ts-Ca))
 = 10816 * 1.1707 * (( 10.33 - 1.25 - 2 * 1.42 )/
   ( 10.33 + 1.25 ))/( 30.0000 * ( 0.6250 - 0.0000 ))
 = 364.40 psi
```

Circumferential Stress at Tip of the Wear Plate

```
 = -Q/(4*(TS-CA)*(SADWTH+1.56*Sqrt(R*(TS-CA))))-12*Q*R*K13/(L*(TS-CA)^2)
 = -10816 /( 4 * 0.6250 * (8.00 + 1.56 * Sqrt(30.0000 *0.6250 )))
   -12.0 * 10816 * 2.50 * 0.0150 / ( 10.3333 * 0.6250^2 )
 = -1496.97 psi
```

Note: Wear Plate thk. could Not be considered in this formula because:

Saddle-Tangent Distance A (1.42 ) is > R/2 (1.25 ft.)

Circumferential Stress at Horn of Saddle

```
 = -Q/(4*TEM*(SADWTH+1.56*sqrt(R*TCA)))-12*Q*R*K.7/(L*TEB)
 = -10816 /( 4 * 0.6250 * (8.00 + 1.56 * sqrt(30.0000 *0.6250 )))
   -12.0 * 10816 * 2.50 * 0.0183 / ( 10.3333 * 0.3906 )
 = -1767.08 psi
```

Circumferential Compression at Bottom of Shell

```
 = (Q*( K.9/( TEM9 * WPDWTH ) ) )
 = ( 10816 *( 0.7603 /( 1.0000 * 12.000 ) ) )
 = -685.28 psi
```

**Input Data for Base Plate Bolting Calculations:**

| | | | |
|---|---|---|---|
| Total Number of Bolts per BasePlate | Nbolts | 8 | |
| Total Number of Bolts in Tension/Baseplate | Nbt | 4 | |
| Bolt Material Specification | | SA-193 B7 | |
| Bolt Allowable Stress | Stba | 25000.00 | psi |
| Bolt Corrosion Allowance | Bca | 0.0000 | in. |
| Distance from Bolts to Edge | Edgedis | 2.0000 | in. |
| Nominal Bolt Diameter | Bnd | 1.3750 | in. |
| Thread Series | Series | TEMA | |
| BasePlate Allowable Stress | S | 13800.00 | psi |
| Area Available in a Single Bolt | BltArea | 1.1550 | sq.in. |
| Saddle Load QO (Weight) | QO | 10677.6 | lb. |
| Saddle Load QL (Wind/Seismic contribution) | QL | 39.7 | lb. |
| Maximum Transverse Force | Ft | 54.6 | lb. |
| Maximum Longitudinal Force | Fl | 82.0 | lb. |

**Bolt Area Calculation per Dennis R. Moss**

Bolt Area Requirement Due to Longitudinal Load [Bltarearl]:

```
 = 0.0 (QO > QL --> No Uplift in Longitudinal direction)
```

Bolt Area due to Shear Load [Bltarears]:

```
 = Fl / (Stba * Nbolts)
 = 81.97 / (25000.00 * 8.00 )
 = 0.0004 sq.in.
```

Bolt Area due to Transverse Load

Moment on Baseplate Due to Transverse Load [Rmom]:
```
 = B * Ft + Sum of X Moments
 = 3.75 * 54.63 + 0.00
 = 204.87 ft.lb.
```

Eccentricity (e):
```
 = Rmom / QO
 = 2458.46 / 10677.57
 = 0.23 in. < Bplen/6 --> No Uplift in Transverse direction
```

Bolt Area due to Transverse Load [Bltareart]:
```
 = 0 (No Uplift)
```

Required of a Single Bolt [Bltarear]
```
 = max[Bltarearl, Bltarears, Bltareart]
 = max[0.0000 , 0.0004 , 0.0000 ]
 = 0.0004 sq.in.
```

**Zick Analysis: Stresses for the Right Saddle**

| | | | |
|---|---|---|---|
| Shell Allowable Stress used in Calculation | | 20000.00 | psi |
| Shell Comp. Yield Stress used in Calculation | | 38000.00 | psi |
| Head Allowable Stress used in Calculation | | 20000.00 | psi |
| Saddle Force Q, Test Case, no Ext. Forces | | 10106.45 | lb. |
| Stress Results for Zick Stresses: | Actual | Allowable | |
| Long. Stress at Top of Saddles | 108.59 | 17000.00 | psi |
| Long. Stress at Bottom of Saddles | -108.59 | 15113.64 | psi |
| Long. Stress at Top of Midspan | -68.85 | -15113.64 | psi |
| Long. Stress at Bottom of Midspan | 68.85 | 17000.00 | psi |
| Tangential Shear in Shell | 340.48 | 16000.00 | psi |
| Circ. Stress at Horn of Saddle | -1651.07 | -30000.00 | psi |
| Circ. Stress at Tip of Wear Plate | -1398.68 | -30000.00 | psi |
| Circ. Compressive Stress in Shell | -640.29 | -19000.00 | psi |
| Hydrostatic Test Pressure at top of Vessel | | 0.000 | psig |

Note: The Longitudinal Stress from the Zick Analysis is combined with the Longitudinal Pressure Stress to get the total stress.

**Intermediate Results: Saddle Reaction Q due to Wind or Seismic**

Saddle Reaction Force due to Wind Ft [Fwt]:
```
 = Ftr * ( Ft/Num of Saddles + Z Force Load ) * B / E
 = 3.00 * ( 109.3 /2 + 0 ) * 45.0000 / 53.0441
 = 139.0 lb.
```

Saddle Reaction Force due to Wind Fl or Friction [Fwl]:
```
 = Max( Fl, Friction Load, Sum of X Forces) * B / Ls
 = Max( 81.97 , 0.00 , 0 ) * 45.0000 / 93.0000
 = 39.7 lb.
```

Load Combination Results for Q + Wind or Seismic [Q]:
```
 = Saddle Load + Max( Fwl, Fwt, Fsl, Fst )
 = 9967 + Max( 39 , 139 , 0 , 0 )
```

= 10106.5 lb.

**Summary of Loads on this Saddle Support:**

| | | |
|---|---|---|
| Vertical Load on this Saddle | 10106.45 | lb. |
| Transverse Shear Load on this Saddle | 54.63 | lb. |
| Longitudinal Shear Load on this Saddle | 81.97 | lb. |

**Formulas and Substitutions for Zick Analysis Results:**

Longitudinal Bending (+-) at Midspan
= ( 3 * Q * L * K.2 / ( pi * $R^2$ * ( Ts - Ca )))
= ( 3 * 10106 * 10.33 * 0.3883 ) /
( 3.141 * 30.0000 * 30.0000 * ( 0.6250 - 0.0000 )))
= 68.85 psi

Compute the area ratio [K]:
= Pi * (Sin(Delta)/Delta - Cos(Delta) ) / (Delta + Sin(Delta) * Cos(Delta) -
(Delta + Sin(Delta) * Cos(Delta) - 2 * Sin(Delta) * Sin(Delta)/Delta)
= Pi * (Sin(1.396 ) / 1.396 - Cos(1.396 )) / ( 1.396 + Sin(1.396 ) *
Cos(1.396 ) - 2 * Sin(1.396 ) * Sin(1.396 )/ 1.396 )
= 9.3799

Compute the moment fraction [X]:
= 1 - (1 - A/L + ( $R^2$ - $H^2$ )/(2 * A*L ) )/(1 + (4*H )/( 3 * L ) )
= 1 - (1 - 1.417 /10.333 + (30.000$^2$ - 1.250$^2$)/( 2 * 1.417 * 10.333 ) )
(1 + (4 * 1.250 )/(3 * 10.333 ) )
= 0.1191

Intermediate Product [K.1]:
= K * X * 4 * A / L
= 9.380 * 0.119 * 4 * 1.417 / 10.333 = 0.6125

Longitudinal Bending (+-) at Saddle
= ( 3 * Q * L * K.1 / ( pi * $R^2$ * ( Ts - Ca )))
= ( 3 * 10106 * 10.33 * 0.6125 ) /
( 3.141 * 30.0000 * 30.0000 * ( 0.6250 - 0.0000 )))
= 108.59 psi

Tangential Shear in Shell near Saddle
= Q * K.4 * (( L-H-2A )/( L+H ))/( R*(Ts-Ca))
= 10106 * 1.1707 * (( 10.33 - 1.25 - 2 * 1.42 )/
( 10.33 + 1.25 ))/( 30.0000 * ( 0.6250 - 0.0000 ))
= 340.48 psi

Circumferential Stress at Tip of the Wear Plate
= -Q/(4*(TS-CA)*(SADWTH+1.56*Sqrt(R*(TS-CA))))-12*Q*R*K13/(L*(TS-CA)$^2$)
= -10106 /( 4 * 0.6250 * (8.00 + 1.56 * Sqrt(30.0000 *0.6250 )))
-12.0 * 10106 * 2.50 * 0.0150 / ( 10.3333 * 0.6250$^2$ )
= -1398.68 psi

Note: Wear Plate thk. could Not be considered in this formula because:

Saddle-Tangent Distance A (1.42 ) is > R/2 (1.25 ft.)

Circumferential Stress at Horn of Saddle
= -Q/(4*TEM*(SADWTH+1.56*sqrt(R*TCA)))-12*Q*R*K.7/(L*TEB)
= -10106 /( 4 * 0.6250 * (8.00 + 1.56 * sqrt(30.0000 *0.6250 )))
-12.0 * 10106 * 2.50 * 0.0183 / ( 10.3333 * 0.3906 )
= -1651.07 psi

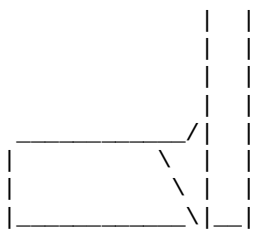
Circumferential Compression at Bottom of Shell
= (Q*( K.9/( TEM9 * WPDWTH ) ) )
= ( 10106 *( 0.7603 /( 1.0000 * 12.000 ) ) )
= -640.29 psi

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

| | | | |
|---|---|---|---|
| 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 | 60.0000 | in. |
| Aspect Ratio of Elliptical Head | Ar | 2.00 | |
| Head Actual Thickness | T | 0.6250 | 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 | 6.0000 | 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 | 2.0000 | in. |
| Weld leg size between Nozzle and Pad/Shell | Wo | 0.3750 | in. |
| Groove weld depth between Nozzle and Vessel | Wgnv | 0.6250 | in. |
| Nozzle Inside Projection | H | 0.0000 | in. |
| Weld leg size, Inside Nozzle to Shell | Wi | 0.0000 | in. |
| ASME Code Weld Type per UW-16 | | None | |
| Class of attached Flange | | 150 | |
| Grade of attached Flange | | GR 1.1 | |

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



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

**NOZZLE CALCULATION, Description: Inspection**

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

```
Actual Nozzle Inside Diameter Used in Calculation      5.761  in.
Actual Nozzle Thickness Used in Calculation            0.432  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*60.2500)/(2 *20000.00*1.00-0.2*100.00)
= 0.1356 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*3.01)/(17100*1.00-0.6*100.00)
= 0.0176 in.

Required Nozzle thickness under External Pressure per UG-28 : 0.0129 in.

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

```
Effective material diameter limit,             Dl    12.0220  in.
Effective material thickness limit, no pad   Tlnp     0.7675  in.
```

**Results of Nozzle Reinforcement Area Calculations:**

```
AREA AVAILABLE, A1 to A5          Design  External     Mapnc
Area Required              Ar      0.827     0.484        NA  sq.in.
Area in Shell              A1      2.158     2.022        NA  sq.in.
Area in Nozzle Wall        A2      0.380     0.386        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      2.658     2.528        NA  sq.in.
```

The Internal 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]:
= (Dlr*Tr+2*Thk*Tr*(1-fr1)) UG-37(c)
= (6.0110*0.1356+2*(0.4320-0.1250)*0.1356*(1-0.8550))
= 0.827 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)
= (12.022-6.011)*(1.00*(0.6250-0.125)-0.136)-2*(0.432-0.125)
*(1.00*(0.6250-0.1250)-0.1356)*(1-0.8550)
= 2.158 sq.in.

Area Available in Nozzle Wall, no Pad [A2np]:
= ( 2 * min(Tlnp,ho) ) * ( Thk - Can - Trn ) * fr2
= ( 2 * min(0.768 ,2.000 ) ) * ( 0.4320 - 0.1250 - 0.0176 ) * 0.8550 )
= 0.380 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 = 0.1426 in.
Wall Thickness per UG16(b),   tr16b = 0.2188 in.
Wall Thickness per UG45(b)(1), trb1 = 0.2757 in.
Wall Thickness per UG45(b)(2), trb2 = 0.1476 in.
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.2757 in.
Std. Wall Pipe per UG45(b)(4), trb4 = 0.3700 in.
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 0.2757 in.

Final Required Thickness,      tr45 = Max(tra, trb) = 0.2757 in.
Available Nozzle Neck Thickness     = .875 * 0.4320 = 0.3780 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              210.688  psig
Nozzle is O.K. for the External Pressure              15.000  psig
```

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

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: Inspection

```
Intermediate Calc. for nozzle/shell Welds   Tmin      0.3070  in.
```

**Results Per UW-16.1:**

```
                     Required Thickness    Actual Thickness
Nozzle Weld         0.2149 = 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
 = (0.8273 - 2.1578 + 2 * ( 0.4320 - 0.1250 ) * 0.8550 *
   (1.00 * ( 0.6250 - 0.1250 ) - 0.1356 ) ) * 20000
 = 0.00 lb.
```

Weld Load [W1]:

```
 = (A2+A5+A4-(Wi-Can/.707)^2*Ffr2)*S
 = ( 0.3798 + 0.0000 + 0.1202 - 0.0000 * 0.86 ) * 20000
 = 10000.01 lb.
```

Weld Load [W2]:

```
 = ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S
 = ( 0.3798 + 0.0000 + 0.1202 + 0.2625 ) * 20000
 = 15249.71 lb.
```

Weld Load [W3]:

```
 = ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S
 = ( 0.3798 + 0.0000 + 0.1202 + 0.0000 + 0.2625 ) * 20000
 = 15249.71 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 * 3.1590 ) * ( 0.4320 - 0.1250 ) * 0.7 * 17100
 = 36470. lb.
```

Tension, Nozzle Groove Weld [Tngw]:
```
 = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
 = ( 3.1416 / 2.0 ) * 6.6250 * ( 0.6250 - 0.1250 ) * 0.74 * 17100
 = 65842. lb.
```

**Strength of Failure Paths:**

```
PATH11 = ( SONW + SNW ) = ( 32698 + 36469 ) = 69168 lb.
PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
       = ( 32698 + 0 + 65842 + 0 ) = 98540 lb.
PATH33 = ( Sonw + Tngw + Sinw )
       = ( 32698 + 65842 + 0 ) = 98540 lb.
```

**Summary of Failure Path Calculations:**
```
Path 1-1 = 69168 lb., must exceed W = 0 lb. or W1 = 10000 lb.
Path 2-2 = 98540 lb., must exceed W = 0 lb. or W2 = 15249 lb.
Path 3-3 = 98540 lb., must exceed W = 0 lb. or W3 = 15249 lb.
```

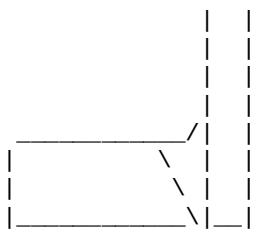
The Drop for this Nozzle is : 0.1008 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 2.7258 in.

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

| | | | |
|---|---|---|---|
| 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 | 60.0000 | in. |
| Aspect Ratio of Elliptical Head | Ar | 2.00 | |
| Head Actual Thickness | T | 0.6250 | in. |
| Head Internal Corrosion Allowance | Cas | 0.1250 | in. |
| Head External Corrosion Allowance | Caext | 0.0000 | in. |
| Distance from Head Centerline | L1 | 15.0000 | 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 | 6.0000 | 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 | 2.0000 | in. |
| Weld leg size between Nozzle and Pad/Shell | Wo | 0.3750 | in. |
| Groove weld depth between Nozzle and Vessel | Wgnv | 0.6250 | in. |
| Nozzle Inside Projection | H | 0.0000 | in. |
| Weld leg size, Inside Nozzle to Shell | Wi | 0.0000 | in. |
| ASME Code Weld Type per UW-16 | | None | |
| Class of attached Flange | | 150 | |
| Grade of attached Flange | | GR 1.1 | |

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



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

**NOZZLE CALCULATION, Description: Outlet**

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

```
Actual Nozzle Inside Diameter Used in Calculation      5.761  in.
Actual Nozzle Thickness Used in Calculation            0.432  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*60.2500)/(2 *20000.00*1.00-0.2*100.00)
 = 0.1356 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*3.01)/(17100*1.00-0.6*100.00)
 = 0.0176 in.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.0129 in.

**UG-40, Thickness and Diameter Limit Results : [Int. Press]**
```
Effective material diameter limit,             Dl    12.0220  in.
Effective material thickness limit, no pad   Tlnp     0.7675  in.
```

**Results of Nozzle Reinforcement Area Calculations:**
```
AREA AVAILABLE, A1 to A5          Design  External     Mapnc
Area Required              Ar      0.827     0.484        NA  sq.in.
Area in Shell              A1      2.158     2.022        NA  sq.in.
Area in Nozzle Wall        A2      0.380     0.386        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      2.658     2.528        NA  sq.in.
```

The Internal 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]:
```
 = (Dlr*Tr+2*Thk*Tr*(1-fr1)) UG-37(c)
 = (6.0110*0.1356+2*(0.4320-0.1250)*0.1356*(1-0.8550))
 = 0.827 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)
 = (12.022-6.011)*(1.00*(0.6250-0.125)-0.136)-2*(0.432-0.125)
   *(1.00*(0.6250-0.1250)-0.1356)*(1-0.8550)
 = 2.158 sq.in.
```

Area Available in Nozzle Wall, no Pad [A2np]:
```
 = ( 2 * min(Tlnp,ho) ) * ( Thk - Can - Trn ) * fr2
 = ( 2 * min(0.768 ,2.000 ) ) * ( 0.4320 - 0.1250 - 0.0176 ) * 0.8550 )
 = 0.380 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 = 0.1426 in.
Wall Thickness per UG16(b),   tr16b = 0.2188 in.
Wall Thickness per UG45(b)(1), trb1 = 0.2757 in.
Wall Thickness per UG45(b)(2), trb2 = 0.1476 in.
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.2757 in.
Std. Wall Pipe per UG45(b)(4), trb4 = 0.3700 in.
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 0.2757 in.

Final Required Thickness,      tr45 = Max(tra, trb) = 0.2757 in.
Available Nozzle Neck Thickness     = .875 * 0.4320 = 0.3780 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              210.688  psig
Nozzle is O.K. for the External Pressure              15.000  psig
```

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

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      0.3070  in.
```

**Results Per UW-16.1:**

| | Required Thickness | Actual Thickness |
|---|---|---|
| Nozzle Weld | 0.2149 = 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
 = (0.8273 - 2.1578 + 2 * ( 0.4320 - 0.1250 ) * 0.8550 *
   (1.00 * ( 0.6250 - 0.1250 ) - 0.1356 ) ) * 20000
 = 0.00 lb.
```

Weld Load [W1]:

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

```
 = ( 0.3798 + 0.0000 + 0.1202 - 0.0000 * 0.86 ) * 20000
 = 10000.01 lb.
```

Weld Load [W2]:

```
 = ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S
 = ( 0.3798 + 0.0000 + 0.1202 + 0.2625 ) * 20000
 = 15249.71 lb.
```

Weld Load [W3]:

```
 = ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S
 = ( 0.3798 + 0.0000 + 0.1202 + 0.0000 + 0.2625 ) * 20000
 = 15249.71 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 * 3.1590 ) * ( 0.4320 - 0.1250 ) * 0.7 * 17100
 = 36470. lb.
```

Tension, Nozzle Groove Weld [Tngw]:
```
 = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
 = ( 3.1416 / 2.0 ) * 6.6250 * ( 0.6250 - 0.1250 ) * 0.74 * 17100
 = 65842. lb.
```

**Strength of Failure Paths:**

```
 PATH11 = ( SONW + SNW ) = ( 32698 + 36469 ) = 69168 lb.
 PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
        = ( 32698 + 0 + 65842 + 0 ) = 98540 lb.
 PATH33 = ( Sonw + Tngw + Sinw )
        = ( 32698 + 65842 + 0 ) = 98540 lb.
```

**Summary of Failure Path Calculations:**
```
Path 1-1 = 69168 lb., must exceed W = 0 lb. or W1 = 10000 lb.
Path 2-2 = 98540 lb., must exceed W = 0 lb. or W2 = 15249 lb.
Path 3-3 = 98540 lb., must exceed W = 0 lb. or W3 = 15249 lb.
```

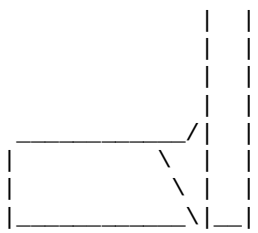
The Drop for this Nozzle is : 0.1008 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 2.7258 in.

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

| | | | |
|---|---|---|---|
| Pressure for Nozzle Reinforcement Calculations | P | 150.000 | 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 | 60.0000 | in. |
| Design Length of Section | L | 134.0000 | in. |
| Shell Actual Thickness | T | 0.6250 | in. |
| Shell Internal Corrosion Allowance | Cas | 0.1250 | in. |
| Shell External Corrosion Allowance | Caext | 0.0000 | in. |
| Distance from Bottom/Left Tangent | | 5.1667 | ft. |
| User Entered Minimum Design Metal Temperature | | -20.00 | F |
| Nozzle Material | | SA-516 70 | |
| Nozzle Allowable Stress at Temperature | Sn | 20000.00 | psi |
| Nozzle Allowable Stress At Ambient | Sna | 20000.00 | psi |
| Nozzle Diameter Basis (for tr calc only) | Inbase | ID | |
| Layout Angle | | 0.00 | deg |
| Nozzle Diameter | Dia | 16.0000 | in. |
| Nozzle Size and Thickness Basis | Idbn | Actual | |
| Actual Thickness of Nozzle | Thk | 0.7500 | in. |
| 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 | 4.0000 | in. |
| Weld leg size between Nozzle and Pad/Shell | Wo | 0.3750 | in. |
| Groove weld depth between Nozzle and Vessel | Wgnv | 0.6250 | in. |
| Nozzle Inside Projection | H | 0.0000 | in. |
| Weld leg size, Inside Nozzle to Shell | Wi | 0.0000 | in. |
| ASME Code Weld Type per UW-16 | | None | |
| Class of attached Flange | | 150 | |
| Grade of attached Flange | | GR 1.1 | |

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



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

**NOZZLE CALCULATION, Description: Manhole**

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

```
Actual Nozzle Inside Diameter Used in Calculation     16.000  in.
Actual Nozzle Thickness Used in Calculation            0.750  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)
 = (150.00*30.1250)/(20000*1.00-0.6*150.00)
 = 0.2270 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)
 = (150.00*8.12)/(20000*1.00-0.6*150.00)
 = 0.0612 in.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.0303 in.

**UG-40, Thickness and Diameter Limit Results : [Int. Press]**
```
Effective material diameter limit,             Dl    32.5000  in.
Effective material thickness limit, no pad   Tlnp     1.2500  in.
```

**Results of Nozzle Reinforcement Area Calculations:**

| AREA AVAILABLE, A1 to A5 | | Design | External | Mapnc | |
|---|---|---|---|---|---|
| Area Required | Ar | 3.688 | 2.192 | NA | sq.in. |
| Area in Shell | A1 | 4.437 | 3.741 | NA | sq.in. |
| Area in Nozzle Wall | A2 | 1.409 | 1.487 | NA | sq.in. |
| Area in Inward Nozzle | A3 | 0.000 | 0.000 | NA | sq.in. |
| Area in Welds | A4 | 0.141 | 0.141 | NA | sq.in. |
| Area in Pad | A5 | 0.000 | 0.000 | NA | sq.in. |
| TOTAL AREA AVAILABLE | Atot | 5.987 | 5.368 | NA | sq.in. |

The Internal 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]:
```
 = (Dlr*Tr+2*Thk*Tr*(1-fr1)) UG-37(c)
 = (16.2500*0.2270+2*(0.7500-0.1250)*0.2270*(1-1.0000))
 = 3.688 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)
 = (32.500-16.250)*(1.00*(0.6250-0.125)-0.227)-2*(0.750-0.125)
   *(1.00*(0.6250-0.1250)-0.2270)*(1-1.0000)
 = 4.437 sq.in.
```

Area Available in Nozzle Wall, no Pad [A2np]:
```
 = ( 2 * min(Tlnp,ho) ) * ( Thk - Can - Trn ) * fr2
 = ( 2 * min(1.250 ,4.000 ) ) * ( 0.7500 - 0.1250 - 0.0612 ) * 1.0000 )
 = 1.409 sq.in.
```

Area Available in Welds, no Pad [A4np]:
```
 = Wo^2 * fr2 + ( Wi-Can/0.707 )^2 * fr2
 = 0.3750^2 * 1.0000 + ( 0.0000 )^2 * 1.0000
 = 0.141 sq.in.
```

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

```
Wall Thickness per UG45(a),     tra = 0.1862 in.
Wall Thickness per UG16(b),   tr16b = 0.2188 in.
Wall Thickness per UG45(b)(1), trb1 = 0.3520 in.
Wall Thickness per UG45(b)(2), trb2 = 0.1476 in.
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.3520 in.
Std. Wall Pipe per UG45(b)(4), trb4 = 0.4531 in.
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 0.3520 in.

Final Required Thickness,      tr45 = Max(tra, trb) = 0.3520 in.
Available Nozzle Neck Thickness     = 0.7500 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              195.800  psig
Nozzle is O.K. for the External Pressure              15.000  psig
```

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

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

```
Minimum Temp. w/o impact per UCS-66              16  F
Minimum Temp. at required thickness            -124  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               6  F
Minimum Temp. at required thickness            -134  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 = 150.00 / 285.00 = 0.526
```

Weld Size Calculations, Description: Manhole

```
Intermediate Calc. for nozzle/shell Welds   Tmin      0.5000  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
 = (3.6881 - 4.4369 + 2 * ( 0.7500 - 0.1250 ) * 1.0000 *
   (1.00 * ( 0.6250 - 0.1250 ) - 0.2270 ) ) * 20000
 = 0.00 lb.
```

Weld Load [W1]:

```
 = (A2+A5+A4-(Wi-Can/.707)^2*Ffr2)*S
 = ( 1.4095 + 0.0000 + 0.1406 - 0.0000 * 1.00 ) * 20000
 = 31001.85 lb.
```

Weld Load [W2]:

```
 = ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S
 = ( 1.4095 + 0.0000 + 0.1406 + 0.6250 ) * 20000
 = 43501.85 lb.
```

Weld Load [W3]:

```
 = ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S
 = ( 1.4095 + 0.0000 + 0.1406 + 0.0000 + 0.6250 ) * 20000
 = 43501.85 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 ) * 17.5000 * 0.3750 * 0.49 * 20000
 = 101022. lb.
```

Shear, Nozzle Wall [Snw]:
```
 = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
 = (3.1416 * 8.4375 ) * ( 0.7500 - 0.1250 ) * 0.7 * 20000
 = 231938. lb.
```

Tension, Nozzle Groove Weld [Tngw]:
```
 = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
 = ( 3.1416 / 2.0 ) * 17.5000 * ( 0.6250 - 0.1250 ) * 0.74 * 20000
 = 203418. lb.
```

**Strength of Failure Paths:**

```
 PATH11 = ( SONW + SNW ) = ( 101021 + 231937 ) = 332959 lb.
 PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
        = ( 101021 + 0 + 203418 + 0 ) = 304439 lb.
 PATH33 = ( Sonw + Tngw + Sinw )
        = ( 101021 + 203418 + 0 ) = 304439 lb.
```

**Summary of Failure Path Calculations:**
```
Path 1-1 = 332959 lb., must exceed W = 0 lb. or W1 = 31001 lb.
Path 2-2 = 304439 lb., must exceed W = 0 lb. or W2 = 43501 lb.
Path 3-3 = 304439 lb., must exceed W = 0 lb. or W3 = 43501 lb.
```

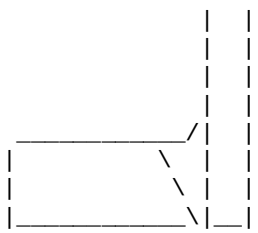
The Drop for this Nozzle is : 1.3044 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 5.9294 in.

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

| | | | |
|---|---|---|---|
| Pressure for Nozzle Reinforcement Calculations | P | 150.000 | 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 | 60.0000 | in. |
| Design Length of Section | L | 134.0000 | in. |
| Shell Actual Thickness | T | 0.6250 | in. |
| Shell Internal Corrosion Allowance | Cas | 0.1250 | in. |
| Shell External Corrosion Allowance | Caext | 0.0000 | in. |
| Distance from Bottom/Left Tangent | | 5.1667 | 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 | | 180.00 | deg |
| Nozzle Diameter | Dia | 2.0000 | in. |
| Nozzle Size and Thickness Basis | Idbn | Nominal | |
| Nominal Thickness of Nozzle | Thknom | 160 | |
| 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 | 2.0000 | in. |
| Weld leg size between Nozzle and Pad/Shell | Wo | 0.3750 | in. |
| Groove weld depth between Nozzle and Vessel | Wgnv | 0.6250 | in. |
| Nozzle Inside Projection | H | 0.0000 | in. |
| Weld leg size, Inside Nozzle to Shell | Wi | 0.0000 | in. |
| ASME Code Weld Type per UW-16 | | None | |
| Class of attached Flange | | 150 | |
| Grade of attached Flange | | GR 1.1 | |

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



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

**NOZZLE CALCULATION, Description: Drain**

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

```
Actual Nozzle Inside Diameter Used in Calculation      1.687  in.
Actual Nozzle Thickness Used in Calculation            0.344  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)
 = (150.00*30.1250)/(20000*1.00-0.6*150.00)
 = 0.2270 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)
 = (150.00*0.97)/(17100*1.00-0.6*150.00)
 = 0.0085 in.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.0071 in.

**UG-40, Thickness and Diameter Limit Results : [Int. Press]**
```
Effective material diameter limit,             Dl     3.8740  in.
Effective material thickness limit, no pad   Tlnp     0.5475  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 = 0.1335 in.
Wall Thickness per UG16(b),   tr16b = 0.2188 in.
Wall Thickness per UG45(b)(1), trb1 = 0.3520 in.
Wall Thickness per UG45(b)(2), trb2 = 0.1476 in.
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.3520 in.
Std. Wall Pipe per UG45(b)(4), trb4 = 0.2598 in.
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 0.2598 in.

Final Required Thickness,      tr45 = Max(tra, trb) = 0.2598 in.
Available Nozzle Neck Thickness     = .875 * 0.3440 = 0.3010 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 = 150.00 / 285.00 = 0.526
```

Weld Size Calculations, Description: Drain

```
Intermediate Calc. for nozzle/shell Welds   Tmin      0.2190  in.
```

**Results Per UW-16.1:**

| | Required Thickness | Actual Thickness |
|---|---|---|
| Nozzle Weld | 0.1533 = 0.7 * TMIN | 0.2651 = 0.7 * Wo in. |

NOTE : Skipping the nozzle attachment weld strength calculations.
Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a)
(small nozzles) do not require a weld strength check.

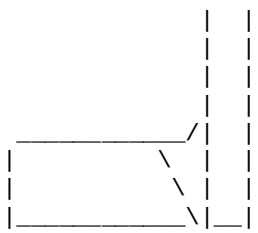
The Drop for this Nozzle is : 0.0235 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 2.6485 in.

**INPUT VALUES, Nozzle Description: Inlet From : 30**

| | | | |
|---|---|---|---|
| Pressure for Nozzle Reinforcement Calculations | P | 150.000 | 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 | 60.0000 | in. |
| Aspect Ratio of Elliptical Head | Ar | 2.00 | |
| Head Actual Thickness | T | 0.6250 | 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 | 4.0000 | in. |
| Nozzle Size and Thickness Basis | Idbn | Nominal | |
| Nominal Thickness of Nozzle | Thknom | 120 | |
| 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 | 2.0000 | in. |
| Weld leg size between Nozzle and Pad/Shell | Wo | 0.3750 | in. |
| Groove weld depth between Nozzle and Vessel | Wgnv | 0.6250 | in. |
| Nozzle Inside Projection | H | 0.0000 | in. |
| Weld leg size, Inside Nozzle to Shell | Wi | 0.0000 | in. |
| ASME Code Weld Type per UW-16 | | None | |
| Class of attached Flange | | 150 | |
| Grade of attached Flange | | GR 1.1 | |

The Pressure Design option was Design Pressure + static head

Nozzle Sketch



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

**NOZZLE CALCULATION, Description: Inlet**

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

```
Actual Nozzle Inside Diameter Used in Calculation      3.624  in.
Actual Nozzle Thickness Used in Calculation            0.438  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)
 = (150.00*0.90*60.2500)/(2 *20000.00*1.00-0.2*150.00)
 = 0.2035 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)
 = (150.00*1.94)/(17100*1.00-0.6*150.00)
 = 0.0171 in.

Required Nozzle thickness under External Pressure per UG-28 : 0.0103 in.

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

```
Effective material diameter limit,             Dl     7.7480  in.
Effective material thickness limit, no pad   Tlnp     0.7825  in.
```

**Results of Nozzle Reinforcement Area Calculations:**

```
AREA AVAILABLE, A1 to A5          Design  External     Mapnc
Area Required              Ar      0.807     0.314        NA  sq.in.
Area in Shell              A1      1.122     1.292        NA  sq.in.
Area in Nozzle Wall        A2      0.396     0.405        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      1.638     1.817        NA  sq.in.
```

The Internal 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]:
 = (Dlr*Tr+2*Thk*Tr*(1-fr1)) UG-37(c)
 = (3.8740*0.2035+2*(0.4380-0.1250)*0.2035*(1-0.8550))
 = 0.807 sq.in.

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

Area Available in Shell [A1]:
 = (DL-Dlr)*(ES*(T-Cas)-Tr)-2*(Thk-Can)*(ES*(T-Cas)-Tr)*(1-fr1)
 = (7.748-3.874)*(1.00*(0.6250-0.125)-0.203)-2*(0.438-0.125)
   *(1.00*(0.6250-0.1250)-0.2035)*(1-0.8550)
 = 1.122 sq.in.

Area Available in Nozzle Wall, no Pad [A2np]:
 = ( 2 * min(Tlnp,ho) ) * ( Thk - Can - Trn ) * fr2
 = ( 2 * min(0.782 ,2.000 ) ) * ( 0.4380 - 0.1250 - 0.0171 ) * 0.8550 )
 = 0.396 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 = 0.1421 in.
Wall Thickness per UG16(b),   tr16b = 0.2188 in.
Wall Thickness per UG45(b)(1), trb1 = 0.3511 in.
Wall Thickness per UG45(b)(2), trb2 = 0.1476 in.
Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 0.3511 in.
Std. Wall Pipe per UG45(b)(4), trb4 = 0.3324 in.
Wall Thickness per UG45(b),     trb = Min(trb3, trb4) = 0.3324 in.

Final Required Thickness,      tr45 = Max(tra, trb) = 0.3324 in.
Available Nozzle Neck Thickness     = .875 * 0.4380 = 0.3832 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              227.940  psig
Nozzle is O.K. for the External Pressure              15.000  psig
```

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

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 = 150.00 / 285.00 = 0.526
```

Weld Size Calculations, Description: Inlet

```
Intermediate Calc. for nozzle/shell Welds   Tmin      0.3130  in.
```

**Results Per UW-16.1:**

| | Required Thickness | Actual Thickness |
|---|---|---|
| Nozzle Weld | 0.2191 = 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
 = (0.8068 - 1.1217 + 2 * ( 0.4380 - 0.1250 ) * 0.8550 *
   (1.00 * ( 0.6250 - 0.1250 ) - 0.2035 ) ) * 20000
 = 0.00 lb.
```

Weld Load [W1]:

```
 = (A2+A5+A4-(Wi-Can/.707)^2*Ffr2)*S
 = ( 0.3960 + 0.0000 + 0.1202 - 0.0000 * 0.86 ) * 20000
 = 10323.92 lb.
```

Weld Load [W2]:

```
 = ((A2+A6)+A3+A4+(2*(Thk-Can)*(T-Ca)*Fr1))*S
 = ( 0.3960 + 0.0000 + 0.1202 + 0.2676 ) * 20000
 = 15676.22 lb.
```

Weld Load [W3]:

```
 = ((A2+A6)+A3+A4+A5+(2*(Thk-Can)*(T-Ca)*Fr1))*S
 = ( 0.3960 + 0.0000 + 0.1202 + 0.0000 + 0.2676 ) * 20000
 = 15676.22 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 ) * 4.5000 * 0.3750 * 0.49 * 17100
 = 22210. lb.
```

Shear, Nozzle Wall [Snw]:
```
 = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
 = (3.1416 * 2.0935 ) * ( 0.4380 - 0.1250 ) * 0.7 * 17100
 = 24641. lb.
```

Tension, Nozzle Groove Weld [Tngw]:
```
 = (PI/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
 = ( 3.1416 / 2.0 ) * 4.5000 * ( 0.6250 - 0.1250 ) * 0.74 * 17100
 = 44723. lb.
```

**Strength of Failure Paths:**

```
 PATH11 = ( SONW + SNW ) = ( 22210 + 24641 ) = 46851 lb.
 PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
        = ( 22210 + 0 + 44722 + 0 ) = 66933 lb.
 PATH33 = ( Sonw + Tngw + Sinw )
        = ( 22210 + 44722 + 0 ) = 66933 lb.
```

**Summary of Failure Path Calculations:**
```
Path 1-1 = 46851 lb., must exceed W = 0 lb. or W1 = 10323 lb.
Path 2-2 = 66933 lb., must exceed W = 0 lb. or W2 = 15676 lb.
Path 3-3 = 66933 lb., must exceed W = 0 lb. or W3 = 15676 lb.
```

The Drop for this Nozzle is : 0.0465 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 2.6715 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. |
|---|---|---|---|---|---|---|---|---|
| Drain | 2.000 | 160 | WNF | 2.375 | 0.344 | - | - | 2.65 |
| Inlet | 4.000 | 120 | WNF | 4.500 | 0.438 | - | - | 2.67 |
| Inspection | 6.000 | 80 | WNF | 6.625 | 0.432 | - | - | 2.73 |
| Outlet | 6.000 | 80 | WNF | 6.625 | 0.432 | - | - | 2.73 |
| Manhole | 16.000 | 150 | WNF | 17.500 | 0.750 | - | - | 5.93 |

*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. |
|---|---|---|---|---|---|---|
| Drain | SA-106 B | 0.625 | 0.375 | - | - | - |
| Inlet | SA-106 B | 0.625 | 0.375 | - | - | - |
| Inspect | SA-106 B | 0.625 | 0.375 | - | - | - |
| Outlet | SA-106 B | 0.625 | 0.375 | - | - | - |
| Manhole | SA-516 70 | 0.625 | 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 |
|---|---|---|---|---|---|
| Drain | 5.167 | 180.00 | 2.00 | 0.00 | Shell |
| Inlet | | 0.00 | 2.00 | 0.00 | RT Head |
| Inspection | | 0.00 | 2.00 | 0.00 | LF Head |
| Outlet | | 0.00 | 2.00 | 0.00 | LF Head |
| Manhole | 5.167 | 0.00 | 4.00 | 0.00 | Shell |

**Nozzle Calculation Summary**

| Description | Internal psig | Ext | MAPNC psig | UG45 [tr] | Weld Path | Areas |
|---|---|---|---|---|---|---|
| Inspection | 210.69 | OK | ... | OK 0.276 | OK | Passed |
| Outlet | 210.69 | OK | ... | OK 0.276 | OK | Passed |
| Manhole | 195.80 | OK | ... | OK 0.352 | OK | Passed |
| Drain | 2801.97 | ... | ... | OK 0.260 | OK | Passed |
| Inlet | 227.94 | OK | ... | OK 0.332 | OK | Passed |
| Min. - Nozzles | 195.80 Manhole | | | | | |
| Min. Shell&Flgs | 260.00 | | | | | |

Computed Vessel M.A.W.P. 195.80 psig

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

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

Check the Spatial Relationship between the Nozzles

| From Node | Nozzle Description | X Coordinate, | Layout Angle, | Dia. Limit |
|---|---|---|---|---|
| 10 | Inspection | 0.000 | 0.000 | 12.022 |
| 10 | Outlet | 0.000 | 0.000 | 12.022 |
| 20 | Manhole | 62.000 | 0.000 | 32.500 |
| 20 | Drain | 62.000 | 180.000 | 3.874 |
| 30 | Inlet | 0.000 | 0.000 | 7.748 |

**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 !

**Design Code: ASME Code Section VIII Division 1, 2007**

| | | |
|---|---|---|
| Diameter Spec : 60.000 in. ID | | |
| Vessel Design Length, Tangent to Tangent | 10.33 | ft. |
| Specified Datum Line Distance | 0.00 | ft. |
| Shell/Head Matl | SA-516 70 | |
| Nozzle Material | SA-106 B | |
| Nozzle Material | SA-516 70 | |
| Internal Design Temperature | 0 | F |
| External Design Temperature | 0 | F |
| Maximum Allowable Working Pressure | 195.80 | psig |
| External Max. Allowable Working Pressure | 70.48 | psig |
| Hydrostatic Test Pressure | 0.00 | psig |
| Required Minimum Design Metal Temperature | -20 | F |
| Warmest Computed Minimum Design Metal Temperature | -55 | F |
| Wind Design Code | IBC 2006 | |
| Earthquake Design Code | IBC 2006 | |

**Element Pressures and MAWP: psig**

| Element Desc | Internal | External | M.A.W.P | Corr. All. |
|---|---|---|---|---|
| LF Head | 100.000 | 15.000 | 331.400 | 0.1250 |
| Shell | 150.000 | 15.000 | 279.376 | 0.1250 |
| RT Head | 150.000 | 15.000 | 331.400 | 0.1250 |

| Element Type | "To" Elev ft. | Length ft. | Element Thk in. | R e q d T h k Int. | Ext. | Joint Eff Long | Circ |
|---|---|---|---|---|---|---|---|
| Ellipse | 0.17 | 0.167 | 0.625 | 0.276 | 0.284 | 1.00 | 1.00 |
| Cylinder | 10.17 | 10.000 | 0.625 | 0.392 | 0.395 | 0.85 | 0.85 |
| Ellipse | 10.33 | 0.167 | 0.625 | 0.351 | 0.284 | 1.00 | 0.85 |

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

**Saddle Parameters:**

| | | |
|---|---|---|
| Saddle Width | 8.000 | in. |
| Saddle Bearing Angle | 120.000 | deg. |
| Centerline Dimension | 45.000 | in. |
| Wear Pad Width | 12.000 | in. |
| Wear Pad Thickness | 0.375 | in. |
| Wear Pad Bearing Angle | 132.000 | deg. |
| Distance from Saddle to Tangent | 17.000 | in. |

**Summary of Maximum Saddle Loads, Operating Case :**

| | | |
|---|---|---|
| Maximum Vertical Saddle Load | 3384.02 | lb. |
| Maximum Transverse Saddle Shear Load | 348.49 | lb. |
| Maximum Longitudinal Saddle Shear Load | 696.97 | lb. |

**Summary of Maximum Saddle Loads, Hydrotest Case :**

| | | |
|---|---|---|
| Maximum Vertical Saddle Load | 10816.61 | lb. |
| Maximum Transverse Saddle Shear Load | 54.63 | lb. |
| Maximum Longitudinal Saddle Shear Load | 81.97 | lb. |

**Weights:**

| | | |
|---|---|---|
| Fabricated - Bare W/O Removable Internals | 6118.4 | lbm |
| Shop Test - Fabricated + Water ( Full ) | 20821.0 | lbm |
| Shipping - Fab. + Rem. Intls.+ Shipping App. | 6118.4 | lbm |
| Erected - Fab. + Rem. Intls.+ Insul. (etc) | 6118.4 | lbm |
| Empty - Fab. + Intls. + Details + Wghts. | 6118.4 | lbm |

**PV Elite 2008 Licensee: KEDKEP CONSULTING, INC.**
**FileName : Horizontal Tank ----------**
**Vessel Design Summary Step: 19 4:19p Oct 23,2008**

| | | |
|---|---|---|
| Operating - Empty + Operating Liquid (No CA) | 6118.4 | lbm |
| Field Test - Empty Weight + Water (Full) | 20821.0 | lbm |

Listed below are the known problem areas for the current design. If
one or more of the design flags are turned on, please re-run the analysis.
Some of these issues may be resolved when using updated input values.

*** Warning: An ANSI Flange is limiting the MAWP and this may affect the
pressure used in the Nozzle Reinforcement Calculations.*

**Please review all reports carefully!**