CUSTOMER
Pressure Vessel Engineering
120 Randall Drive, Suite ‘B’
Waterloo, Ontario N2V 1C6

VESSEL LOCATION
Pressure Vessel Engineering
Vessel With Large Opening
Sample Vessel 5

Vessel designed per the ASME Boiler & Pressure Vessel Code,
Section VIII, Division 1, 2007 Edition
with Advanced Pressure Vessel, Version: 10.0.2
Vessel is ASME Code Stamped

Job No: PVE-Sample 5
Vessel Number: Sample Vessel 5

NAMEPLATE INFORMATION
Vessel MAWP: 200.00 PSI at 350 °F
MDDT: -20 °F at 200.00 PSI
Serial Number(s): ________________________________
National Board Number(s): ________________________________
Year Built: 2007
Radiography: NONE
Postweld Heat Treated: NONE
Construction Type: W

Notes
2” FERRULE CRN ASLOA 7213.51246089
8” FERRULE PROOF TESTED TO UG-101(m)

Signatures
P.Eng: ___________________________________________ Date: ___/___/___
Laurence Brundrett

Mechanical Technologist: ______________________________ Date: ___/___/___
Ben Vanderloo
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Pressure Vessel Engineering, Ltd.
Outlet 8” Ferrule Nozzle D

Customer: Pressure Vessel Engineering
Job No: PVE-Sample5
Number: 1
Vessel Number: Sample Vessel 5
Mark Number: N-D
Date Printed: 11/20/2008

Cylindrical Shell Design Information

Design Pressure: 200.00 PSI
Static Head: 1.00 PSI
Shell Material: SA-479 304, High
Shell Length: 1.1020 in.
Corrosion Allowance: 0.0000 in.
Outside Diameter (new): 8.0300 in.
Shell Surface Area: 0.19 Sq. Ft.
Shell Estimated Volume: 0.23 Gal.
Circ. Joint Efficiency: 70 %

Design Temperature: 350 °F
Long. Joint Efficiency: 85 %
Factor B Chart: HA-1
Material Stress (hot): 18600 PSI
Material Stress (cold): 20000 PSI
Compressive Stress: 9170 PSI
Actual Circumferential Stress: 12078 PSI
Actual Longitudinal Stress: 7189 PSI
Specific Gravity: 1.00
Weight of Fluid: 1.94 lb.
Total Flooded Shell Weight: 2.56 lb.
Shell Weight: 0.62 lb.

Minimum Design Metal Temperature Data
Minimum Design Metal Temperature: -20 °F
Material exempt from impact testing per UCS-66(b), stress ratio <= 0.35

Design Thickness Calculations

Longitudinal Stress Calculations per Paragraph UG-27(c)(2)

\[ t = \frac{PR}{2SE + 0.4P} = \frac{201.00 \times 3.9370}{2 \times 18600 \times 0.70 + 0.4 \times 201.00} \]

= Greater Of (0.0303(Calculated), 0.0625(Minimum Allowed)) + 0.0000 (corrosion) + 0.0000 (ext. corrosion) = minimum of 0.0625 in.

Circumferential Stress Calculations per Appendix 1-1(a)(1)

\[ t = \frac{PR_0}{SE + 0.4P} = \frac{201.00 \times 4.0150}{18600 \times 0.85 + 0.4 \times 201.00} \]

= Greater of (0.0508(Calculated), 0.0625(Minimum Allowed)) + 0.0000 (corrosion) + 0.0000 (ext. corrosion) = minimum of 0.0625 in.

Extreme Fiber Elongation Calculation per Paragraph UHA-44

\[ \text{Elongation} = \frac{50t}{Rf} = \frac{50 \times 0.0780}{3.9760} \]

= elongation of 0.98 %

Nominal Shell Thickness Selected = 0.0780 in.
Pressure Vessel Engineering, Ltd.

Customer: Pressure Vessel Engineering
Job No: PVE-Sample5
Number: 2

Vessel Number: Sample Vessel 5
Mark Number: S2

Date Printed: 11/20/2008

Cylindrical Shell Design Information

- **Design Pressure:** 200.00 PSI
- **Static Head:** 1.00 PSI
- **Shell Material:** SA-240 304, High
- **Shell Length:** 15.5000 in.
- **Material Stress (hot):** 18600 PSI
- **Material Stress (cold):** 20000 PSI
- **Compressive Stress:** 10102 PSI
- **Corrosion Allowance:** 0.0000 in.
- **External Corrosion Allowance:** 0.0000 in.
- **Outside Diameter (new):** 12.7500 in.
- **Outside Diameter (corroded):** 12.7500 in.
- **Shell Surface Area:** 4.31 Sq. Ft.
- **Shell Estimated Volume:** 8.07 Gal.
- **Circ. Joint Efficiency:** 70%
- **Minimum Design Metal Temperature:** -20 °F
- **Material exempt from impact testing per UCS-66(b), stress ratio <= 0.35

**Design Thickness Calculations**

**Longitudinal Stress Calculations per Paragraph UG-27(c)(2)**

\[
t = \frac{PR}{2SE + 0.4P} = \frac{201.00 * 6.1870}{2 * 18600 * 0.70 + 0.4 * 201.00}
\]

\[
t = \text{Greater Of (0.0476 (Calculated), 0.0625 (Minimum Allowed)) + 0.0000 (corrosion) + 0.0000 (ext. corrosion)} = \text{minimum of 0.0625 in.}
\]

**Circumferential Stress Calculations per Appendix 1-1(a)(1)**

\[
t = \frac{PR_o}{SE + 0.4P} = \frac{201.00 * 6.3750}{18600 * 0.70 + 0.4 * 201.00}
\]

\[
t = \text{0.0979 + 0.0000 (corrosion) + 0.0000 (ext. corrosion)} = \text{minimum of 0.0979 in.}
\]

**Extreme Fiber Elongation Calculation per Paragraph UHA-44**

\[
\text{Elongation} = \frac{50t}{Rf} = \frac{50 * 0.1880}{6.2810}
\]

\[
\text{Elongation} = 1.50 \%
\]

Nominal Shell Thickness Selected = **0.1880** in.
Customer: Pressure Vessel Engineering
Job No: PVE-Sample5
Number: 3

Vessel Number: Sample Vessel 5
Mark Number: S3

Date Printed: 11/20/2008

Cylindrical Shell Design Information

Design Pressure: 200.00 PSI
Static Head: 1.00 PSI
Shell Material: SA-312 TP304 SMLS, High
Shell Length: 4.5000 in.
Corrosion Allowance: 0.0000 in.
Outside Diameter (new): 12.7500 in.
Outside Diameter (corroded): 12.7500 in.

Design Temperature: 350 °F
Long. Joint Efficiency: 85 %
Shell Surface Area: 1.25 Sq. Ft.
Shell Estimated Volume: 1.98 Gal.
Circ. Joint Efficiency: 70 %

Material Stress (hot): 18600 PSI
Material Stress (cold): 20000 PSI
Compressive Stress: 11376 PSI
Actual Circumferential Stress: 2413 PSI
Actual Longitudinal Stress: 1301 PSI

Material Stress (hot): 18600 PSI
Material Stress (cold): 20000 PSI
Compressive Stress: 11376 PSI
Actual Circumferential Stress: 2413 PSI
Actual Longitudinal Stress: 1301 PSI

Minimum Design Metal Temperature Data

Minimum Design Metal Temperature: -20 °F
Material is exempt from impact testing per UHA-51(d)

Design Thickness Calculations

Longitudinal Stress Calculations per Paragraph UG-27(c)(2)

\[
t = \frac{PR}{2SE + 0.4P} \leq \frac{201.00 \times 5.6880}{2 \times 18600 \times 0.70 + 0.4 \times 201.00}
\]

= Greater Of (0.0438 (Calculated), 0.0625 (Minimum Allowed)) + 0.0000 (corrosion) + 0.0000 (ext. corrosion) + 0.0859 (12 1/2% for pipe)
= minimum of 0.1484 in.

Circumferential Stress Calculations per Appendix 1-1(a)(1)

\[
t = \frac{PR_0}{SE + 0.4P} \leq \frac{201.00 \times 6.3750}{18600 \times 0.85 + 0.4 \times 201.00}
\]

= 0.0807 + 0.0000 (corrosion) + 0.0000 (ext. corrosion) + 0.0859 (12 1/2% for pipe)
= minimum of 0.1666 in.

Pipe Selected: Size = 12 in., Schedule = 80, Diameter = 12.7500 in., Wall = 0.6870 in.
**Conical Reducer Design Information**

<table>
<thead>
<tr>
<th>Design Pressure</th>
<th>200.00 PSI</th>
<th>Design Temperature</th>
<th>350 °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Head</td>
<td>1.00 PSI</td>
<td>Joint Efficiency</td>
<td>70 %</td>
</tr>
<tr>
<td>Conical Reducer Material</td>
<td>SA-240 304, High</td>
<td>Factor B Chart</td>
<td>HA-1</td>
</tr>
<tr>
<td>Corrosion Allowance</td>
<td>0.0000 in.</td>
<td>Material Stress (hot)</td>
<td>18600 PSI</td>
</tr>
<tr>
<td>External Corrosion Allowance</td>
<td>0.0000 in.</td>
<td>Material Stress (cold)</td>
<td>20000 PSI</td>
</tr>
<tr>
<td>Small End of Cone Located at</td>
<td>Bottom</td>
<td>Actual Conical Reducer Stress</td>
<td>10681 PSI</td>
</tr>
<tr>
<td>Outside Diameter</td>
<td>12.7500 in.</td>
<td>Cone Height (h)</td>
<td>4.9994 in.</td>
</tr>
<tr>
<td>angle α (°)</td>
<td>25.27°</td>
<td>Specific Gravity</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Conical Reducer Surface Area**: 1.25 Sq. Ft.
**Conical Reducer Estimated Volume**: 1.72 Gal.
**Conical Reducer Weight**: 9.62 lb.
**Total Flooded Conical Reducer Weight**: 23.99 lb.

**Minimum Design Metal Temperature Data**

| Minimum Design Metal Temperature | -20 °F |
| Other Exemption                  |       |

### Design Thickness Calculations

**Design Thickness Calculations per Appendix 1-4(e)**

\[
t = \frac{PD_o}{2 \cos \alpha (SE + 0.4P)} = \frac{201.00 \times 12.7500}{2 \times 0.9043 \times (18600 \times 0.70 + 0.4 \times 201.00)} = 0.1082 + 0.0000 \text{ (corrosion)} + 0.0000 \text{ (ext. corrosion)}
\]

= minimum of 0.1082 in.

### Extreme Fiber Elongation Calculation per Paragraph UHA-44

\[
elongation = \frac{50t}{R_f} = \frac{50 \times 0.1875}{3.9213} = \text{elongation of 2.39 %}
\]

**Nominal Conical Reducer Thickness Selected = 0.1875 in.**
**Nozzle Design Information**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Pressure (Ps)</td>
<td>200.00 PSI</td>
</tr>
<tr>
<td>Design Temperature (Ts)</td>
<td>350 °F</td>
</tr>
<tr>
<td>Nozzle Material</td>
<td>SA-312 TP304 SMLS, High</td>
</tr>
<tr>
<td>Nozzle Efficiency (E)</td>
<td>85%</td>
</tr>
<tr>
<td>Nozzle ID (new)</td>
<td>10.0200 in.</td>
</tr>
<tr>
<td>Nozzle Wall Thickness (new)</td>
<td>0.3650 in.</td>
</tr>
<tr>
<td>Nozzle ID (corroded)</td>
<td>10.0200 in.</td>
</tr>
<tr>
<td>Nozzle Wall Thickness (corroded)</td>
<td>0.3650 in.</td>
</tr>
<tr>
<td>Internal &quot;h&quot; Limit</td>
<td>0.4700 in.</td>
</tr>
<tr>
<td>Internal Weld Leg Size (Weld 43)</td>
<td>0.2500 in.</td>
</tr>
<tr>
<td>OD, Limit of Reinforcement (dLR)</td>
<td>15.0300 in.</td>
</tr>
<tr>
<td>Outside Groove Weld Depth</td>
<td>0.1880 in.</td>
</tr>
<tr>
<td>Minimum Design Metal Temperature</td>
<td>-20 °F</td>
</tr>
<tr>
<td>Material exempt from impact testing per UCS-66(b), stress ratio &lt;= 0.35</td>
<td></td>
</tr>
</tbody>
</table>

**Host Component:** Shell 2 - Shell 2 - thin shell

<table>
<thead>
<tr>
<th>Material</th>
<th>Stress (Sv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA-240 304, High</td>
<td>18600 PSI</td>
</tr>
</tbody>
</table>

**Nozzle Detail Information**

- Upper Weld Leg Size (Weld 41): 0.2500 in.
- Nozzle Wall Thickness (tₙ): 0.3650 in.
- Outside Groove Weld Depth: 0.1880 in.

Nozzle passes through the vessel, attached by a groove weld. Pipe Size: 10 Schedule: 40
Nozzle is adequate for UG-45 requirements.
Opening is adequately reinforced for Internal Pressure.
Large opening meets Appendix 1-7 stress calculation requirements
Weld Strength Paths are adequate.
Required Shell Thickness per Paragraph UG-37(a)

\[
tr = \frac{PRo}{SE + 0.4P} = \frac{201.00 \times 6.3750}{18600 \times 1 + 0.4 \times 201.00} = 0.0686 \text{ in.}
\]

Nozzle Required Thickness Calculations

Required Nozzle Thickness for Internal Pressure per Paragraph UG-37(a)

\[
trn = \frac{PRn}{SE - 0.6P} = \frac{201.00 \times 5.0100}{18600 \times 1 - 0.6 \times 201.00} = 0.0545 \text{ in.}
\]

Strength Reduction Factors

\[
fr1 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{18600}{18600}, 1.0000 \right) = 1.0000 \\
fr2 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{18600}{18600}, 1.0000 \right) = 1.0000 \\
fr3 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{18600}{18600}, 1.0000 \right) = 1.0000
\]

UG-45 Thickness Calculations

Nozzle Thickness for Pressure Loading (plus corrosion) per Paragraph UG-45(a)

\[
t = \frac{PRn}{SE - 0.6P} + Ca + \text{ext. Ca} = \frac{201.00 \times 5.0100}{18600 \times 0.85 - 0.6 \times 201.00} + 0.0000 + 0.0000 = 0.0642 \text{ in.}
\]

Nozzle Thickness for Internal Pressure (plus corrosion) per Paragraph UG-45(b)(1)

\[
t = \frac{PRo}{SE + 0.4P} + Ca + \text{ext. Ca} = \frac{201.00 \times 6.3750}{18600 \times 1 + 0.4 \times 201.00} + 0.0000 + 0.0000 = 0.0686 \text{ in.}
\]

Minimum Thickness of Standard Wall Pipe (plus corrosion) per Paragraph UG-45(b)(4)

\[
t = \min \text{ thickness of standard wall pipe} + Ca + \text{ext. Ca} = 0.3194 \text{ in.}
\]

Nozzle Minimum Thickness per Paragraph UG-45(b)

\[
t = \text{Smallest of UG-45(b)(1) or UG-45(b)(4)} = 0.0686 \text{ in.}
\]

Wall thickness = \( tn \times 0.875(\text{pipe}) = 0.3194 \) is greater than or equal to UG-45 value of 0.0686
Nozzle Reinforcement Calculations

Area Required for Internal Pressure

\[ A = \pi tr F + 2 \pi tn tr F (1 - fr1) = (10.0200 \times 0.0686 \times 1.00) + (2 \times 0.3650 \times 0.0686 \times 1.00 \times (1 - 1.0000)) \]

\[ = 0.6874 \text{ sq. in.} \]

Area Available - Internal Pressure

\[ A_1 = \pi (E1 t - F tr) - 2\pi tn (E1 t - F tr)(1 - fr1) = \]

\[ 10.0200 \times (1.00 \times 0.1880 - 1.00 \times 0.0686) - 2 \times 0.3650 \times (1.00 \times 0.1880 - 1.00 \times 0.0686) \times (1 - 1.0000) = 1.1964 \text{ sq. in.} \]

\[ A_2 = 2(t + tn)(E1 t - F tr) - 2\pi tn (E1 t - F tr)(1 - fr1) = \]

\[ 2 \times (0.1880 + 0.3650)(1.00 \times 0.1880 - 1.00 \times 0.0686) - 2 \times 0.3650 \times (1.00 \times 0.1880 - 1.00 \times 0.0686) \times (1 - 1.0000) = 0.1321 \text{ sq. in.} \]

\[ A_1 = \text{Larger value of } A_1 \text{Formula 1 and } A_1 \text{Formula 2} = 1.1964 \text{ sq. in.} \]

\[ A_2 = \text{Smaller value of } A_2 \text{Formula 1 and } A_2 \text{Formula 2} = 0.2919 \text{ sq. in.} \]

\[ A_3 = \text{Smaller value of the following :} \]

\[ 5 \times t \times t_1 \times f_{r2} = 5 \times 0.1880 \times 0.3650 \times 1.0000 = 0.3431 \text{ sq. in.} \]

\[ 5 \times t_1 \times t_1 \times f_{r2} = 5 \times 0.3650 \times 0.3650 \times 1.0000 = 0.6661 \text{ sq. in.} \]

\[ 2 \times h \times t_1 \times f_{r2} = 2 \times 0.0000 \times 0.3650 \times 1.0000 = 0.0000 \text{ sq. in.} \]

\[ = 0.0000 \text{ sq. in.} \]

\[ A_41 = \text{(leg)}^2 \times f_{r2} = (0.2500)^2 \times 1.0000 = 0.0625 \text{ sq. in.} \]

\[ A_43 = \text{(leg)}^2 \times f_{r2} = 0 \times 1.0000 = 0.0000 \text{ sq. in.} \]

\[ \text{Area Available (Internal Pressure)} = A_1 + A_2 + A_3 + A_41 + A_43 = 1.5508 \text{ sq. in., which is greater than A (0.6874)} \]
Appendix 1-7(a) (Large Opening in Shell) Calculations

Area Required for Internal Pressure

\[ A = \frac{2}{3} \times (d \cdot tr + 2 \cdot tn \cdot tr \cdot (1 - fr1)) = \frac{2}{3} \times \left(10.02 \times 0.0686 \times 1 + 2 \times 0.3650 \times 0.0686 \times 1.00 \times (1 - 1.0000)\right) \]

\[ = 0.4583 \text{ sq. in.} \]

Area Available - Internal Pressure

\[ A1 = (d_{LDR} - d) \cdot (E1 \cdot t - F \cdot tr) - 2 \cdot tn \cdot (E1 \cdot t - F \cdot tr) \cdot (1 - fr1) = \]

\[ = (15.0300 - 10.0200) \cdot (1.00 \times 0.1880 - 1.00 \times 0.0686) - 2 \times 0.3650 \times (1.00 \times 0.1880 - 1.00 \times 0.0686) \times (1 - 1.0000) \]

\[ = 0.5982 \text{ sq. in.} \]

**A2 Formula 1**

\[ A2 = 5 \times (tn - trn) \times fr2 \times t = 5 \times (0.3650 - 0.0545) \times 1.0000 \times 0.1880 = 0.2919 \text{ sq. in.} \]

**A2 Formula 2**

\[ A2 = 5 \times (tn - trn) \times fr2 \times tn = 5 \times (0.3650 - 0.0545) \times 1.0000 \times 0.3650 = 0.5667 \text{ sq. in.} \]

**A2 = Smaller value of A2 Formula 1 and A2 Formula 2**

\[ = 0.2919 \text{ sq. in.} \]

**A3 = Smaller value of the following :**

\[ 5 \times t \times t1 \times fr2 = 5 \times 0.1880 \times 0.3650 \times 1.0000 = 0.3431 \text{ sq. in.} \]

\[ 5 \times t1 \times t1 \times fr2 = 5 \times 0.3650 \times 0.3650 \times 1.0000 = 0.6661 \text{ sq. in.} \]

\[ 2 \times h \times t1 \times fr2 = 2 \times 0.0000 \times 0.3650 \times 1.0000 = 0.0000 \text{ sq. in.} \]

\[ = 0.0000 \text{ sq. in.} \]

**A41 = (leg) \times fr2 = (0.2500) \times 1.0000 = 0.0625 \text{ sq. in.} \]

**A43 = (leg) \times fr2 = 0 \times 1.0000 = 0.0000 \text{ sq. in.} \]

\[ \text{Area Available (Internal Pressure)} = A1 + A2 + A3 + A41 + A43 = 0.9526 \text{ sq. in., which is greater than A (0.4583)} \]
Pressure Vessel Engineering, Ltd.

Job No: PVE-Sample5
Number: 1
ID Number: N-C

Date Printed: 11/20/2008

Nozzle Weld Strength Calculations

Attachment Weld Strength per Paragraph UW-16

Weld 41 t\text{min} = \text{smaller of } 0.75, t, \text{ or } tn = \text{smaller of } 0.75, 0.1880, \text{ or } 0.3650 = 0.1880 \text{ in.}

Weld 41 Leg min. = \left(\text{smaller of } 0.25 \text{ or } (t\text{min } \times 0.7) + \text{ext. CA}\right) \div 0.7 = 0.1316 \text{ in.}

Weld 41, actual weld leg = 0.2500 \text{ in.}

Unit Stresses per Paragraphs UG-45(c) and UW-15

Nozzle wall in shear = 0.70 \times Sn = 0.70 \times 18600 = 13020 \text{ PSI}

Upper fillet, Weld 41, in shear = 0.49 \times \text{Material Stress} = 0.49 \times 18600 = 9114 \text{ PSI}

Vessel groove weld, in tension = 0.74 \times \text{Material Stress} = 0.74 \times 18600 = 13764 \text{ PSI}

Strength of Connection Elements

Nozzle wall in shear = \frac{1}{2} \times \pi \times \text{mean nozzle diameter} \times \text{tn} \times \text{Nozzle wall in shear unit stress} = 77500 \text{ lb.}

Upper fillet in shear = \frac{1}{2} \times \pi \times \text{Nozzle OD} \times \text{weld leg} \times \text{upper fillet in shear unit stress} = 38500 \text{ lb.}

Groove Weld in Tension = \frac{1}{2} \times \pi \times \text{Nozzle OD} \times \text{groove depth} \times \text{groove weld tension unit stress} = 43700 \text{ lb.}

Load to be carried by welds, per UG-41(b)(1) and Fig. UG-41.1 sketch (a)

\begin{align*}
W &= [A - A1 + 2 \text{ tn fr1(E1 - Fr1)}] \times \text{Sv} = \left[0.6874 - 1.1964 + 2 \times 0.3650 \times 1.0000 \times (1.00 \times 0.1880 - 1.0000 \times 0.0686)\right] \times 18600 = -7846 \text{ lb.}
W1-1 &= (A2 + A5 + A41 + A42) \times \text{Sv} = (0.2919 + 0.0000 + 0.0625 + 0.0000) \times 18600 = 6590 \text{ lb.}
W2-2 &= (A2 + A3 + A41 + A43 + 2 \text{ tn t fr1}) \times \text{Sv} = (0.2919 + 0.0000 + 0.0625 + 0.0000 + 2 \times 0.3650 \times 0.1880 \times 1.0000) \times 18600 = 9140 \text{ lb.}
W3-3 &= (A2 + A3 + A5 + A41 + A42 + A43 + 2 \text{ tn t fr1}) \times \text{Sv} = (0.2919 + 0.0000 + 0.0000 + 0.0625 + 0.0000 + 0.0000 + 2 \times 0.3650 \times 0.1880 \times 1.0000) \times 18600 = 9140 \text{ lb.}
\end{align*}

Check Strength Paths

\begin{align*}
\text{Path 1-1} &= \text{Upper fillet in shear } + \text{ Nozzle wall in shear } = 38500 + 77500 = 116000 \text{ lb.}
\text{Path 2-2} &= \text{Upper fillet in shear } + \text{ Groove weld in tension } + \text{ Inner fillet in shear } = 38500 + 43700 = 82200 \text{ lb.}
\text{Path 3-3} &= \text{Upper fillet in shear } + \text{ Inner fillet in shear } + \text{ Groove weld in tension } = 38500 + 43700 = 82200 \text{ lb.}
\end{align*}
Pressure Vessel Engineering, Ltd.

2" Inlet Nozzle A

Customer: Pressure Vessel Engineering
Job No: PVE-Sample5
Number: 2
ID Number: N-A

Date Printed: 11/20/2008

Vessel Number: Sample Vessel 5
Mark Number: N-A

Nozzle Design Information

Design Pressure: 200.00 PSI
Design Temperature: 350 °F
Static Head: 1.00 PSI
Nozzle Efficiency (E): 85%
Nozzle Material: SA-312 TP304 SMLS, High
Joint Efficiency (E1): 1.00
Factor B Chart: HA-1

External Projection: 3.0000 in.
Allowable Stress at Design Temperature (Sn): 18600 PSI
Internal Projection: 0.0000 in.
Allowable Stress at Ambient Temperature: 20000 PSI
Inside Corrosion Allowance: 0.0000 in.
Correction Factor (F): 1.00
External Corrosion Allowance: 0.0000 in.
Nozzle Path: None
Nozzle Pipe Size: 2
Nozzle ID (new): 2.0670 in.
Nozzle Wall Thickness (new): 0.1540 in.
Nozzle ID (corroded): 2.0670 in.
Nozzle Wall Thickness (corroded): 0.1540 in.
Developed Opening: 2.1920 in.
Tangential Dimension L: 7.0000 in.
Outer "h" Limit: 0.3850 in.
Upper Weld Leg Size (Weld 41): 0.1880 in.
Internal "h" Limit: 0.3850 in.
Internal Weld Leg Size (Weld 43): 0.0000 in.
OD, Limit of Reinforcement: 4.3840 in.
Outside Groove Weld Depth: 0.1875 in.

Minimum Design Metal Temperature

Minimum Design Metal Temperature: -20 °F
Material exempt from impact testing per UCS-66(b), stress ratio <= 0.35

Host Component: Cone 1 - Conical Reducer 1
Material: SA-240 304, High
Conical Reducer wall thickness (new): 0.1875 in.
Material Stress (Sv): 18600 PSI
Conical Reducer wall thickness - thin out (corroded): 0.1875 in.
Distance from small end of cone: 2.5000 in.
Diameter of Cone at Nozzle: 10.3903 in.

Nozzle Detail Information

Upper Weld Leg Size (Weld 41): 0.1880 in.
Nozzle Wall Thickness (tn): 0.1540 in.
Outside Groove Weld Depth: 0.1875 in.

tangential to the vessel wall, attached by a groove weld.
Pipe Size: 2 Schedule: 40
Nozzle is adequate for UG-45 requirements.
Opening is adequately reinforced for Internal Pressure.
Reinforcement calculations are not required per UG-36(c)(3)(a)See Uw-14 for exceptions.
Weld Strength Paths are adequate.
Required Conical Reducer Thickness per Paragraph UG-37(a)

\[ t_r = \frac{P_Do \cdot 10.3903}{(2 \cdot \cos \alpha (SE + 0.4P))} = \frac{201.00 \cdot 10.3903}{(2 \cdot 0.9043 \cdot (18600 \cdot 1 + 0.4 \cdot 201.00))} \approx 0.0618 \text{ in.} \]

Nozzle Required Thickness Calculations

Required Nozzle Thickness for Internal Pressure per Paragraph UG-37(a)

\[ trn = \frac{P_{Rn}}{SE - 0.6P} = \frac{201.00 \cdot 1.0335}{18600 \cdot 1 - 0.6 \cdot 201.00} \approx 0.0112 \text{ in.} \]

Strength Reduction Factors

\[ fr1 = \min \left( \frac{S_n}{S_v}, 1.0000 \right) = \min \left( \frac{18600}{18600}, 1.0000 \right) = 1.0000 \]
\[ fr2 = \min \left( \frac{S_n}{S_v}, 1.0000 \right) = \min \left( \frac{18600}{18600}, 1.0000 \right) = 1.0000 \]
\[ fr3 = \min \left( \frac{S_n}{S_v}, 1.0000 \right) = \min \left( \frac{18600}{18600}, 1.0000 \right) = 1.0000 \]

UG-45 Thickness Calculations

Nozzle Thickness for Pressure Loading (plus corrosion) per Paragraph UG-45(a)

\[ t = \frac{P_{Rn}}{SE - 0.6P} + Ca + ext. Ca = \frac{201.00 \cdot 1.0335}{18600 \cdot 0.85 - 0.6 \cdot 201.00} + 0.0000 + 0.0000 \approx 0.0132 \text{ in.} \]

Nozzle Thickness for Internal Pressure (plus corrosion) per Paragraph UG-45(b)(1)

\[ t = \frac{P_{Do} \cdot 10.3903}{(2 \cdot \cos \alpha (SE + 0.4P))} + Ca + ext. Ca = \frac{201.00 \cdot 10.3903}{(2 \cdot 0.9043 \cdot (18600 \cdot 1 + 0.4 \cdot 201.00))} + 0.0000 + 0.0000 \]
\[ = \text{Greater Of} (0.0618 \text{(Calculated)}, 0.0625 \text{(Minimum Allowed)}) + 0.0000 \text{ (corrosion)} + 0.0000 \text{ (ext. corrosion)} \approx 0.0625 \text{ in.} \]

Minimum Thickness of Standard Wall Pipe (plus corrosion) per Paragraph UG-45(b)(4)

\[ t = \text{minimum thickness of standard wall pipe} + Ca + ext. Ca \]
\[ = 0.1347 \text{ in.} \]

Nozzle Minimum Thickness per Paragraph UG-45(b)

\[ t = \text{Smallest of UG-45(b)(1) or UG-45(b)(4)} = 0.0625 \text{ in.} \]

Wall thickness = \( tn \cdot 0.875 \text{(pipe)} = 0.1347 \) is greater than or equal to UG-45 value of 0.0625
Nozzle Weld Strength Calculations

Attachment Weld Strength per Paragraph UW-16

Weld 41 \( t_{\text{min}} \) = smaller of 0.75, \( t \), or \( t_n \) = smaller of 0.75, 0.1875, or 0.1540

\[
\text{Weld 41 Leg min.} = \frac{\text{(smaller of 0.25 or } (t_{\text{min}} \times 0.7)) + \text{ ext. CA}}{0.7} = \frac{0.1078}{0.7} = 0.1540 \text{ in.}
\]

Weld 41, actual weld leg = 0.1880 in.

Unit Stresses per Paragraphs UG-45(c) and UW-15

Nozzle wall in shear = 0.70 * \( S_n \) = 0.70 * 18600 = 13020 PSI
Upper fillet, Weld 41, in shear = 0.49 * Material Stress = 0.49 * 18600 = 9114 PSI
Vessel groove weld, in tension = 0.74 * Material Stress = 0.74 * 18600 = 13764 PSI

Strength of Connection Elements

Nozzle wall in shear = \( \frac{1}{2} \pi \times \text{mean nozzle diameter} \times \text{tn} \) Nozzle wall in shear unit stress = \( \frac{1}{2} \pi \times 2.2210 \times 0.1540 \times 13020 = 6990 \) lb.
Upper fillet in shear = \( \frac{1}{2} \pi \times \text{Nozzle OD} \times \text{weld leg} \) upper fillet in shear unit stress = \( \frac{1}{2} \pi \times 2.3750 \times 0.1880 \times 9114 = 6390 \) lb.
Groove Weld in Tension = \( \frac{1}{2} \pi \times \text{Nozzle OD} \times \text{groove depth} \times \text{groove weld tension unit stress} = \frac{1}{2} \pi \times 2.3750 \times 0.1875 \times 13764 = 9620 \) lb.

Load to be carried by welds, per UG-41(b)(1) and Fig. UG-41.1 sketch (a)

\[
W = [A - A1 + 2 \text{ tn fr1(E1t - Ftr)}] \times S_v = [0.1355 - 0.2755 + 2 \times 0.1540 \times 1.0000 \times (1.00 \times 0.1875 - 1.0000 \times 0.0618)] \times 18600 = -1883 \text{ lb.}
\]

\[
W1-1 = (A2 + A5 + A41 + A42) \times S_v = (0.1100 + 0.0000 + 0.0353 + 0.0000) \times 18600 = 2700 \text{ lb.}
\]

\[
W2-2 = (A2 + A3 + A41 + A43 + 2 \text{ tn fr1}) \times S_v = (0.1100 + 0.0000 + 0.0353 + 0.0000 + 2 \times 0.1540 \times 0.1875 \times 1.0000) \times 18600 = 3780 \text{ lb.}
\]

\[
W3-3 = (A2 + A3 + A5 + A41 + A42 + A43 + 2 \text{ tn fr1}) \times S_v = (0.1100 + 0.0000 + 0.0000 + 0.0353 + 0.0000 + 0.0000 + 2 \times 0.1540 \times 0.1875 \times 1.0000) \times 18600 = 3780 \text{ lb.}
\]

Check Strength Paths

Path 1-1 = Upper fillet in shear + Nozzle wall in shear = 6390 + 6990 = 13380 lb.
Path 2-2 = Upper fillet in shear + Groove weld in tension + Inner fillet in shear = 6390 + 9620 + 0 = 16010 lb.
Path 3-3 = Upper fillet in shear + Inner fillet in shear + Groove weld in tension = 6390 + 0 + 9620 = 16010 lb.
Pressure Vessel Engineering, Ltd.

Customer: Pressure Vessel Engineering
Job No: PVE-Sample5
Number: 3
ID Number: N-E

Vessel Number: Sample Vessel 5
Mark Number: N-E

Date Printed: 11/20/2008

Nozzle Design Information

- **Design Pressure**: 200.00 PSI
- **Static Head**: 0.00 PSI
- **Nozzle Material**: SA-182 F304 <=5», High
- **Design Temperature**: 350 °F
- **Nozzle Efficiency (E)**: 70 %
- **Joint Efficiency (E₁)**: 1.00
- **Factor B Chart**: HA-1
- **External Projection**: 1.0000 in.
- **Allowable Stress at Design Temperature (S_n)**: 18600 PSI
- **Allowable Stress at Ambient Temperature**: 20000 PSI
- **Inside Corrosion Allowance**: 0.0000 in.
- **Correction Factor (F)**: 1.00
- **External Corrosion Allowance**: 0.0000 in.
- **Nozzle Path**: None
- **Nozzle ID (new)**: 2.0970 in.
- **Nozzle Wall Thickness (new)**: 0.2730 in.
- **Nozzle ID (corroded)**: 2.0970 in.
- **Nozzle Wall Thickness (corroded)**: 0.2730 in.
- **Outer "h" Limit**: 0.6825 in.
- **Upper Weld Leg Size (Weld 41)**: 0.3130 in.
- **OD, Limit of Reinforcement**: 4.6430 in.
- **Outside Groove Weld Depth**: 0.2730 in.

Minimum Design Metal Temperature

- **Minimum Design Metal Temperature**: -20 °F
- **Material exempt from impact testing per UCS-66(b), stress ratio </= 0.35**

Host Component: Flange 2 - Cover Flange

- **Material**: SA-240 304, Low
- **Host Flange wall thickness (new)**: 1.0000 in.
- **Material Stress (S_v)**: 14400 PSI
- **Host Flange wall thickness (corroded)**: 1.0000 in.

Nozzle Detail Information

- **Upper Weld Leg Size (Weld 41)**: 0.3130 in.
- **Nozzle Wall Thickness (tₙ)**: 0.2730 in.
- **Outside Groove Weld Depth**: 0.2730 in.

Nozzle abuts the vessel, attached by a groove weld.
Nozzle is adequate for UG-45 requirements.
Opening is adequately reinforced for Internal Pressure.
Reinforcement calculations are not required per UG-36(c)(3)(a)See Uw-14 for exceptions.
Weld Strength Paths are adequate.
Pressure Vessel Engineering, Ltd.

Job No: PVE-Sample5
Number: 3
ID Number: N-E

Vessel Number: Sample Vessel 5
Mark Number: N-E

Date Printed: 11/20/2008

Required Host Flange Thickness per Paragraph UG-39(b)(1)

\[
tr = G \cdot \sqrt{\frac{CP}{SE}} + \frac{1.9 \cdot W_{m1} \cdot hG}{SE \cdot G^2} = 12.4800 \cdot \sqrt{\frac{0.3000 \cdot 200.00}{14400 \cdot 1}} + \frac{1.9 \cdot 25923 \cdot 1.1350}{14400 \cdot 1 \cdot 12.4800^2} = 0.9798 \text{ in.}
\]

Nozzle Required Thickness Calculations

Required Nozzle Thickness for Internal Pressure per Paragraph UG-37(a)

\[
trn = \frac{PRn}{SE - 0.6P} = \frac{200.00 \cdot 1.0485}{18600 \cdot 1 - 0.6 \cdot 200.00} = 0.0113 \text{ in.}
\]

Strength Reduction Factors

\[
fr2 = \min \left( \frac{S_n}{S_v}, 1.0000 \right) = \min \left( \frac{18600}{14400}, 1.0000 \right) = 1.0000
\]

\[
fr3 = \min \left( \frac{S_n}{S_v}, 1.0000 \right) = \min \left( \frac{18600}{14400}, 1.0000 \right) = 1.0000
\]

UG-45 Thickness Calculations

Nozzle Thickness for Pressure Loading (plus corrosion) per Paragraph UG-45(a)

\[
t = \frac{PRn}{SE - 0.6P} + Ca + \text{ext. Ca} = \frac{200.00 \cdot 1.0485}{18600 \cdot 0.70 - 0.6 \cdot 200.00} + 0.0000 + 0.0000 = 0.0163 \text{ in.}
\]

Nozzle Thickness for Internal Pressure (plus corrosion) per Paragraph UG-45(b)(1)

\[
t = G \cdot \sqrt{\frac{CP}{SE}} + \frac{1.9 \cdot W_{m1} \cdot hG}{SE \cdot G^2} + Ca + \text{ext. Ca} = 12.4800 \cdot \sqrt{\frac{0.3000 \cdot 200.00}{14400 \cdot 1}} + \frac{1.9 \cdot 25923 \cdot 1.1350}{14400 \cdot 1 \cdot 12.4800^2} + 0.0000 + 0.0000 = 0.9798 \text{ in.}
\]

Minimum Thickness of Standard Wall Pipe (plus corrosion) per Paragraph UG-45(b)(4)

\[
t = \text{minimum thickness of standard wall pipe} + Ca + \text{ext. Ca} = 0.1776 \text{ in.}
\]

Nozzle Minimum Thickness per Paragraph UG-45(b)

\[
t = \text{Smallest of UG-45(b)(1) or UG-45(b)(4)} = 0.1776 \text{ in.}
\]

Wall thickness = \( tn = 0.2730 \) is greater than or equal to UG-45 value of 0.1776
Nozzle Weld Strength Calculations

Attachment Weld Strength per Paragraph UW-16

Weld 41 $t_{min} = \text{smaller of } 0.75, t, \text{ or } t_n = \text{smaller of } 0.75, 1.0000, \text{ or } 0.2730 = 0.2730 \text{ in.}$

Weld 41 Leg min. $= \text{smaller of } 0.25 \text{ or } (t_{min} \times 0.7) + \text{ ext. CA}$

$= \frac{0.1911}{0.7} = 0.2730 \text{ in.}$

Weld 41, actual weld leg $= 0.3130 \text{ in.}$

Unit Stresses per Paragraphs UG-45(c) and UW-15

Groove weld in shear $= 0.60 \times \text{Groove Material Stress} = 0.60 \times 14400 = 8640 \text{ PSI}$

Upper fillet, Weld 41, in shear $= 0.49 \times \text{Material Stress} = 0.49 \times 14400 = 7056 \text{ PSI}$

Strength of Connection Elements

Groove weld in shear $= \frac{1}{2} \times \pi \times \text{mean nozzle diameter} \times t_n \times \text{Groove weld in shear unit stress} = \frac{1}{2} \times \pi \times 2.3700 \times 0.2730 \times 8640 = 8780 \text{ lb.}$

Upper fillet in shear $= \frac{1}{2} \times \pi \times \text{Nozzle OD} \times \text{weld leg} \times \text{upper fillet in shear unit stress} = \frac{1}{2} \times \pi \times 2.6430 \times 0.3130 \times 7056 = 9160 \text{ lb.}$

Load to be carried by welds, per UG-41(b)(1) and Fig. UG-41.1 sketch (b)

$W = (A - A1) \times Sv = (1.0273 - 0.0514) \times 14400 = 14100 \text{ lb.}$

$W1-1 = (A2 + A5 + A41 + A42) \times Sv = (0.3572 + 0.0000 + 0.0980 + 0.0000) \times 14400 = 6550 \text{ lb.}$

$W2-2 = (A2 + A41) \times Sv = (0.3572 + 0.0980) \times 14400 = 6550 \text{ lb.}$

Check Strength Paths

Path 1-1 $= \text{Upper fillet in shear} + \text{Groove weld in shear} = 9160 + 8780 = 17940 \text{ lb.}$

Path 2-2 $= \text{Upper fillet in shear} + \text{Groove weld in shear} = 9160 + 8780 = 17940 \text{ lb.}$
Nozzle Design Information

Design Pressure: 200.00 PSI  Design Temperature: 350 °F
Static Head: 0.00 PSI  Nozzle Efficiency (E): 70%
Nozzle Material: SA-479 304, High  Joint Efficiency (E₁): 1.00
Factor B Chart: HA-1
External Projection: 1.5000 in.  Allowable Stress at Design Temperature (Sₚ): 18600 PSI
Internal Projection: 0.0000 in.  Allowable Stress at Ambient Temperature: 20000 PSI
Inside Corrosion Allowance: 0.0000 in.  Correction Factor (F): 1.00
External Corrosion Allowance: 0.0000 in.  Nozzle Path: None
Outer "h" Limit: 0.4025 in.  Upper Weld Leg Size(Weld 41): 0.1880 in.
Internal "h" Limit: 0.4025 in.  Internal Weld Leg Size(Weld 43): 0.0000 in.
OD, Limit of Reinforcement: 3.7400 in.  Outside Groove Weld Depth: 0.1880 in.

Minimum Design Metal Temperature

Minimum Design Metal Temperature: -20 °F
Material exempt from impact testing per UCS-66(b), stress ratio <= 0.35
Host Component: Shell 2 - Shell 2 - thin shell
Material: SA-240 304, High  Shell wall thickness(new): 0.1880 in.
Material Stress(Sᵥ): 18600 PSI  Shell wall thickness(corroded): 0.1880 in.

Nozzle Detail Information

Upper Weld Leg Size(Weld 41): 0.1880 in.
Nozzle Wall Thickness(tₚ): 0.1610 in.
Outside Groove Weld Depth: 0.1880 in.

Fig. UV-15.1 (c)

Nozzle passes through the vessel, attached by a groove weld.
Nozzle is adequate for UG-45 requirements.
Opening is adequately reinforced for Internal Pressure.
Reinforcement calculations are not required per UG-36(c)(3)(a)See Uw-14 for exceptions.
Weld Strength Paths are adequate.
Pressure Vessel Engineering, Ltd.

2" Heavy Ferrule Nozzle B

Job No: PVE-Sample5
Number: 4
ID Number: N-B

Vessel Number: Sample Vessel 5
Mark Number: N-B

Date Printed: 11/20/2008

---

**Required Shell Thickness per Paragraph UG-37(a)**

\[
tr = \frac{P_{Ro}}{SE + 0.4P} = \frac{200.00 \times 6.3750}{18600 \times 1 + 0.4 \times 200.00} = 0.0683 \text{ in.}
\]

---

**Nozzle Required Thickness Calculations**

**Required Nozzle Thickness for Internal Pressure per Paragraph UG-37(a)**

\[
trn = \frac{P_{Rn}}{SE - 0.6P} = \frac{200.00 \times 0.9350}{18600 \times 1 - 0.6 \times 200.00} = 0.0101 \text{ in.}
\]

---

**Strength Reduction Factors**

\[
fr1 = \min \left( \frac{S_n}{S_v}, 1.0000 \right) = \min \left( \frac{18600}{18600}, 1.0000 \right) = 1.0000
\]

\[
fr2 = \min \left( \frac{S_n}{S_v}, 1.0000 \right) = \min \left( \frac{18600}{18600}, 1.0000 \right) = 1.0000
\]

\[
fr3 = \min \left( \frac{S_n}{S_v}, 1.0000 \right) = \min \left( \frac{18600}{18600}, 1.0000 \right) = 1.0000
\]

---

**UG-45 Thickness Calculations**

**Nozzle Thickness for Pressure Loading (plus corrosion) per Paragraph UG-45(a)**

\[
t = \frac{P_{Rn}}{SE - 0.6P} + Ca + ext. Ca = \frac{200.00 \times 0.9350}{18600 \times 1 - 0.6 \times 200.00} + 0.0000 + 0.0000 = 0.0145 \text{ in.}
\]

**Nozzle Thickness for Internal Pressure (plus corrosion) per Paragraph UG-45(b)(1)**

\[
t = \frac{P_{Ro}}{SE + 0.4P} + Ca + ext. Ca = \frac{200.00 \times 6.3750}{18600 \times 1 + 0.4 \times 200.00} + 0.0000 + 0.0000 = 0.0683 \text{ in.}
\]

**Minimum Thickness of Standard Wall Pipe (plus corrosion) per Paragraph UG-45(b)(4)**

\[
t = \text{minimum thickness of standard wall pipe} + Ca + ext. Ca = 0.1347 \text{ in.}
\]

**Nozzle Minimum Thickness per Paragraph UG-45(b)**

\[
t = \text{Smallest of UG-45(b)(1) or UG-45(b)(4)} = 0.0683 \text{ in.}
\]

Wall thickness = \( tn = 0.1610 \) is greater than or equal to UG-45 value of 0.0683
**Pressure Vessel Engineering, Ltd.**

Job No: PVE-Sample5  
Number: 4  
ID Number: N-B  

2" Heavy Ferrule Nozzle B  

Vessel Number: Sample Vessel 5  
Mark Number: N-B  

Date Printed: 11/20/2008

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### Nozzle Weld Strength Calculations

**Attachment Weld Strength per Paragraph UW-16**

Weld 41 \( t_{\text{min}} \) = smaller of 0.75, \( t \), or \( t_n \) = smaller of 0.75, 0.1880, or 0.1610  

\[ t_{\text{min}} = 0.1610 \text{ in.} \]

Weld 41 Leg \( \text{min.} \) = \( \frac{\text{smaller of 0.25 or } (t_{\text{min}} \times 0.7) + \text{ext. CA}}{0.7} \)

\[ \frac{0.1127}{0.7} = 0.1610 \text{ in.} \]

Weld 41, actual weld leg = 0.1880 in.

---

### Unit Stresses per Paragraphs UG-45(c) and UW-15

Nozzle wall in shear = 0.70 * \( S_n \) = 0.70 * 18600  

Upper fillet, Weld 41, in shear = 0.49 * Material Stress = 0.49 * 18600  

Vessel groove weld, in tension = 0.74 * Material Stress = 0.74 * 18600  

**Strength of Connection Elements**

Nozzle wall in shear = \( \frac{1}{2} \pi \) * mean nozzle diameter * \( t_n \)  

Nozzle wall in shear unit stress = \( \frac{1}{2} \pi \) * \( 2.0310 \times 0.1610 \times 13020 \)

Upper fillet in shear = \( \frac{1}{2} \pi \) * Nozzle OD * weld leg * upper fillet in shear unit stress = \( \frac{1}{2} \pi \) * 2.1920 * 0.1880 * 9114

Groove Weld in Tension = \( \frac{1}{2} \pi \) * Nozzle OD * groove depth * groove weld tension unit stress = \( \frac{1}{2} \pi \) * 2.1920 * 0.1880 * 13764

---

### Load to be carried by welds, per UG-41(b)(1) and Fig. UG-41.1 sketch (a)

\[ W = (A - A1 + 2 \times t_n \times f1(E1 - F1)) \times S_v = [0.1277 - 0.2238 + 2 \times 0.1610 \times 1.0000 \times (1.00 \times 0.1880 - 1.0000 \times 0.0683)] \times 18600 \]

\[ W1-1 = (A2 + A5 + A41 + A42) \times S_v = (0.1215 + 0.0000 + 0.0353 + 0.0000) \times 18600 \]

\[ W2-2 = (A2 + A3 + A41 + A43 + 2 \times t_n \times f1) \times S_v = (0.1215 + 0.0000 + 0.0353 + 0.0000 + 2 \times 0.1610 \times 0.1880 \times 1.0000) \times 18600 \]

\[ W3-3 = (A2 + A3 + A5 + A41 + A42 + A43 + 2 \times t_n \times f1) \times S_v = (0.1215 + 0.0000 + 0.0000 + 0.0353 + 0.0000 + 0.0000 + 2 \times 0.1610 \times 0.1880 \times 1.0000) \times 18600 \]

**Check Strength Paths**

**Path 1-1** = Upper fillet in shear + Nozzle wall in shear = 5900 + 6680

**Path 2-2** = Upper fillet in shear + Groove weld in tension + Inner fillet in shear = 5900 + 8910 + 0

**Path 3-3** = Upper fillet in shear + Inner fillet in shear + Groove weld in tension = 5900 + 0 + 8910

---

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Section VIII, Division 1, 2007 Edition
### Loose Flange Design Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Design Pressure</td>
<td>200.00 PSI</td>
</tr>
<tr>
<td>Static Head</td>
<td>1.00 PSI</td>
</tr>
<tr>
<td>Material</td>
<td>SA-240 304H, High</td>
</tr>
<tr>
<td>Outside Diameter (A)</td>
<td>14.7500 in.</td>
</tr>
<tr>
<td>Bolt Circle (C)</td>
<td>13.0000 in.</td>
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<tr>
<td>Flange Weight</td>
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<td>Design Temperature</td>
<td>350°F</td>
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<tr>
<td>Corrosion Allowance</td>
<td>0.0000 in.</td>
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<tr>
<td>Factor B Chart</td>
<td>HA-1</td>
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<tr>
<td>Material Stress Hot (S_H)</td>
<td>18600 PSI</td>
</tr>
<tr>
<td>Material Stress Cold (S_C)</td>
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<tr>
<td>Flange I.D. (B)</td>
<td>10.8750 in.</td>
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</table>

### Minimum Design Metal Temperature

Material is exempt from impact testing per UHA-51(d)

### Bolting Information

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<thead>
<tr>
<th>Material</th>
<th>SA-193 Gr B8 &lt;=3/4&quot;</th>
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<tbody>
<tr>
<td>Material Condition</td>
<td>Class 2</td>
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<tr>
<td>Bolt Size</td>
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<tr>
<td>Nominal Bolt Diameter (a)</td>
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<tr>
<td>Bolt Hole Diameter</td>
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<tr>
<td>Material Stress Hot (S_B)</td>
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<td>Material Stress Cold (S_A)</td>
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<tr>
<td>Bolt Root Area</td>
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### Gasket & Facing Information

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<tr>
<th>Material</th>
<th>Self energizing</th>
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<tr>
<td>Type</td>
<td>Ring</td>
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<tr>
<td>Seating Stress (y)</td>
<td>200 PSI</td>
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<tr>
<td>O.D. Contact Face</td>
<td>12.1250 in.</td>
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<tr>
<td>Factor m</td>
<td>1.00</td>
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<tr>
<td>Gasket Width (N)</td>
<td>0.5000 in.</td>
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### Host Component: Nozzle 1 - 10" Inlet Nozzle C

<table>
<thead>
<tr>
<th>Material</th>
<th>SA-312 TP304 SMLS, High</th>
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<tbody>
<tr>
<td>Material Stress Hot (S_Ho)</td>
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<tr>
<td>Material Stress Cold (S_Ca)</td>
<td>20000 PSI</td>
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<tr>
<td>Inside Diameter</td>
<td>10.0200 in.</td>
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<tr>
<td>Wall Thickness (t_n)</td>
<td>0.3650 in.</td>
</tr>
</tbody>
</table>

### ASME Flange Calculations per Appendix 2

**Gasket Seating Calculations (Table 2-5.2)**

\[
 b_0 = \frac{N}{2} = \frac{0.5000}{2} = 0.2500 \text{ in.}
\]

Since \( b_0 \leq 1/4 \text{ in.} \), \( b = 0.2500 \text{ in.} \)

\[
 G = \text{O.D. contact face} - N = 12.1250 - 0.5000 = 11.6250 \text{ in.}
\]

Bolting is Adequate for Flange Design

Nominal Thickness is Adequate for Seating Conditions

Nominal Thickness is Adequate for Operating Conditions

Flange Thickness is Adequate for Flange Design

Flange Rigidity is Adequate.
Load and Bolting Calculations - Internal Pressure

The absolute value of effective pressure “P” is used for calculations.

\[
P = \frac{16\, M}{\pi\, G^2} + \frac{4\, F_A}{\pi\, G^2} + P_{\text{int}} + \text{Static Head} = \frac{16\, 0}{3.14159 \times 11.6250^2} + \frac{4\times 0}{3.14159 \times 11.6250^2} + 200.00 + 1.00 = 201.00 \text{ PSI}
\]

Minimum \(W_{m2} = \pi b G y = 3.14159 \times 0.2500 \times 11.6250 \times 200 = 1826 \text{ lb.}\)

\[
H = \frac{\pi}{4} G^2 P = \frac{3.14159}{4} \times 11.6250^2 \times 201.00 = 21334 \text{ lb.}
\]

\[
H_p = 2bGmP = 2 \times 0.2500 \times 3.14159 \times 11.6250 \times 1.00 \times 201.00 = 3670 \text{ lb.}
\]

Minimum \(W_{m1} = H + H_p = 21334 + 3670 = 25004 \text{ lb.}\)

\[
A_{m1} = \frac{W_{m1}}{S_b} = \frac{41173}{25000} = 1.6469 \text{ sq. in.}
\]

\[
A_{m2} = \frac{W_{m2}}{S_a} = \frac{1826}{25000} = 0.0730 \text{ sq. in.}
\]

\(A_m = \text{Greater of } A_{m1} \text{ or } A_{m2} = \text{greater of } 1.6469 \text{ or } 0.0730 = 1.6469 \text{ sq. in.}\)

\(A_b = \text{Number of Bolts} \times \text{Bolt Root Area} = 8 \times 0.3020 = 2.4160 \text{ sq. in.}\)

\[
W = \frac{(A_m + A_b)S_a}{2} = \frac{(1.6469 + 2.4160) \times 25000}{2} = 50786 \text{ lb.}
\]

\(A_b \geq A_m, \text{ Bolting is Adequate for Flange Design}\)

Internal Pressure Moment Calculations - Operating Conditions

\[
H_D = \frac{\pi}{4} B^2 P = \frac{3.1416}{4} \times 10.8750^2 \times 201.00 = 18670 \text{ lb.}
\]

\[
H_G = W_{m1} \times H = 41173 \times 21334 = 19839 \text{ lb.}
\]

\[
H_T = H - H_D = 21334 - 18670 = 2664 \text{ lb.}
\]

\[
h_D = \frac{C - B}{2} = \frac{13.0000 - 10.8750}{2} = 1.0625 \text{ in.}
\]

\[
h_G = \frac{C - G}{2} = \frac{13.0000 - 11.6250}{2} = 0.6875 \text{ in.}
\]

\[
h_T = \frac{h_D + h_G}{2} = \frac{1.0625 + 0.6875}{2} = 0.8750 \text{ in.}
\]

\[
M_D = H_D h_D = 18670 \times 1.0625 = 19837 \text{ in.-lb.}
\]

\[
M_G = H_G h_G = 19839 \times 0.6875 = 13639 \text{ in.-lb.}
\]

\[
M_T = H_T h_T = 2664 \times 0.8750 = 2331 \text{ in.-lb.}
\]

\[
M_o = M_D + M_G + M_T = 19837 + 13639 + 2331 = 35807 \text{ in.-lb.}
\]
Internal Pressure Moment Calculations - Gasket Seating

\[ M_g = W_h G = 50786 \times 0.6875 = 34915 \text{ in.-lb.} \]

Shape Constants
Calculated from Figure 2-7.1

\[
K = \frac{A}{B} = \frac{14.7500}{10.8750} = 1.3563
\]

\[
Y = \frac{1}{K - 1} \left( 0.66845 + \frac{5.71690 \times \ln(10) K}{K^2 - 1} \right) = \frac{1}{1.3563 - 1} \left( 0.66845 + \frac{5.71690 \times 1.3563 \times \ln(10) \times 1.3563}{1.3563^2 - 1} \right) = 6.5293
\]

Bolt Spacing Calculations

Internal Pressure Stress Calculations - Operating Conditions

\[
S_T = \frac{Y_C M_o}{B \epsilon} = \frac{6.5293 \times 1.0000 \times 35807}{10.8750 \times 1.3750} = 11371 \text{ PSI}
\]

Since \( S_T \leq S_{fo} \), nominal thickness is \text{ADEQUATE} for operating conditions.

Internal Pressure Stress Calculations - Gasket Seating

\[
S_T = \frac{Y_C M_s}{B \epsilon} = \frac{6.5293 \times 1.0000 \times 34915}{10.8750 \times 1.3750} = 11088 \text{ PSI}
\]

Since \( S_T \leq S_{fa} \), nominal thickness is \text{ADEQUATE} for seating conditions.

Internal Pressure Rigidity Index per Appendix 2-14 - Operating Conditions

\[
J = 109.4 \frac{M_o}{Et^2 \ln(K) K_L} = 109.4 \frac{35807}{26.7 \times 10^4 \times 1.3750^3 \times \ln(1.3563) \times 0.2} = 0.93
\]

\[ J \leq 1, \text{design meets Flange Rigidity requirements for Operating Conditions} \]

Internal Pressure Rigidity Index per Appendix 2-14 - Seating Conditions

\[
J = 109.4 \frac{M_s}{Et^2 \ln(K) K_L} = 109.4 \frac{34915}{28.3 \times 10^4 \times 1.3750^3 \times \ln(1.3563) \times 0.2} = 0.85
\]

\[ J \leq 1, \text{design meets Flange Rigidity requirements for Seating Conditions} \]

Internal Pressure Minimum Thickness

\[ = 1.3380 \text{ in.} \]
Nominal Thickness Selected = 1.3750 in.
Blind Flange Design Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Pressure</td>
<td>200.00 PSI</td>
</tr>
<tr>
<td>Static Head</td>
<td>0.00 PSI</td>
</tr>
<tr>
<td>Material</td>
<td>SA-240 304, Low</td>
</tr>
<tr>
<td>Outside Diameter (A)</td>
<td>12.7500 in.</td>
</tr>
<tr>
<td>Bolt Circle (C)</td>
<td>14.7500 in.</td>
</tr>
<tr>
<td>Flange Weight</td>
<td>37.03 lb.</td>
</tr>
<tr>
<td>Head Factor C</td>
<td>0.3000</td>
</tr>
<tr>
<td>Weld Efficiency</td>
<td>100 %</td>
</tr>
</tbody>
</table>

Minimum Design Metal Temperature
Material is exempt from impact testing per UHA-51(d)

Bolting Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>SA-193 Gr B8</td>
</tr>
<tr>
<td>Material Condition</td>
<td>Class 1</td>
</tr>
<tr>
<td>Bolt Size</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td>Nominal Bolt Diameter (a)</td>
<td>0.7500 in.</td>
</tr>
</tbody>
</table>

Gasket & Facing Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Asbestos with suitable binder</td>
</tr>
<tr>
<td>Type</td>
<td>1/16 in. thick</td>
</tr>
<tr>
<td>O.D. Contact Face</td>
<td>12.7500 in.</td>
</tr>
<tr>
<td>Factor m</td>
<td>2.75</td>
</tr>
<tr>
<td>Facing Sketch</td>
<td>6</td>
</tr>
<tr>
<td>Facing Width (w)</td>
<td>0.2700 in.</td>
</tr>
</tbody>
</table>

ASME Flange Calculations per Appendix 2
Gasket Seating Calculations(Table 2-5.2)

Since $b_0 <= 1/4$ in., $b = b_0$

\[ G = O.D. \text{ contact face} - w = 12.7500 - 0.2700 = 12.4800 \text{ in.} \]

Nominal Thickness Selected = 1.0000 in.
Load and Bolting Calculations - Internal Pressure

The absolute value of effective pressure “P” is used for calculations.

\[ P = \frac{16 \times 10^6}{\pi \times G} + \frac{4 \times A}{G} + P_{\text{int}} + \text{Static Head} = \frac{16 \times 0}{3.14159 \times 12.4800} + \frac{4 \times 0}{3.14159 \times 12.4800} + 200.00 + 0.00 = 200.00 \text{ PSI} \]

Minimum \( W_{m2} = \pi bGy = 3.14159 \times 0.0338 \times 12.4800 \times 3700 = 4903 \text{ lb.} \)

\[ H = \frac{\pi}{4} G \times P = \frac{3.14159}{4} \times 12.4800 \times 200.00 = 24465 \text{ lb.} \]

\[ H_p = 2bGmP = 2 \times 0.0338 \times 3.14159 \times 12.4800 \times 2.75 \times 200.00 = 1458 \text{ lb.} \]

Minimum \( W_{m1} = H + H_p = 24465 + 1458 = 25923 \text{ lb.} \)

\[ A_{m1} = \frac{W_{m1}}{S_b} = \frac{25923}{14400} = 1.8002 \text{ sq. in.} \]

\[ A_{m2} = \frac{W_{m2}}{S_a} = \frac{4903}{18800} = 0.2608 \text{ sq. in.} \]

\( A_m = \text{Greater of } A_{m1} \text{ or } A_{m2} = \text{ greater of 1.8002 or 0.2608} = 1.8002 \text{ sq. in.} \)

\( A_b = \text{Number of Bolts} \times \text{Bolt Root Area} = 6 \times 0.3020 = 1.8120 \text{ sq. in.} \)

\[ W = \frac{(A_m + A_b)S_a}{2} = \frac{(1.8002 + 1.8120) \times 18800}{2} = 33955 \text{ lb.} \]

\[ h_G = \frac{(C - G)}{2} = \frac{(14.7500 - 12.4800)}{2} = 1.1350 \text{ in.} \]

Ab \( \geq A_m, \) Bolting is Adequate for Flange Design

Thickness Calculations

Operating Minimum \( t = G \sqrt{\frac{CP}{SE} + \frac{1.9W_{m1}h_G}{SEG^2}} = 12.4800 \times \sqrt{\frac{0.3000 \times 200.00}{14400 \times 1.00} + \frac{1.9 \times 25923 \times 1.1350}{14400 \times 1.00 \times 12.4800^2}} = 0.9798 \text{ in.} \)

Seating Minimum \( t = G \sqrt{\frac{1.9Wh_G}{SEG^2}} = 12.4800 \times \sqrt{\frac{1.9 \times 33955 \times 1.1350}{20000 \times 1.00 \times 12.4800^2}} = 0.5416 \text{ in.} \)

Minimum \( t = \text{maximum}(0.9798, 0.5416) + CA = 0.9798 + 0.0000 = 0.9798 \text{ in.} \)
# ASME Flange Design Information

<table>
<thead>
<tr>
<th>Host</th>
<th>Description</th>
<th>Type</th>
<th>Size (in.)</th>
<th>Material</th>
<th>ASME Class</th>
<th>Material Group</th>
<th>MAP (PSI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot; Inlet Nozzle A</td>
<td>ASME Flange 1</td>
<td>Slip-On</td>
<td>2</td>
<td>SA-182 F304</td>
<td>300</td>
<td>2.1</td>
<td>517.50</td>
</tr>
</tbody>
</table>
Cone-to-Cylinder Reinforcement
Design Calculations for Small End Juncture

Juncture is not a line of support

**Description:** Cone to Cylinder 1

**Design Temperature:** 350 °F

**Design Pressure:** 200.00 PSI

**Static Head:** 1.00 PSI

**Axial Load in Compression (f2):** 0 lb./in.

**Shell Design Information**

8.03 OD Ferrule Advanced Coupling

- **Design Pressure:** 200.00 PSI
- **Static Head:** 1.00 PSI
- **Material Stress (hot) (S_s):** 14400 PSI
- **Material Stress (cold):** 20000 PSI
- **Nominal Thickness (t_s):** 0.0780 in.

**Cone Material:** SA-240 304, High

- **Modulus of Elasticity (E_s):** 26.7 10^6 PSI
- **Cone Surface Length (L_c):** 5.5284 in.
- **Cone Small End Diameter:** 8.0300 in.
- **Cone Angle (\(\alpha\)):** 25°

\[
Q_S = f_2 + f_2 + \left(\frac{PR_S}{2}\right) = 0.00 + \left(\frac{201.00 \times 3.9370}{2}\right) = 395.67 \text{ lb./in.}
\]

\[
Y = S_eE_s = 14400 \times 26.7 \times 10^6 = 384480 \times 10^6 \text{ PSI}^2
\]

k = 1, No ring stiffener.

\[
A_{S1} = \left(\frac{kQ_sR_s}{S_eE_1}\right) \left(1 - \frac{\Delta}{\alpha}\right) \tan(\alpha) = \frac{1.0000 \times 395.67 \times 3.9370}{18600 \times 0.70} \left(1 - \frac{12.5}{25.3}\right) 0.4721 = 0.0369 \text{ sq. in.}
\]

\[
A_{S2} = \frac{P}{4} \sqrt{R_s t_s \left(t_s - t\right) + \left(\frac{t_c - t_r}{\cos \alpha}\right)} = \frac{3.14159 \times 3.9370 \times 0.0780}{4} \left[0.0780 \times 0.0655 + \left(\frac{0.1875 \times 0.0682}{0.9043}\right)\right] = 0.0629 \text{ sq. in.}
\]

\[
A_{S1} + A_{S2} = 0.0629 + 0.0000 = 0.0629 \text{ sq. in.}
\]

**Conical Reducer Design Information**

Conical Reducer 1

- **Design Pressure:** 200.00 PSI
- **Static Head:** 1.00 PSI
- **Material Stress (hot) (S_c):** 18600 PSI
- **Material Stress (cold):** 20000 PSI
- **Nominal Thickness (t_c):** 0.1875 in.
- **Minimum Thickness (t_r):** 0.0682 in.

Internal Pressure per Appendix 1-5

For \(\frac{P}{S_eE_1} = \frac{201.00}{14400 \times 0.70} = 0.019940\), maximum cone angle (\(\Delta\)) = 12.5°

Actual Cone Angle of 25° > maximum cone angle of 12.5°, reinforcement area requirements must be checked.

\[
A_{S1} = \frac{P_i}{4} \sqrt{R_s t_s \left(t_s - t\right) + \left(\frac{t_c - t_r}{\cos \alpha}\right)} = \frac{3.14159 \times 3.9370 \times 0.0780}{4} \left[0.0780 \times 0.0655 + \left(\frac{0.1875 \times 0.0682}{0.9043}\right)\right] = 0.0629 \text{ sq. in.}
\]

\[
A_{S2} = \frac{P_i}{4} \sqrt{R_s t_s \left(t_s - t\right) + \left(\frac{t_c - t_r}{\cos \alpha}\right)} = \frac{3.14159 \times 3.9370 \times 0.0780}{4} \left[0.0780 \times 0.0655 + \left(\frac{0.1875 \times 0.0682}{0.9043}\right)\right] = 0.0629 \text{ sq. in.}
\]

\[
A_{S1} + A_{S2} = 0.0629 + 0.0000 = 0.0629 \text{ sq. in.}
\]

**Cone area + shell area >= required area for internal reinforcement**

JUNCTURE PASSES
Cone-to-Cylinder Reinforcement
Design Calculations for Small End Juncture

**Juncture is not a line of support**

**Description:** Cone to Cylinder 2

Design Pressure: 200.00 PSI
Axial Load in Compression ($f_2$): 0 lb./in.

**Shell Design Information**

- **Design Pressure:** 200.00 PSI
- **Design Temperature:** 350 °F
- **Static Head:** 1.00 PSI
- **Material Stress (hot) ($S_s$):** 14400 PSI
- **Modulus of Elasticity ($E_s$):** 26.7 10^6 PSI
- **Shell Length ($L_s$):** 3.9370 in.
- **Inside Radius:** 3.9370 in.
- **Minimum Thickness ($t_s$):** 0.0655 in.

**Conical Reducer Design Information**

- **Design Pressure:** 200.00 PSI
- **Design Temperature:** 350 °F
- **Static Head:** 1.00 PSI
- **Material Stress (hot) ($S_c$):** 18600 PSI
- **Modulus of Elasticity ($E_c$):** 26.7 10^6 PSI
- **Cone Surface Length ($L_c$):** 5.5284 in.
- **Cone Small End Diameter:** 8.0300 in.
- **Nominal Thickness ($t_c$):** 0.1875 in.
- **Minimum Thickness ($t_r$):** 0.0682 in.

**Internal Pressure per Appendix 1-5**

For $P = \frac{201.00}{14400 \times 0.70} = 0.019940$, maximum cone angle ($\Lambda$)

$= 12.5^\circ$

**Actual Cone Angle of 25° > maximum cone angle of 12.5°**, reinforcement area requirements must be checked.

$Q_S = f_2 + \left( \frac{PR_S}{2} \right) = 0.00 + \left( \frac{201.00 \times 3.9370}{2} \right) = 395.67$ lb./in.

$Y = S_sE_s = 14400 \times 26.7 \times 10^6$

$k = 1$, No ring stiffener.

$A_{rs} = \left( \frac{kQ_SR_S}{S_sE_s} \right) \left( 1 - \frac{\Lambda}{\alpha} \right) \tan(\alpha) = \frac{1.0000 \times 395.67 \times 3.9370}{18600 \times 0.70} \left( 1 - \frac{12.5}{25.3} \right) 0.4721 = 0.0369$ sq. in.

$A_{rs} + A_{rs} = 0.0629 + 0.0000$

Conical Reducer $A_{rs} + A_{rs} = 0.0629$ sq. in.

**Juncture Passes**

---

Cone to Cylinder 2

Design Temperature: 350 °F
Static Head: 1.00 PSI

Shell Material: SA-479 304, Low

Material Stress (hot) ($S_s$): 14400 PSI
Modulus of Elasticity ($E_s$): 26.7 10^6 PSI
Shell Length ($L_s$): 3.9370 in.
Inside Radius: 3.9370 in.
Minimum Thickness ($t_s$): 0.0655 in.

Conical Reducer 1

Design Temperature: 350 °F
Static Head: 1.00 PSI
Shell Material: SA-240 304, High

Material Stress (hot) ($S_c$): 18600 PSI
Modulus of Elasticity ($E_c$): 26.7 10^6 PSI
Cone Surface Length ($L_c$): 5.5284 in.
Cone Small End Diameter: 8.0300 in.
Nominal Thickness ($t_c$): 0.1875 in.
Minimum Thickness ($t_r$): 0.0682 in.
Cone-to-Cylinder Reinforcement
Design Calculations for Large End Juncture

Juncture is not a line of support

Description: Cone to Cylinder 3
Design Pressure: 200.00 PSI
Axial Load in Compression ($f_1$): 0 lb./in.

Shell Design Information

Shell 2
Design Pressure: 200.00 PSI
Static Head: 1.00 PSI
Shell Material: SA-240 304H, High
Modulus of Elasticity ($E_s$): 26.7 $10^6$ PSI
Shell Length ($L_s$): 15.5000 in.
Inside Radius: 6.1870 in.
Minimum Thickness ($t_s$): 0.0974 in.

Conical Reducer Design Information

Conical Reducer 1
Design Pressure: 200.00 PSI
Static Head: 1.00 PSI
Cone Material: SA-240 304, High
Modulus of Elasticity ($E_c$): 26.7 $10^6$ PSI
Cone Surface Length ($L_c$): 5.5284 in.
Cone Small End Diameter: 8.0300 in.
Nominal Thickness ($t_c$): 0.1875 in.
Cone Angle ($\alpha$): 25°

Internal Pressure per Appendix 1-5

\[
\frac{P}{S_s E_1} = \frac{200.00}{18600 \times 0.70} = 0.015361, \text{ maximum cone angle (} \Lambda) = 30.0°
\]

Actual Cone Angle of 25° <= maximum cone angle of 30.0°, reinforcement not required for internal pressure.

Maximum cone angle > Cone angle, reinforcement not needed for internal pressure

JUNCTURE PASSES
**MDMT Report by Components**

Design MDMT is -20 °F

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
<th>Curve</th>
<th>Pressure</th>
<th>MDMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outlet 8&quot; Ferrule Nozzle D</td>
<td>SA-479 304, High</td>
<td>Exempt per UCS-66(b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shell 2 - thin shell</td>
<td>SA-240 304, High</td>
<td>Exempt per UCS-66(b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10&quot; Inlet Nozzle C</td>
<td>SA-312 TP304 SMLS,</td>
<td>Exempt per UCS-66(b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10&quot; Inlet Flange</td>
<td>SA-240 304H, High</td>
<td>Exempt per UHA-51(d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2&quot; Heavy Ferrule Nozzle B</td>
<td>SA-479 304, High</td>
<td>Exempt per UCS-66(b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>thick shell</td>
<td>SA-312 TP304 SMLS,</td>
<td>Exempt per UHA-51(d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conical Reducer 1</td>
<td>SA-240 304, High</td>
<td>Other Exemption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2&quot; Inlet Nozzle A</td>
<td>SA-312 TP304 SMLS,</td>
<td>Exempt per UCS-66(b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cover Flange</td>
<td>SA-240 304, Low</td>
<td>Exempt per UHA-51(d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2&quot;3000# Cplg N-E</td>
<td>SA-182 F304 &lt;=5&quot;, Hig</td>
<td>Exempt per UCS-66(b)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The required design MDMT of -20 °F has been met or exceeded for the calculated MDMT values.

ASME Flanges Are Not Included in MDMT Calculations.
### MAWP Report by Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Design Pressure</th>
<th>Static Head</th>
<th>Vessel MAWP New &amp; Cold UG-98(a)</th>
<th>Component MAWP Hot &amp; Corroded UG-98(b)</th>
<th>Vessel MAWP Hot &amp; Corroded UG-98(a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outlet 8” Ferrule Nozzle D</td>
<td>200.00 PSI</td>
<td>1.00 PSI</td>
<td>31.85 PSI</td>
<td>309.55 PSI</td>
<td>308.55 PSI</td>
</tr>
<tr>
<td>Shell 2 - thin shell</td>
<td>200.00 PSI</td>
<td>1.00 PSI</td>
<td>341.24 PSI</td>
<td>318.29 PSI</td>
<td>317.29 PSI</td>
</tr>
<tr>
<td>10” Inlet Nozzle C</td>
<td>200.00 PSI</td>
<td>1.00 PSI</td>
<td>341.24 PSI</td>
<td>318.29 PSI</td>
<td>317.29 PSI</td>
</tr>
<tr>
<td>10” Inlet Flange</td>
<td>200.00 PSI</td>
<td>1.00 PSI</td>
<td>NC</td>
<td>476.81 PSI</td>
<td>475.81 PSI</td>
</tr>
<tr>
<td>2” Heavy Ferrule Nozzle B</td>
<td>200.00 PSI</td>
<td>0.00 PSI</td>
<td>597.00 PSI</td>
<td>555.21 PSI</td>
<td>555.21 PSI</td>
</tr>
<tr>
<td>2” thick shell</td>
<td>200.00 PSI</td>
<td>1.00 PSI</td>
<td>1664.83 PSI</td>
<td>1549.16 PSI</td>
<td>1548.16 PSI</td>
</tr>
<tr>
<td>Conical Reducer 1</td>
<td>200.00 PSI</td>
<td>1.00 PSI</td>
<td>375.37 PSI</td>
<td>350.02 PSI</td>
<td>349.02 PSI</td>
</tr>
<tr>
<td>2” Inlet Nozzle A</td>
<td>200.00 PSI</td>
<td>1.00 PSI</td>
<td>660.56 PSI</td>
<td>615.25 PSI</td>
<td>614.25 PSI</td>
</tr>
<tr>
<td>ASME Flange Class: 300 Gr:2.1</td>
<td>200.00 PSI</td>
<td>1.00 PSI</td>
<td>719.00 PSI</td>
<td>517.50 PSI</td>
<td>516.50 PSI</td>
</tr>
<tr>
<td>Cover Flange</td>
<td>200.00 PSI</td>
<td>0.00 PSI</td>
<td>262.82 PSI</td>
<td>201.31 PSI</td>
<td>201.31 PSI</td>
</tr>
<tr>
<td>2”3000# Cplg N-E</td>
<td>200.00 PSI</td>
<td>0.00 PSI</td>
<td>289.37 PSI</td>
<td>208.34 PSI</td>
<td>208.34 PSI</td>
</tr>
</tbody>
</table>

NC = Not Calculated  Inc = Incomplete

### Summary

Component with the lowest vessel MAWP(New & Cold) : **Cover Flange**

The lowest vessel MAWP(New & Cold) : **262.82 PSI**

Component with the lowest vessel MAWP(Hot & Corroded) : **Cover Flange**

The lowest vessel MAWP(Hot & Corroded) : **201.31 PSI**

Pressures are exclusive of any external loads.

Flange pressures listed here do not consider external loadings
### Summary Information

<table>
<thead>
<tr>
<th></th>
<th>Dry Weight</th>
<th>Flooded Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell</td>
<td>67.95 lb.</td>
<td>153.85 lb.</td>
</tr>
<tr>
<td>Conical Reducer</td>
<td>9.62 lb.</td>
<td>23.99 lb.</td>
</tr>
<tr>
<td>Nozzle</td>
<td>17.14 lb.</td>
<td>17.14 lb.</td>
</tr>
<tr>
<td>Flange</td>
<td>68.13 lb.</td>
<td>68.13 lb.</td>
</tr>
<tr>
<td>ASME Flange</td>
<td>7.00 lb.</td>
<td>7.00 lb.</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>169.83 lb.</strong></td>
<td><strong>270.11 lb.</strong></td>
</tr>
</tbody>
</table>

### Volume

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell</td>
<td>10.28 Gal.</td>
</tr>
<tr>
<td>Conical Reducer</td>
<td>1.72 Gal.</td>
</tr>
<tr>
<td>Nozzle</td>
<td>1.68 Gal.</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>13.68 Gal.</strong></td>
</tr>
</tbody>
</table>

### Area

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell</td>
<td>5.76 Sq. Ft.</td>
</tr>
<tr>
<td>Conical Reducer</td>
<td>1.25 Sq. Ft.</td>
</tr>
<tr>
<td>Nozzle</td>
<td>2.67 Sq. Ft.</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>9.68 Sq. Ft.</strong></td>
</tr>
</tbody>
</table>

### Hydrostatic Test Information

**Gauge at Top**

- **Calculated Test Pressure:** 279.57 PSI
- **Specified Test Pressure:** 260.00 PSI

This calculation assumes one chamber.

This calculation is limited by the lowest component pressure per chamber.