VESSEL DESCRIPTION

Horizontal Retention Tank

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: Sample Vessel 3
Vessel Number: Horizontal Vessel

NAMEPLATE INFORMATION

Vessel MAWP: 75.00 PSI at 150 °F
MDMT: -20 °F at 75.00 PSI
Serial Number(s): ________________
National Board Number(s): ________________
Year Built: 2008
Radiography: NONE
Postweld Heat Treated: NONE

Signatures

Mechanical Technologist: __________________________________ Date: ___/___/____
Alex Turvey

P.Eng: __________________________________________ Date: ___/___/____
Laurence Brundrett

<table>
<thead>
<tr>
<th>REV</th>
<th>DESCRIPTION</th>
<th>DATE</th>
<th>INITIALS</th>
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<td>1</td>
<td>REVISED</td>
<td>10/22/2008</td>
<td>ART</td>
</tr>
<tr>
<td>0</td>
<td>RELEASE</td>
<td>5/23/2002</td>
<td>LB</td>
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Pressure Vessel Engineering, Ltd.
120 Randall Dr.  Waterloo, Ontario  N2V 1C6

Date Printed: 10/27/2008
### Cylindrical Shell Design Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Pressure</td>
<td>75.00 PSI</td>
</tr>
<tr>
<td>Static Head</td>
<td>3.50 PSI</td>
</tr>
<tr>
<td>Shell Material</td>
<td>SA-516 Gr 70</td>
</tr>
<tr>
<td>Shell Length</td>
<td>120.0000 in.</td>
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<tr>
<td>Corrosion Allowance</td>
<td>0.0000 in.</td>
</tr>
<tr>
<td>External Corrosion Allowance</td>
<td>0.0000 in.</td>
</tr>
<tr>
<td>Outside Diameter (new)</td>
<td>96.0000 in.</td>
</tr>
<tr>
<td>Outside Diameter (corroded)</td>
<td>96.0000 in.</td>
</tr>
<tr>
<td>Shell Material Stress (hot)</td>
<td>20000 PSI</td>
</tr>
<tr>
<td>Shell Material Stress (cold)</td>
<td>20000 PSI</td>
</tr>
<tr>
<td>Compressive Stress</td>
<td>11484 PSI</td>
</tr>
<tr>
<td>Material Stress (hot)</td>
<td>20000 PSI</td>
</tr>
<tr>
<td>Material Stress (cold)</td>
<td>20000 PSI</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.00</td>
</tr>
<tr>
<td>Shell Surface Area</td>
<td>251.33 Sq. Ft.</td>
</tr>
<tr>
<td>Shell Estimated Volume</td>
<td>3711.74 Gal.</td>
</tr>
<tr>
<td>Circ. Joint Efficiency</td>
<td>70 %</td>
</tr>
<tr>
<td>Min. Temperature Curve</td>
<td>B</td>
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<tr>
<td>Pressure at MDMT</td>
<td>75.00 PSI</td>
</tr>
<tr>
<td>Minimum Design Metal Temperature: -20 °F</td>
<td></td>
</tr>
<tr>
<td>Computed Minimum Temperature: -20 °F</td>
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</tr>
</tbody>
</table>

### Design Thickness Calculations

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

\[
t = \frac{PR}{2SE + 0.4P} = \frac{78.50 \times 47.6875}{2 \times 20000 \times 0.70 + 0.4 \times 78.50} = 0.1335 + 0.0000 \text{ (corrosion)} + 0.0000 \text{ (ext. corrosion)} = \text{minimum of 0.1335 in.}
\]

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

\[
t = \frac{PR_0}{SE + 0.4P} = \frac{78.50 \times 48.0000}{20000 \times 0.70 + 0.4 \times 78.50} = 0.2686 + 0.0000 \text{ (corrosion)} + 0.0000 \text{ (ext. corrosion)} = \text{minimum of 0.2686 in.}
\]

**Extreme Fiber Elongation Calculation per Paragraph UCS-79**

\[
\text{Elongation} = \frac{50t}{R_f} = \frac{50 \times 0.3125}{47.8438} = \text{elongation of 0.33 %}
\]

Nominal Shell Thickness Selected = **0.3125** in.
**Ellipsoidal Head Design Information**

- **Design Pressure:** 75.00 PSI
- **Static Head:** 3.50 PSI
- **Head Material:** SA-516 Gr 70
- **Corrosion Allowance:** 0.0000 in.
- **External Corrosion Allowance:** 0.0000 in.
- **Material Stress (hot):** 20000 PSI
- **Material Stress (cold):** 20000 PSI
- **Actual Head Stress:** 15637 PSI
- **K = \( \frac{PD_oK}{2SE + 2P(K - 0.1)} \):** 1.00
- **Head Surface Area:** 72.44 Sq. Ft.
- **Head Depth (ho):** 24.1563 in.
- **Head Location:** Right
- **Head Weight:** 922.50 lb.
- **Total Flooded Head Weight:** 5410.04 lb.
- **Minimum Design Metal Temperature Data**
  - **Min. Temperature Curve:** B
  - **UCS-66(b) reduction:** No
  - **UCS-68(c) reduction:** No
  - **Pressure at MDMT:** 75.00 PSI
  - **Minimum Design Metal Temperature:** -20 °F
  - **Computed Minimum Temperature:** -20 °F
- **Design Thickness Calculations**
  - **Design Thickness Calculations per Appendix 1-4(c)**
    - \( \frac{PD_oK}{2SE + 2P(K - 0.1)} = \frac{78.50 \times 96.0000 \times 1.00}{2 \times 20000 \times 0.85 + 2 \times 78.50 \times (1.00 - 0.1)} = 0.2208 + 0.0000 \text{ (corrosion)} + 0.0000 \text{ (ext. corrosion)} + 0.0305 \text{ (thin out)} = \text{minimum of 0.2513 in.} \)
- **Extreme Fiber Elongation Calculation per Paragraph UCS-79**
  - \( \frac{75t}{R_f} = \frac{75 \times 0.3125}{16.2669} = \text{elongation of 1.44 %} \)
- **Nominal Head Thickness Selected:** 0.3125 in.
- **Minimum Thickness after forming, \( t_s \) (uncorroded):** 0.2820 in.
Ellipsoidal Head Design Information

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Pressure</td>
<td>75.00 PSI</td>
</tr>
<tr>
<td>Static Head</td>
<td>3.50 PSI</td>
</tr>
<tr>
<td>Head Material</td>
<td>SA-516 Gr 70</td>
</tr>
<tr>
<td>Corrosion Allowance</td>
<td>0.0000 in.</td>
</tr>
<tr>
<td>External Corrosion Allowance</td>
<td>0.0000 in.</td>
</tr>
<tr>
<td>Head Location</td>
<td>Left</td>
</tr>
<tr>
<td>Outside Diameter</td>
<td>96.0000 in.</td>
</tr>
<tr>
<td>Thin Out</td>
<td>0.0305 in.</td>
</tr>
<tr>
<td>K = ( \frac{1}{\pi} \left[ 2 + \frac{D}{2h} \right] )</td>
<td>1.00</td>
</tr>
<tr>
<td>Head Surface Area</td>
<td>72.44 Sq. Ft.</td>
</tr>
<tr>
<td>Head Estimated Volume</td>
<td>538.07 Gal.</td>
</tr>
<tr>
<td>Head Weight</td>
<td>922.50 lb.</td>
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<tr>
<td>Specific Gravity</td>
<td>1.00</td>
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<tr>
<td>Weight of Fluid</td>
<td>4487.55 lb.</td>
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<tr>
<td>Total Flooded Head Weight</td>
<td>5410.04 lb.</td>
</tr>
<tr>
<td>Minimum Design Metal Temperature Data</td>
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<tr>
<td>Min. Temperature Curve: B</td>
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<tr>
<td>UCS-66(b) reduction: No</td>
<td></td>
</tr>
<tr>
<td>UCS-68(c) reduction: No</td>
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<tr>
<td>Pressure at MDMT:</td>
<td>75.00 PSI</td>
</tr>
<tr>
<td>Minimum Design Metal Temperature:</td>
<td>-20 °F</td>
</tr>
<tr>
<td>Computed Minimum Temperature</td>
<td>-20 °F</td>
</tr>
</tbody>
</table>

Design Thickness Calculations

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

\[
t = \frac{PD_0K}{2SE + 2P(K - 0.1)} = \frac{78.50 \times 96.0000 \times 1.00}{2 \times 20000 \times 0.85 + 2 \times 78.50 \times (1.00 - 0.1)} = 0.2208 + 0.0000 \text{ (corrosion)} + 0.0000 \text{ (ext. corrosion)} + 0.0305 \text{ (thin out)} = \text{minimum of } 0.2513 \text{ in.}
\]

**Extreme Fiber Elongation Calculation per Paragraph UCS-79**

\[
elongation = \frac{75t}{R_f} = \frac{75 \times 0.3125}{16.2669} = \text{elongation of } 1.44 \%
\]

Nominal Head Thickness Selected = 0.3125 in.
Minimum Thickness after forming, \( t_s \) (uncorroded) = 0.2820 in.
Pressure Vessel Engineering, Ltd.

Job No: Sample Vessel 3
Number: 9
ID Number: A

Date Printed: 10/27/2008

Design Pressure: 75.00 PSI
Static Head: 3.50 PSI
Nozzle Material: SA-105

Design Temperature: 150 °F
Nozzle Efficiency (E): 100%
Joint Efficiency (E_j): 1.00

External Projection: 0.6270 in.
Internal Projection: 0.0000 in.
Inside Corrosion Allowance: 0.0000 in.
External Corrosion Allowance: 0.0000 in.

Nozzle ID (new): 1.0650 in.
Nozzle Wall Thickness (new): 0.1625 in.
Nozzle ID (corroded): 1.0650 in.
Nozzle Wall Thickness (corroded): 0.1625 in.

Nozzle Detail Information

Backing strip if used may be removed after welding

Upper Weld Leg Size (Weld 41): 0.2500 in.
Nozzle Wall Thickness (t_n): 0.1625 in.
Outside Groove Weld Depth: 0.3125 in.

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.

Advanced Pressure Vessel version: 10.0.2 ©Computer Engineering, Inc.
Required Shell Thickness per Paragraph UG-37(a)

$$\frac{PR_o}{SE + 0.4P} = \frac{78.50 \cdot 48.0000}{20000 \cdot 1 + 0.4 \cdot 78.50} = 0.1881 \text{ in.}$$

Nozzle Required Thickness Calculations

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

$$\frac{PR_n}{SE - 0.6P} = \frac{78.50 \cdot 0.5325}{20000 \cdot 1 - 0.6 \cdot 78.50} = 0.0021 \text{ in.}$$

Strength Reduction Factors

$$fr_1 = \min \left( \frac{S_n}{S_v}, 1.0000 \right) = \min \left( \frac{20000}{20000}, 1.0000 \right) = 1.0000$$

$$fr_2 = \min \left( \frac{S_n}{S_v}, 1.0000 \right) = \min \left( \frac{20000}{20000}, 1.0000 \right) = 1.0000$$

$$fr_3 = \min \left( \frac{S_n}{S_v}, 1.0000 \right) = \min \left( \frac{20000}{20000}, 1.0000 \right) = 1.0000$$

UG-45 Thickness Calculations

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

$$t = \frac{PR_n}{SE - 0.6P} + Ca + \text{ext. Ca} = \frac{78.50 \cdot 0.5325}{20000 \cdot 1 - 0.6 \cdot 78.50} + 0.0000 + 0.0000 = 0.0021 \text{ in.}$$

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

$$t = \frac{PR_o}{SE + 0.4P} + Ca + \text{ext. Ca} = \frac{78.50 \cdot 48.0000}{20000 \cdot 1 + 0.4 \cdot 78.50} + 0.0000 + 0.0000 = 0.1881 \text{ in.}$$

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

$$t = \text{minimum thickness of standard wall pipe} + Ca + \text{ext. Ca}$$

$$t = 0.1225 \text{ in.}$$

Nozzle Minimum Thickness per Paragraph UG-45(b)

$$t = \text{Smallest of UG-45(b)(1) or UG-45(b)(4)}$$

$$t = 0.1225 \text{ in.}$$

Wall thickness = tn = 0.1625 is greater than or equal to UG-45 value of 0.1225
Nozzle Weld Strength Calculations

Attachment Weld Strength per Paragraph UW-16

Weld 41 tmin = smaller of 0.75, t, or tn = smaller of 0.75, 0.3125, or 0.1625

Weld 41 Leg min. = \(\frac{(\text{smaller of } 0.25 \text{ or } (t_{\text{min}} \times 0.7)) + \text{ext. CA}}{0.7}\) = \(0.1138\) in.

Weld 41, actual weld leg = 0.2500 in.

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

Nozzle wall in shear = 0.70 \times Sn = 0.70 \times 20000 = 14000 PSI

Upper fillet, Weld 41, in shear = 0.49 \times Material Stress = 0.49 \times 20000 = 9800 PSI

Vessel groove weld, in tension = 0.74 \times Material Stress = 0.74 \times 20000 = 14800 PSI

Strength of Connection Elements

Nozzle wall in shear = \(0.5 \times \pi \times \text{mean nozzle diameter} \times tn \times \text{Nozzle wall in shear unit stress} = 4380\) lb.

Upper fillet in shear = \(0.5 \times \pi \times \text{Nozzle OD} \times \text{weld leg} \times \text{upper fillet in shear unit stress} = 5350\) lb.

Groove Weld in Tension = \(0.5 \times \pi \times \text{Nozzle OD} \times \text{groove depth} \times \text{groove weld tension unit stress} = 10100\) lb.

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

\[W = [A - A_1 + 2 \text{ tn fr1(E1t - Ftr)}] SV = [0.2003 - 0.1325 + 2 \times 0.1625 \times 1.0000 \times (1.00 \times 0.3125 - 1.0000 \times 0.1881)] \times 20000 = 2160\) lb.

\[W_{1-1} = (A_2 + A_5 + A_41 + A_42) \times SV = (0.1303 + 0.0000 + 0.0625 + 0.0000) \times 20000 = 3860\) lb.

\[W_{2-2} = (A_2 + A_3 + A_41 + A_43 + 2 \text{ tn fr1}) SV = (0.1303 + 0.0000 + 0.0625 + 0.0000 + 2 \times 0.1625 \times 0.3125 \times 1.0000) \times 20000 = 5890\) lb.

\[W_{3-3} = (A_2 + A_3 + A_4 + A_4 + A_43 + 2 \text{ tn fr1}) \times SV = (0.1303 + 0.0000 + 0.0625 + 0.0000 + 2 \times 0.1625 \times 0.3125 \times 1.0000) \times 20000 = 5890\) lb.

Check Strength Paths

Path 1-1 = Upper fillet in shear + Nozzle wall in shear = 5350 + 4380 = 9730 lb.

Path 2-2 = Upper fillet in shear + Groove weld in tension + Inner fillet in shear = 5350 + 10100 + 0 = 15450 lb.

Path 3-3 = Upper fillet in shear + Inner fillet in shear + Groove weld in tension = 5350 + 0 + 10100 = 15450 lb.
Job No: Sample Vessel 3
Number: 1
ID Number: 1

Date Printed: 10/27/2008

Nozzle Design Information

Design Pressure: 75.00 PSI
Static Head: 3.50 PSI
Nozzle Material: SA-106 Gr B
External Projection: 4.0000 in.
Internal Projection: 1.0000 in.
Inside Corrosion Allowance: 0.0000 in.
External Corrosion Allowance: 0.0000 in.
Nozzle Pipe Size: 6
Nozzle ID (new): 5.7610 in.
Nozzle ID (corroded): 5.7610 in.
Developed Opening: 7.4700 in.
Outer "h" Limit: 0.7050 in.
Internal "h" Limit: 0.7050 in.
OD, Limit of Reinforcement: 14.9400 in.

Minimum Design Metal Temperature

Min. Temp. Curve: B
Pressure at MDMT: 3.50 PSI
UCS-66(b) reduction: Yes
UCS-68(c) reduction: No
Computed Minimum Temperature: -155 °F

Host Component: Head 2 - Left Side Head

Material: SA-516 Gr 70
Material Stress(S_v): 20000 PSI
Head wall thickness(new): 0.3125 in.
Head wall thickness - thin out (corroded): 0.2820 in.

Nozzle Detail Information

Upper Weld Leg Size(Weld 41): 0.3125 in.
Internal Weld Leg Size(Weld 43): 0.3125 in.
Nozzle Wall Thickness(t_n): 0.4320 in.
Outside Groove Weld Depth: 0.2820 in.

Nozzle is adequate for UG-45 requirements.
Opening is adequately reinforced for Internal Pressure.
Weld Strength Paths are adequate.
Required Head Thickness per Paragraph UG-37(a)

\[ tr = \frac{P \cdot K \cdot D_o}{(2SE + 0.8P)} = \frac{78.50 \cdot 0.9000 \cdot 96.0000}{(2 \cdot 20000 \cdot 1 + 0.8 \cdot 78.50)} = 0.1693 \text{ in.} \]

Nozzle Required Thickness Calculations

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

\[ tr_n = \frac{PR_n}{SE \cdot 0.6P} = \frac{78.50 \cdot 2.8805}{17100 \cdot 1 \cdot 0.6 \cdot 78.50} = 0.0133 \text{ in.} \]

Strength Reduction Factors

\[ fr_1 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{17100}{20000}, 1.0000 \right) = 0.8550 \]
\[ fr_2 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{17100}{20000}, 1.0000 \right) = 0.8550 \]
\[ fr_3 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{17100}{20000}, 1.0000 \right) = 0.8550 \]

UG-45 Thickness Calculations

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

\[ t = \frac{PR_n}{SE \cdot 0.6P} + Ca + ext. Ca = \frac{78.50 \cdot 2.8805}{17100 \cdot 1 \cdot 0.6 \cdot 78.50} + 0.0000 + 0.0000 = 0.0133 \text{ in.} \]

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

\[ t = \frac{P \cdot K \cdot D_o}{(2SE + 2P(K - 0.1))} + Ca + ext. Ca = \frac{78.50 \cdot 1.0000 \cdot 96.0000}{(2 \cdot 20000 \cdot 1 + 2 \cdot 78.50 \cdot (1.0000 - 0.1))} + 0.0000 + 0.0000 = 0.1877 \text{ in.} \]

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

\[ t = \text{minimum thickness of standard wall pipe} + Ca + ext. Ca = 0.2450 \text{ in.} \]

Nozzle Minimum Thickness per Paragraph UG-45(b)

\[ t = \text{Smallest of UG-45(b)(1) or UG-45(b)(4)} = 0.1877 \text{ in.} \]

Wall thickness = \( tn \cdot 0.875(\text{pipe}) = 0.3780 \text{ is greater than or equal to UG-45 value of 0.1877} \)
Nozzle Reinforcement Calculations

Area Required for Internal Pressure

\[ A = d \cdot r \cdot t + 2 \cdot t \cdot r \cdot t \cdot (1 - f_r1) = (7.4700 \times 0.1693 \times 1.00) + (2 \times 0.4320 \times 0.1693 \times 1.00 \times (1 - 0.8550)) = 1.2859 \text{ sq. in.} \]

Area Available - Internal Pressure

\[ A_1 \text{ Formula 1} = d(E_1 \cdot t - F \cdot tr) - 2tn(E_1 \cdot t - F \cdot tr)(1 - f_r1) = \\
7.4700 \times (1.00 \times 0.2820 - 1.00 \times 0.1693) - 2 \times 0.4320 \times (1.00 \times 0.2820 - 1.00 \times 0.1693) \times (1 - 0.8550) = 0.8277 \text{ sq. in.} \]

\[ A_1 \text{ Formula 2} = 2(t + tn)(E_1 \cdot t - F \cdot tr) - 2tn(E_1 \cdot t - F \cdot tr)(1 - f_r1) = \\
2 \times (0.2820 + 0.4320)(1.00 \times 0.2820 - 1.00 \times 0.1693) - 2 \times 0.4320 \times (1.00 \times 0.2820 - 1.00 \times 0.1693) \times (1 - 0.8550) = 0.1468 \text{ sq. in.} \]

\[ A_1 = \text{Larger value of } A_1 \text{ Formula 1 and } A_1 \text{ Formula 2} = 0.8277 \text{ sq. in.} \]

\[ A_2 \text{ Formula 1} = 5(tn - trn) \cdot f_r2 \cdot t = 5(0.4320 - 0.0133) \times 0.8550 \times 0.2820 = 0.5048 \text{ sq. in.} \]

\[ A_2 \text{ Formula 2} = 5(tn - trn) \cdot fr2 \cdot tn = 5(0.4320 - 0.0133) \times 0.8550 \times 0.4320 = 0.7733 \text{ sq. in.} \]

\[ A_2 = \text{Smaller value of } A_2 \text{ Formula 1 and } A_2 \text{ Formula 2} = 0.5048 \text{ sq. in.} \]

\[ A_3 = \text{Smaller value of the following} : \\
5 \times t_i \cdot f_r2 = 5 \times 0.2820 \times 0.4320 \times 0.8550 = 0.5208 \text{ sq. in.} \\
5 \times t_i \cdot t_i \cdot f_r2 = 5 \times 0.4320 \times 0.4320 \times 0.8550 = 0.7978 \text{ sq. in.} \\
2 \times h \times t_i \cdot f_r2 = 2 \times 1.0000 \times 0.4320 \times 0.8550 = 0.7387 \text{ sq. in.} \

= 0.5208 \text{ sq. in.} \]

\[ A_{41} = (\text{leg})^2 \times f_r2 = (0.3125)^2 \times 0.8550 = 0.0835 \text{ sq. in.} \]

\[ A_{43} = (\text{leg})^2 \times f_r2 = (0.3125)^2 \times 0.8550 = 0.0835 \text{ sq. in.} \]

Area Available (Internal Pressure) = A_1 + A_2 + A_3 + A_{41} + A_{43} = 2.0203 \text{ sq. in., which is greater than } A_1 (1.2859)
Nozzle Weld Strength Calculations

Attachment Weld Strength per Paragraph UW-16

Weld 41 \( t_{\text{min}} = \text{smaller of } 0.75, t, \text{ or } t_n = \text{smaller of } 0.75, 0.2820, \text{ or } 0.4320 \) = 0.2820 in.

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

= 0.1974 in.

Weld 41, actual weld leg = 0.3125 in.

Weld 43 \( t_{\text{min}} = \text{smaller of } 0.75, t, \text{ or } t_n = \text{smaller of } 0.75, 0.2820, \text{ or } 0.4320 \) = 0.2820 in.

Weld 43 Leg min. = \[
\frac{\text{smaller of } 0.25 \text{ or } (t_{\text{min}} \times 0.7)}{0.7} + \text{CA}
\]

= 0.1974 in.

Weld 43, actual weld leg = 0.3125 in.

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

Nozzle wall in shear = 0.70 \* Sn = 0.70 \* 17100 = 11970 PSI

Upper fillet, Weld 41, in shear = 0.49 \* Material Stress = 0.49 \* 17100 = 8379 PSI

Vessel groove weld, in tension = 0.74 \* Material Stress = 0.74 \* 17100 = 12654 PSI

Inner fillet, Weld 43, in shear = 0.49 \* Material Stress = 0.49 \* 17100 = 8379 PSI

Strength of Connection Elements

Nozzle wall in shear = \( \frac{1}{2} \times \pi \times \text{mean nozzle diameter} \times t_n \times \text{Nozzle wall in shear unit stress} \)

= \( \frac{1}{2} \times \pi \times 6.1930 \times 0.4320 \times 11970 \) = 50300 lb.

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

= \( \frac{1}{2} \times \pi \times 6.6250 \times 0.3125 \times 8379 \) = 27200 lb.

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

= \( \frac{1}{2} \times \pi \times 6.6250 \times 0.2820 \times 12654 \) = 37100 lb.

Inner fillet in shear = \( \frac{1}{2} \times \pi \times \text{Nozzle OD} \times \text{weld leg} \times \text{inner fillet in shear unit stress} \)

= \( \frac{1}{2} \times \pi \times 6.6250 \times 0.3125 \times 8379 \) = 27200 lb.

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

\[
W = [A - A1 + 2 \times \text{fr1(E1t - Ftr)}] \times Sv = [1.2859 - 0.8277 + 2 \times 0.4320 \times 0.8550 \times (1.00 \times 0.2820 - 1.0000 \times 0.1693)] \times 20000 = 10800 \text{ lb.}
\]

\[
W1-1 = (A2 + A5 + A41 + A42) \times Sv = (0.5048 + 0.0000 + 0.0835 + 0.0000) \times 20000 = 11800 \text{ lb.}
\]

\[
W2-2 = (A2 + A3 + A41 + A43 + 2 \times \text{fr1}) \times Sv = (0.5048 + 0.5208 + 0.0835 + 0.0835 + 2 \times 0.4320 \times 0.2820 \times 0.8550) \times 20000 = 28000 \text{ lb.}
\]

\[
W3-3 = (A2 + A3 + A5 + A41 + A42 + A43 + 2 \times \text{fr1}) \times Sv = (0.5048 + 0.5208 + 0.0000 + 0.0835 + 0.0000 + 0.0835 + 2 \times 0.4320 \times 0.2820 \times 0.8550) \times 20000 = 28000 \text{ lb.}
\]

Check Strength Paths

Path 1-1 = Upper fillet in shear + Nozzle wall in shear = 27200 + 50300 = 77500 lb.

Path 2-2 = Upper fillet in shear + Groove weld in tension + Inner fillet in shear = 27200 + 37100 + 27200 = 91500 lb.

Path 3-3 = Upper fillet in shear + Inner fillet in shear + Groove weld in tension = 27200 + 27200 + 37100 = 91500 lb.
Pressure Vessel Engineering, Ltd.

C - 6" Pipe

Job No: Sample Vessel 3
Number: 7
ID Number: C

Date Printed: 10/27/2008

Nozzle Design Information

Design Pressure: 75.00 PSI
Static Head: 3.50 PSI
Nozzle Material: SA-106 Gr B
External Projection: 4.0000 in.
Internal Projection: 0.0000 in.
Inside Corrosion Allowance: 0.0000 in.
External Corrosion Allowance: 0.0000 in.
Nozzle Pipe Size: 6
Nozzle Pipe Schedule: 80
Nozzle ID (new): 5.7610 in.
Nozzle ID (corroded): 5.7610 in.
Developed Opening: 6.8000 in.
Outer "h" Limit: 0.7050 in.
Internal "h" Limit: 0.7050 in.
OD, Limit of Reinforcement: 10.0000 in.

Allowable Stress at Design Temperature ($S_n$): 17100 PSI
Allowable Stress at Ambient Temperature: 17100 PSI
Correction Factor (F): 1.00
Tangential Dimension L: 5.2500 in.

Nozzle Wall Thickness (new): 0.4320 in.
Nozzle Wall Thickness (corroded): 0.4320 in.

Nozzle Efficiency (E): 100%
Joint Efficiency ($E_1$): 1.00
Factor B Chart: CS-2

Minimum Design Metal Temperature

Min. Temp. Curve: B
UCS-66(b) reduction: Yes
UCS-68(c) reduction: No
Pressure at MDMT: 3.50 PSI
Minimum Design Metal Temperature: -20 °F
Computed Minimum Temperature: -155 °F

Reinforcing Pad Information

Reinforcing Material: SA-516 Gr 70
Reinforcing Plate Thickness ($t_e$): 0.3125 in.
OD, Reinforcing Plate ($D_p$): 12.0000 in.
Repad to Vessel Weld Leg Size (Weld 42): 0.2500 in.
Repad to Nozzle Groove Weld Depth: 0.0000 in.

Host Component: Head 1 - Right Side Head
Material: SA-516 Gr 70
Head wall thickness (new): 0.3125 in.
Head wall thickness - thin out (corroded): 0.2820 in.
Material Stress ($S_v$): 20000 PSI

Nozzle Detail Information

Upper Weld Leg Size (Weld 41): 0.3125 in.
Nozzle Wall Thickness ($t_n$): 0.4320 in.
Outside Groove Weld Depth: 0.2820 in.
Repad to Vessel Weld Leg Size (Weld 42): 0.2500 in.
Repad Thickness ($t_e$): 0.3125 in.

Fig. UG-15.1 (c)

tangential to the vessel wall, attached by a groove weld.

Pipe Size: 6 Schedule: 80

Nozzle is adequate for UG-45 requirements.
Opening is adequately reinforced for Internal Pressure.
Weld Strength Paths are adequate.
Required Head Thickness per Paragraph UG-37(a)

$$tr = \frac{P \cdot K \cdot D_0}{(2 \cdot SE + 2P(K - 0.1))} = \frac{78.50 \cdot 1.0000 \cdot 96.0000}{(2 \cdot 20000 \cdot 1 + 2 \cdot 78.50 \cdot (1.0000 - 0.1))} = 0.1877 \text{ in.}$$

Nozzle Required Thickness Calculations

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

$$trn = \frac{PRn}{SE - 0.6P} = \frac{78.50 \cdot 2.8805}{17100 \cdot 1 - 0.6 \cdot 78.50} = 0.0133 \text{ in.}$$

Strength Reduction Factors

$$fr1 = \min\left(\frac{Sn}{Sv}, 1.0000\right) = \min\left(\frac{17100}{20000}, 1.0000\right) = 0.8550$$

$$fr2 = \min\left(\frac{Sn}{Sv}, 1.0000\right) = \min\left(\frac{17100}{20000}, 1.0000\right) = 0.8550$$

$$fr3 = \min\left(\frac{Sn}{Sv}, 1.0000\right) = \min\left(\frac{17100}{20000}, 1.0000\right) = 0.8550$$

$$fr4 = \min\left(\frac{Sp}{Sv}, 1.0000\right) = \min\left(\frac{20000}{20000}, 1.0000\right) = 1.0000$$

UG-45 Thickness Calculations

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

$$t = \frac{PRn}{SE - 0.6P} + Ca + ext.\ Ca = \frac{78.50 \cdot 2.8805}{17100 \cdot 1.00 - 0.6 \cdot 78.50} + 0.0000 + 0.0000 = 0.0133 \text{ in.}$$

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

$$t = \frac{P \cdot K \cdot D_0}{(2 \cdot SE + 2P(K - 0.1))} + Ca + ext.\ Ca = \frac{78.50 \cdot 1.0000 \cdot 96.0000}{(2 \cdot 20000 \cdot 1 + 2 \cdot 78.50 \cdot (1.0000 - 0.1))} + 0.0000 + 0.0000 = 0.1877 \text{ in.}$$

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

$$t = \text{minimum thickness of standard wall pipe} + Ca + ext.\ Ca = 0.2450 \text{ in.}$$

Nozzle Minimum Thickness per Paragraph UG-45(b)

$$t = \text{Smallest of UG-45(b)(1) or UG-45(b)(4)} = 0.1877 \text{ in.}$$

Wall thickness = $tn \cdot 0.875($pipe) = $0.3780$ is greater than or equal to UG-45 value of $0.1877$
Nozzle Reinforcement Calculations

**Area Required for Internal Pressure**

\[ A = d \, tr \, F + 2 \, t n \, tr \, F \, (1 - fr1) = (6.8000 \times 0.1877 \times 1.00) + (2 \times 0.4320 \times 0.1877 \times 1.00 \times (1 - 0.8550)) = 1.2999 \text{ sq. in.} \]

**Area Available - Internal Pressure**

\[ A_1 = (d_{LR} - d)(E1 \, t - F \, tr) - 2tn(E1 \, t - F \, tr)(1 - fr1) = (10.0000 \times 6.8000) \times (1.00 \times 0.2820 - 1.00 \times 0.1877) - 2 \times 0.4320 \times (1.00 \times 0.2820 - 1.00 \times 0.1877) \times (1 - 0.8550) = 0.2899 \text{ sq. in.} \]

\[ A_2 \text{ Formula 1} = 5(tn - trn) \, fr2 \, t = 5(0.4320 - 0.0133) \times 0.8550 \times 0.2820 = 0.5048 \text{ sq. in.} \]

\[ A_2 \text{ Formula 2} = 2(tn - trn) \, fr2 \, (2.5 \, tn + te) = 2(0.4320 - 0.0133) \times 0.8550 \times (2.5 \times 0.4320 + 0.3125) = 0.9970 \text{ sq. in.} \]

\[ A_2 \text{ = Smaller value of } A_2 \text{ Formula 1 and } A_2 \text{ Formula 2} = 0.5048 \text{ sq. in.} \]

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

\[ 5 \times t \times t_1 \times f_{r2} = 5 \times 0.2820 \times 0.4320 \times 0.8550 = 0.5208 \text{ sq. in.} \]

\[ 5 \times t_1 \times t_1 \times f_{r2} = 5 \times 0.4320 \times 0.4320 \times 0.8550 = 0.7978 \text{ sq. in.} \]

\[ 2 \times h \times t_1 \times f_{r2} = 2 \times 0.0000 \times 0.4320 \times 0.8550 = 0.0000 \text{ sq. in.} \]

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

\[ A_{41} = (\text{leg})^2 \times fr3 = (0.3125)^2 \times 0.8550 = 0.0835 \text{ sq. in.} \]

\[ A_{42} = \text{Allowable Weld 42 area} \times fr4 = 0.0000 \times 1.0000 = 0.0000 \text{ sq. in.} \]

\[ A_{43} = (\text{leg})^2 \times fr2 = 0 \times 0.8550 = 0.0000 \text{ sq. in.} \]

\[ A_5 = (Dp - d - 2tn) \, te \, fr4 = (10.0000 - 6.8000 - 2 \times 0.4320) \times 0.3125 \times 1.0000 = 0.7300 \text{ sq. in.} \]

\[ \text{Area Available (Internal Pressure)} = A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 = 1.6082 \text{ sq. in., which is greater than } A (1.2999) \]
Nozzle Weld Strength Calculations

Attachment Weld Strength per Paragraph UW-16

Weld 41 $t_{\text{min}}$ = smaller of 0.75, $t_e$, or $t_n$ = smaller of 0.75, 0.3125, or 0.4320

Weld 41 Leg min. = \(\frac{(\text{smaller of } 0.25 \text{ or } (t_{\text{min}} \times 0.7)) + \text{ext. CA}}{0.7}\) = 0.2188

Weld 41, actual weld leg = 0.3125 in.

Weld 42 $t_{\text{min}}$ = smaller of 0.75, $t$, or $t_e$ = smaller of 0.75, 0.2820, or 0.3125

Weld 42 Leg min. = \(\frac{0.5 \times t_{\text{min}} + \text{ext. CA}}{0.7}\) = 0.2014 in.

Weld 42, actual weld leg = 0.2500 in.

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

Nozzle wall in shear = 0.70 * $S_n$ = 0.70 * 17100 = 11970 PSI

Upper fillet, Weld 41, in shear = 0.49 * Material Stress = 0.49 * 17100 = 8379 PSI

Vessel groove weld, in tension = 0.74 * Material Stress = 0.74 * 17100 = 12654 PSI

Outer fillet, Weld 42, in shear = 0.49 * Material Stress = 0.49 * 20000 = 9800 PSI

Strength of Connection Elements

Nozzle wall in shear = \(\frac{1}{2} \times \pi \times \text{mean nozzle diameter} \times t_n \times \text{Nozzle wall in shear unit stress}\)

\(\frac{1}{2} \times \pi \times 6.1930 \times 0.4320 \times 11970 = 50300\) lb.

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

\(\frac{1}{2} \times \pi \times 6.6250 \times 0.2820 \times 0.8550 \times 8379 = 27200\) lb.

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

\(\frac{1}{2} \times \pi \times 6.6250 \times 0.2820 \times 12654 = 37100\) lb.

Outer fillet in shear = \(\frac{1}{2} \times \pi \times \text{Plate OD} \times \text{weld leg} \times \text{outer fillet in shear unit stress}\)

\(\frac{1}{2} \times \pi \times 12.0000 \times 0.2500 \times 9800 = 46200\) lb.

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

\(W = [A \cdot A1 + 2 \cdot \text{tn fr1(E1t - Fr1)}] \cdot S_v = [1.2999 - 0.2899 + 2 \cdot 0.4320 \cdot 0.8550 \cdot (1.00 \cdot 0.2820 - 1.0000 \cdot 0.1877)] \cdot 20000 = 21600\) lb.

\(W_{1-1} = (A2 + A5 + A41 + A42) \cdot S_v = (0.5048 + 0.7300 + 0.0835 + 0.0000) \cdot 20000 = 26400\) lb.

\(W_{2-2} = (A2 + A3 + A41 + A43 + 2 \cdot \text{tn fr1}) \cdot S_v = (0.5048 + 0.0000 + 0.0835 + 0.0000 + 2 \cdot 0.4320 \cdot 0.2820 \cdot 0.8550) \cdot 20000 = 15900\) lb.

\(W_{3-3} = (A2 + A3 + A5 + A41 + A42 + A43 + 2 \cdot \text{tn fr1}) \cdot S_v = (0.5048 + 0.0000 + 0.7300 + 0.0835 + 0.0000 + 0.0000 + 2 \cdot 0.4320 \cdot 0.2820 \cdot 0.8550) \cdot 20000 = 30500\) lb.

Check Strength Paths

Path 1-1 = Outer fillet in shear + Nozzle wall in shear = 46200 + 50300 = 96500 lb.

Path 2-2 = Upper fillet in shear + Groove weld in tension + Inner fillet in shear = 27200 + 37100 + 0 = 64300 lb.

Path 3-3 = Outer fillet in shear + Inner fillet in shear + Groove weld in tension = 46200 + 0 + 37100 = 83300 lb.

Plate Strength = $A5 \cdot S_p = 0.7300 \cdot 20000 = 14600\) lb.

Outer fillet weld strength(46200) is greater than plate strength(14600).
Pressure Vessel Engineering, Ltd.

D - 12x16" MWY

Job No: Sample Vessel 3
Number: 6
ID Number: D

Date Printed: 10/27/2008

Nozzle Design Information

<table>
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<tr>
<th>Design Pressure:</th>
<th>75.00 PSI</th>
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<tr>
<td>Static Head:</td>
<td>3.50 PSI</td>
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<tr>
<td>Nozzle Material:</td>
<td>SA-106 Gr B</td>
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<td>Nozzle Efficiency (E):</td>
<td>100 %</td>
</tr>
<tr>
<td>Joint Efficiency (E₁):</td>
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<td>Factor B Chart:</td>
<td>CS-2</td>
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<td>External Projection:</td>
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<tr>
<td>Internal Projection:</td>
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<tr>
<td>Inside Corrosion Allowance:</td>
<td>0.0000 in.</td>
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<tr>
<td>External Corrosion Allowance:</td>
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<tr>
<td>Nozzle ID (new):</td>
<td>16.0000 in.</td>
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<tr>
<td>Nozzle ID (corroded):</td>
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<tr>
<td>Outer &quot;h&quot; Limit:</td>
<td>0.7050 in.</td>
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<tr>
<td>Internal &quot;h&quot; Limit:</td>
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<tr>
<td>OD, Limit of Reinforcement:</td>
<td>32.0000 in.</td>
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</tbody>
</table>

Allowable Stress at Design Temperature (Sₚₐ): 17100 PSI
Allowable Stress at Ambient Temperature: 17100 PSI

Nozzle Wall Thickness (new): 0.7500 in.
Nozzle Wall Thickness (corroded): 0.7500 in.
Upper Weld Leg Size (Weld 41): 0.3125 in.
Internal Weld Leg Size (Weld 43): 0.3125 in.
Outside Groove Weld Depth: 0.2820 in.

Minimum Design Metal Temperature

<table>
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<th>Min. Temp. Curve:</th>
<th>B</th>
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<tbody>
<tr>
<td>Pressure at MDMT:</td>
<td>75.00 PSI</td>
</tr>
<tr>
<td>Minimum Design Metal Temperature:</td>
<td>-20 °F</td>
</tr>
<tr>
<td>Computed Minimum Temperature:</td>
<td>-125 °F</td>
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</tbody>
</table>

Host Component: Head 2 - Left Side Head

Material: SA-516 Gr 70
Material Stress (Sᵥ): 20000 PSI
Head wall thickness (new): 0.3125 in.
Head wall thickness - thin out (corroded): 0.2820 in.

Nozzle Detail Information

Upper Weld Leg Size (Weld 41): 0.3125 in.
Internal Weld Leg Size (Weld 43): 0.3125 in.
Nozzle Wall Thickness (tₙ): 0.7500 in.
Outside Groove Weld Depth: 0.2820 in.

Fig. U/A-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.
Weld Strength Paths are adequate.
### Required Head Thickness per Paragraph UG-37(a)

\[
tr = \frac{P \times K_1 \times Do}{(2SE + 0.8P)} = \frac{78.50 \times 0.9000 \times 96.0000}{(2 \times 20000 \times 1 + 0.8 \times 78.50)} = 0.1693 \text{ in.}
\]

### Nozzle Required Thickness Calculations

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

\[
trn = \frac{PRn}{SE - 0.6P} = \frac{78.50 \times 8.0000}{17100 \times 1 - 0.6 \times 78.50} = 0.0368 \text{ in.}
\]

### Strength Reduction Factors

\[
fr1 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{17100}{20000}, 1.0000 \right) = 0.8550 \\
fr2 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{17100}{20000}, 1.0000 \right) = 0.8550 \\
fr3 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{17100}{20000}, 1.0000 \right) = 0.8550
\]

### UG-45 Thickness Calculations

This calculation is for an access or inspection opening.

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

\[
t = \frac{PRn}{SE - 0.6P} + Ca + \text{ext. Ca} = \frac{78.50 \times 8.0000}{17100 \times 1.00 - 0.6 \times 78.50} + 0.0000 + 0.0000 = 0.0368 \text{ in.}
\]
Nozzle Reinforcement Calculations

**Area Required for Internal Pressure**

\[ A = d\ tr\ F + 2\ tn\ tr\ F\ (1 - fr1) = (16.0000 * 0.1693 * 1.00) + (2 * 0.7500 * 0.1693 * 1.00 * (1 - 0.8550)) \]

\[ = 2.7456 \text{ sq. in.} \]

**Area Available - Internal Pressure**

\[ A1 = d(E1\ t - F\ tr) - 2tn(E1\ t - F\ tr)(1 - fr1) = 16.0000 * (1.00 * 0.2820 - 1.00 * 0.1693) - 2 * 0.7500 * (1.00 * 0.2820 - 1.00 * 0.1693) * (1 - 0.8550) = 1.7787 \text{ sq. in.} \]

\[ A1 = 2(t + tn)(E1\ t - F\ tr) - 2tn(E1\ t - F\ tr)(1 - fr1) = 2 * (0.2820 + 0.7500)(1.00 * 0.2820 - 1.00 * 0.1693) - 2 * 0.7500 * (1.00 * 0.2820 - 1.00 * 0.1693) * (1 - 0.8550) = 0.2081 \text{ sq. in.} \]

\[ A1 = \text{Larger value of } A1 \text{ Formula 1 and } A1 \text{ Formula 2} = 1.7787 \text{ sq. in.} \]

\[ A2 = 5(tn - trn) fr2 \ t = 5(0.7500 - 0.0368) * 0.8550 * 0.2820 = 0.8598 \text{ sq. in.} \]

\[ A2 = 5(tn - trn) fr2 \ tn = 5(0.7500 - 0.0368) * 0.8550 * 0.7500 = 2.2867 \text{ sq. in.} \]

\[ A2 = \text{Smaller value of } A2 \text{ Formula 1 and } A2 \text{ Formula 2} = 0.8598 \text{ sq. in.} \]

\[ A3 = \text{Smaller value of the following :} \]

\[ 5 \times t \times t_i \times f_2 = 5 \times 0.2820 \times 0.7500 \times 0.8550 = 0.9042 \text{ sq. in.} \]

\[ 5 \times t_i \times t_i \times f_2 = 5 \times 0.7500 \times 0.7500 \times 0.8550 = 2.4047 \text{ sq. in.} \]

\[ 2 \times h \times t_i \times f_2 = 2 \times 1.0000 \times 0.7500 \times 0.8550 = 1.2825 \text{ sq. in.} \]

\[ A41 = (\text{leg})^2 \times fr2 = (0.3125)^2 \times 0.8550 = 0.0835 \text{ sq. in.} \]

\[ A43 = (\text{leg})^2 \times fr2 = (0.3125)^2 \times 0.8550 = 0.0835 \text{ sq. in.} \]

\[ \text{Area Available (Internal Pressure)} = A1 + A2 + A3 + A41 + A43 = 3.7097 \text{ sq. in., which is greater than } A (2.7456) \]
Nozzle Weld Strength Calculations

Attachment Weld Strength per Paragraph UW-16

Weld 41 tmin = smaller of 0.75, t, or tn = smaller of 0.75, 0.2820, or 0.7500 = 0.2820 in.

Weld 41 Leg min. = \[ \frac{(\text{smaller of } 0.25 \text{ or } (\text{tmin} \times 0.7)) + \text{ext. CA}}{0.7} \] = 0.1974

Weld 41, actual weld leg = 0.3125 in.

Weld 43 tmin = smaller of 0.75, t, or tn = smaller of 0.75, 0.2820, or 0.7500 = 0.2820 in.

Weld 43 Leg min. = \[ \frac{(\text{smaller of } 0.25 \text{ or } (\text{tmin} \times 0.7)) + \text{ca}}{0.7} \] = 0.1974

Weld 43, actual weld leg = 0.3125 in.

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

Nozzle wall in shear = 0.70 * Sn = 0.70 * 17100 = 11970 PSI

Upper fillet, Weld 41, in shear = 0.49 * Material Stress = 0.49 * 17100 = 8379 PSI

Vessel groove weld, in tension = 0.74 * Material Stress = 0.74 * 17100 = 12654 PSI

Inner fillet, Weld 43, in shear = 0.49 * Material Stress = 0.49 * 17100 = 8379 PSI

Strength of Connection Elements

Nozzle wall in shear = \( \frac{1}{2} \pi \times \text{mean nozzle diameter} \times \text{tn} \times \text{Nozzle wall in shear unit stress} \) = 236100 lb.

Upper fillet in shear = \( \frac{1}{2} \pi \times \text{Nozzle OD} \times \text{weld leg} \times \text{upper fillet in shear unit stress} \) = 71900 lb.

Groove Weld in Tension = \( \frac{1}{2} \pi \times \text{Nozzle OD} \times \text{groove depth} \times \text{groove weld tension unit stress} \) = 98000 lb.

Inner fillet in shear = \( \frac{1}{2} \pi \times \text{Nozzle OD} \times \text{weld leg} \times \text{inner fillet in shear unit stress} \) = 71900 lb.

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

\[ W = [A - A1 + 2 \text{ tn fr1(E1t - Ftr)}] \text{ Sv} = [2.7456 - 1.7787 + 2 \times 0.7500 \times 0.8550 \times (1.00 \times 0.2820 - 1.0000 \times 0.1693)] \times 20000 \] = 22200 lb.

\[ W1-1 = (A2 + A5 + A41 + A42) \times \text{Sv} = (0.8598 + 0.0000 + 0.0835 + 0.0000) \times 20000 \] = 18900 lb.

\[ W2-2 = (A2 + A3 + A41 + A43 + 2 \text{ tn fr1}) \text{ Sv} = (0.8598 + 0.9042 + 0.0835 + 0.0835 + 2 \times 0.7500 \times 0.2820 \times 0.8550) \times 20000 \] = 45900 lb.

\[ W3-3 = (A2 + A3 + A5 + A41 + A42 + A43 + 2 \text{ tn fr1}) \times \text{Sv} = (0.8598 + 0.9042 + 0.0000 + 0.0835 + 0.0000 + 0.0835 + 2 \times 0.7500 \times 0.2820 \times 0.8550) \times 20000 \] = 45900 lb.

Check Strength Paths

Path 1-1 = Upper fillet in shear + Nozzle wall in shear = 71900 + 236100 = 308000 lb.

Path 2-2 = Upper fillet in shear + Groove weld in tension + Inner fillet in shear = 71900 + 98000 + 71900 = 241800 lb.

Path 3-3 = Upper fillet in shear + Inner fillet in shear + Groove weld in tension = 71900 + 71900 + 98000 = 241800 lb.
Nozzle Design Information

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<td>Static Head:</td>
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<td>Joint Efficiency (E1):</td>
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<td>Factor B Chart:</td>
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<td>External Projection:</td>
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<tr>
<td>Internal Projection:</td>
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<tr>
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<tr>
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<tr>
<td>Nozzle ID (corroded):</td>
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<tr>
<td>Nozzle Wall Thickness (new):</td>
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<tr>
<td>Nozzle Wall Thickness (corroded):</td>
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<tr>
<td>Outer &quot;h&quot; Limit:</td>
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<tr>
<td>Internal &quot;h&quot; Limit:</td>
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</tr>
<tr>
<td>OD, Limit of Reinforcement:</td>
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<tr>
<td>Allowable Stress at Design Temperature (Sn):</td>
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<tr>
<td>Allowable Stress at Ambient Temperature:</td>
<td>17100 PSI</td>
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<tr>
<td>Correction Factor (F):</td>
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<tr>
<td>Nozzle Path:</td>
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</tr>
<tr>
<td>Nozzle Wall Thickness (new):</td>
<td>0.7500 in.</td>
</tr>
<tr>
<td>Nozzle Wall Thickness (corroded):</td>
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</tr>
<tr>
<td>Upper Weld Leg Size (Weld 41):</td>
<td>0.3125 in.</td>
</tr>
<tr>
<td>Internal Weld Leg Size (Weld 43):</td>
<td>0.3125 in.</td>
</tr>
<tr>
<td>Outside Groove Weld Depth:</td>
<td>0.2820 in.</td>
</tr>
</tbody>
</table>

Minimum Design Metal Temperature

- Min. Temp. Curve: B
- Pressure at MDMT: 75.00 PSI
- Minimum Design Metal Temperature: -20 °F
- Computed Minimum Temperature: -125 °F

Host Component: Head 1 - Right Side Head

- Material: SA-516 Gr 70
- Head wall thickness (new): 0.3125 in.
- Head wall thickness - thin out (corroded): 0.2820 in.

Material Stress (Sv): 20000 PSI

Nozzle Detail Information

- Upper Weld Leg Size (Weld 41): 0.3125 in.
- Internal Weld Leg Size (Weld 43): 0.3125 in.
- Nozzle Wall Thickness (t_n): 0.7500 in.
- Outside Groove Weld Depth: 0.2820 in.

Nozzle passes through the vessel, attached by a groove weld.

Nozzle is adequate for UG-45 requirements.

Opening is adequately reinforced for internal pressure.

Weld Strength Paths are adequate.
Required Head Thickness per Paragraph UG-37(a)

\[
tr = \frac{PK1Do}{(2SE + 0.8P)} = \frac{78.50 \times 0.9000 \times 96.0000}{(2 \times 20000 \times 1 + 0.8 \times 78.50)} = 0.1693 \text{ in.}
\]

Nozzle Required Thickness Calculations

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

\[
trn = \frac{PRn}{SE - 0.6P} = \frac{78.50 \times 8.0000}{17100 \times 1 - 0.6 \times 78.50} = 0.0368 \text{ in.}
\]

Strength Reduction Factors

\[
fr1 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{17100}{20000}, 1.0000 \right) = 0.8550 \quad fr2 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{17100}{20000}, 1.0000 \right) = 0.8550
\]

\[
fr3 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{17100}{20000}, 1.0000 \right) = 0.8550
\]

UG-45 Thickness Calculations

This calculation is for an access or inspection opening.

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

\[
t = \frac{PRn}{SE - 0.6P} + Ca + \text{ext. } Ca = \frac{78.50 \times 8.0000}{17100 \times 1.00 - 0.6 \times 78.50} + 0.0000 + 0.0000 = 0.0368 \text{ in.}
\]
Nozzle Reinforcement Calculations

Area Required for Internal Pressure

\[ A = \pi \cdot t \cdot r \cdot \left( 1 - \frac{t}{t_1} \right) = (16.0000 \cdot 0.1693 \cdot 1.00) + (2 \cdot 0.7500 \cdot 0.1693 \cdot 1.00 \cdot (1 - 0.8550)) = 2.7456 \text{ sq. in.} \]

Area Available - Internal Pressure

\[ A_1 = \pi \cdot (E_1 - F \cdot t) - 2 \cdot t \cdot n \cdot (E_1 - F \cdot t) \left( 1 - \frac{t}{t_1} \right) = 16.0000 \cdot (1.00 \cdot 0.2820 - 1.00 \cdot 0.1693) - 2 \cdot 0.7500 \cdot (1.00 \cdot 0.2820 - 1.00 \cdot 0.1693) \cdot (1 - 0.8550) = 1.7787 \text{ sq. in.} \]

\[ A_2 = 2 \cdot (t + t_n) \cdot (E_1 - F \cdot t) - 2 \cdot t_n \cdot (E_1 - F \cdot t) \left( 1 - \frac{t}{t_1} \right) = 2 \cdot (0.2820 + 0.7500) \cdot (1.00 \cdot 0.2820 - 1.00 \cdot 0.1693) - 2 \cdot 0.7500 \cdot (1.00 \cdot 0.2820 - 1.00 \cdot 0.1693) \cdot (1 - 0.8550) = 0.2081 \text{ sq. in.} \]

\[ A_1 = \text{Larger value of } A_1 \text{ Formula 1 and } A_1 \text{ Formula 2} = 1.7787 \text{ sq. in.} \]

\[ A_2 = \text{Smaller value of } A_2 \text{ Formula 1 and } A_2 \text{ Formula 2} = 0.8598 \text{ sq. in.} \]

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

\[ 5 \cdot t \cdot t_i \cdot \frac{t_2}{t} = 5 \cdot 0.2820 \cdot 0.7500 \cdot 0.8550 = 0.9042 \text{ sq. in.} \]

\[ 5 \cdot t_i \cdot t_i \cdot \frac{t_2}{t} = 5 \cdot 0.7500 \cdot 0.7500 \cdot 0.8550 = 2.4047 \text{ sq. in.} \]

\[ 2 \cdot h \cdot t_i \cdot \frac{t_2}{t} = 2 \cdot 1.0000 \cdot 0.7500 \cdot 0.8550 = 1.2825 \text{ sq. in.} \]

\[ A_{41} = (\text{leg})^2 \cdot \frac{t_2}{t} = (0.3125)^2 \cdot 0.8550 = 0.0835 \text{ sq. in.} \]

\[ A_{43} = (\text{leg})^2 \cdot \frac{t_2}{t} = (0.3125)^2 \cdot 0.8550 = 0.0835 \text{ sq. in.} \]

Area Available (Internal Pressure) = A_1 + A_2 + A_3 + A_{41} + A_{43} = 3.7097 \text{ sq. in., which is greater than A (2.7456)} \]
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, 0.2820, or 0.7500 = 0.2820 in.

\[
Weld 41 \text{ Leg min.} = \frac{\text{(smaller of 0.25 or (} t_{\text{min}} \times 0.7\text{))} + \text{ext. CA}}{0.7} = 0.1974
\]

Weld 41, actual weld leg = 0.3125 in.

Weld 43 \( t_{\text{min}} \) = smaller of 0.75, \( t \), or \( t_n \) = smaller of 0.75, 0.2820, or 0.7500 = 0.2820 in.

\[
Weld 43 \text{ Leg min.} = \frac{\text{(smaller of 0.25 or (} t_{\text{min}} \times 0.7\text{))} + \text{ca}}{0.7} = 0.1974
\]

Weld 43, actual weld leg = 0.3125 in.

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

Nozzle wall in shear = 0.70 * \( S_n \) = 0.70 * 17100 = 11970 PSI

Upper fillet, Weld 41, in shear = 0.49 * Material Stress = 0.49 * 17100 = 8379 PSI

Vessel groove weld, in tension = 0.74 * Material Stress = 0.74 * 17100 = 12654 PSI

Inner fillet, Weld 43, in shear = 0.49 * Material Stress = 0.49 * 17100 = 8379 PSI

Strength of Connection Elements

Nozzle wall in shear = \( \frac{1}{2} \pi \times \text{mean nozzle diameter} \times t_n \times \text{Nozzle wall in shear unit stress} = \frac{1}{2} \pi \times 16.7500 \times 0.7500 = 236100 \) lb.

Upper fillet in shear = \( \frac{1}{2} \pi \times \text{Nozzle OD} \times \text{weld leg} \times \text{upper fillet in shear unit stress} = \frac{1}{2} \pi \times 17.5000 \times 0.3125 \times 8379 = 71900 \) lb.

Groove Weld in Tension = \( \frac{1}{2} \pi \times \text{Nozzle OD} \times \text{groove depth} \times \text{groove weld tension unit stress} = \frac{1}{2} \pi \times 17.5000 \times 0.2820 \times 12654 = 98000 \) lb.

Inner fillet in shear = \( \frac{1}{2} \pi \times \text{Nozzle OD} \times \text{weld leg} \times \text{inner fillet in shear unit stress} = \frac{1}{2} \pi \times 17.5000 \times 0.3125 \times 8379 = 71900 \) lb.

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

\[
W = [A - A1 + 2 \text{ tn fr1(E1t - } \text{ Frt})] \times Sv = [2.7456 - 1.7787 + 2 \times 0.7500 \times 0.8550 \times (1.00 \times 0.2820 - 1.0000 \times 0.1693)] \times 20000 = 22200 \text{ lb.}
\]

\[
W1-1 = (A2 + A5 + A41 + A42) \times Sv = (0.8598 + 0.0000 + 0.0835 + 0.0835) \times 20000 = 18900 \text{ lb.}
\]

\[
W2-2 = (A2 + A3 + A41 + A43 + 2 \text{ tn fr1}) \times Sv = (0.8598 + 0.9042 + 0.8550 + 0.0835 + 0.0835 + 2 \times 0.7500 \times 0.2820 \times 0.8550) \times 20000 = 45900 \text{ lb.}
\]

\[
W3-3 = (A2 + A3 + A5 + A41 + A42 + A43 + 2 \text{ tn fr1}) \times Sv = (0.8598 + 0.9042 + 0.0000 + 0.0835 + 0.0835 + 2 \times 0.7500 \times 0.2820 \times 0.8550) \times 20000 = 45900 \text{ lb.}
\]

Check Strength Paths

Path 1-1 = Upper fillet in shear + Nozzle wall in shear = 71900 + 236100 = 308000 lb.

Path 2-2 = Upper fillet in shear + Groove weld in tension + Inner fillet in shear = 71900 + 98000 + 71900 = 241800 lb.

Path 3-3 = Upper fillet in shear + Inner fillet in shear + Groove weld in tension = 71900 + 71900 + 98000 = 241800 lb.
### Nozzle Design Information

<table>
<thead>
<tr>
<th>Design Pressure:</th>
<th>75.00 PSI</th>
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<tbody>
<tr>
<td>Static Head:</td>
<td>3.50 PSI</td>
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<tr>
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<td>Nozzle Efficiency (E):</td>
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<tr>
<td>Joint Efficiency (E₁):</td>
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<tr>
<td>Factor B Chart:</td>
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<td>External Projection:</td>
<td>2.0000 in.</td>
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<tr>
<td>Internal Projection:</td>
<td>1.0000 in.</td>
</tr>
<tr>
<td>Inside Corrosion Allowance:</td>
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<tr>
<td>External Corrosion Allowance:</td>
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</tr>
<tr>
<td>Nozzle ID (new):</td>
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<tr>
<td>Nozzle ID (corroded):</td>
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<tr>
<td>Nozzle Wall Thickness(new):</td>
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</tr>
<tr>
<td>Nozzle Wall Thickness(corroded):</td>
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</tr>
<tr>
<td>Upper Weld Leg Size(Weld 41):</td>
<td>0.3125 in.</td>
</tr>
<tr>
<td>Internal Weld Leg Size(Weld 43):</td>
<td>0.3125 in.</td>
</tr>
<tr>
<td>OD, Limit of Reinforcement:</td>
<td>32.0000 in.</td>
</tr>
</tbody>
</table>

### Minimum Design Metal Temperature

- **Min. Temp. Curve:** B
- **Pressure at MDMT:** 75.00 PSI
- **Minimum Design Metal Temperature:** -20 °F
- **Computed Minimum Temperature:** -125 °F

### Host Component: Shell 1 - Shell 1

- **Material:** SA-516 Gr 70
- **Material Stress(Sᵥ):** 20000 PSI
- **Shell wall thickness(new):** 0.3125 in.
- **Shell wall thickness(corroded):** 0.3125 in.

### Nozzle Detail Information

- **Upper Weld Leg Size(Weld 41):** 0.3125 in.
- **Internal Weld Leg Size(Weld 43):** 0.3125 in.
- **Nozzle Wall Thickness(tₙ):** 0.7500 in.
- **Outside Groove Weld Depth:** 0.3125 in.

---

Nozzle passes through the vessel, attached by a groove weld.
Nozzle is adequate for UG-45 requirements.
Opening is adequately reinforced for Internal Pressure.
Weld Strength Paths are adequate.
### Required Shell Thickness per Paragraph UG-37(a)

\[
tr = \frac{PR_o}{SE + 0.4P} = \frac{78.50 \times 48.0000}{20000 \times 1 + 0.4 \times 78.50} = 0.1881 \text{ in.}
\]

### Nozzle Required Thickness Calculations

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

\[
tr_n = \frac{PR_n}{SE - 0.6P} = \frac{78.50 \times 8.0000}{17100 \times 1 - 0.6 \times 78.50} = 0.0368 \text{ in.}
\]

### Strength Reduction Factors

\[
fr_1 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{17100}{20000}, 1.0000 \right) = 0.8550 \quad fr_2 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{17100}{20000}, 1.0000 \right) = 0.8550 \\
fr_3 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{17100}{20000}, 1.0000 \right) = 0.8550
\]

### UG-45 Thickness Calculations

This calculation is for an access or inspection opening.

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

\[
t = \frac{PR_n}{SE - 0.6P} + Ca + \text{ext. Ca} = \frac{78.50 \times 8.0000}{17100 \times 1.00 - 0.6 \times 78.50} + 0.0000 + 0.0000 = 0.0368 \text{ in.}
\]
### Nozzle Reinforcement Calculations

#### Area Required for Internal Pressure

\[
A = d \, tr \, F + 2 \, tn \, tr \, F \, (1 - fr1) = (16.0000 \times 0.1881 \times 1.00) + (2 \times 0.7500 \times 0.1881 \times 1.00 \times (1 - 0.8550)) = 3.0505 \text{ sq. in.}
\]

#### Area Available - Internal Pressure

- **A1 Formula 1**
  \[
  16.0000 \times (1.00 \times 0.3125 - 1.00 \times 0.1881) - 2 \times 0.7500 \times (1.00 \times 0.3125 - 1.00 \times 0.1881) \times (1 - 0.8550) = 1.9633 \text{ sq. in.}
  \]

- **A1 Formula 2**
  \[
  2 \times (0.3125 + 0.7500)(1.00 \times 0.3125 - 1.00 \times 0.1881) - 2 \times 0.7500 \times (1.00 \times 0.3125 - 1.00 \times 0.1881) \times (1 - 0.8550) = 0.2373 \text{ sq. in.}
  \]

**A1** = Larger value of **A1 Formula 1** and **A1 Formula 2**
\[
= 1.9633 \text{ sq. in.}
\]

- **A2 Formula 1**
  \[
  5(0.7500 - 0.0368) \times 0.8550 \times 0.3125 = 0.9528 \text{ sq. in.}
  \]

- **A2 Formula 2**
  \[
  5(0.7500 - 0.0368) \times 0.8550 \times 0.7500 = 2.2867 \text{ sq. in.}
  \]

**A2** = Smaller value of **A2 Formula 1** and **A2 Formula 2**
\[
= 0.9528 \text{ sq. in.}
\]

#### A3

- **5 * t * t_i * f_r2**
  \[
  5 \times 0.3125 \times 0.7500 \times 0.8550 = 1.0020 \text{ sq. in.}
  \]

- **2 * h * t_i * f_r2**
  \[
  2 \times 1.0000 \times 0.7500 \times 0.8550 = 1.2825 \text{ sq. in.}
  \]

**A41** = (leg)² * fr2 = (0.3125)² * 0.8550
\[
= 0.0835 \text{ sq. in.}
\]

**A43** = (leg)² * fr2 = (0.3125)² * 0.8550
\[
= 0.0835 \text{ sq. in.}
\]

**Area Available** (Internal Pressure) = A1 + A2 + A3 + A41 + A43 = 4.0851 sq. in., which is greater than A (3.0505)
**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, 0.3125, or 0.7500 = 0.3125 in.

Weld 41 Leg min. = \( \frac{\text{smaller of } 0.25 \text{ or } (t_{\text{min}} \times 0.7) + \text{ext. CA}}{0.7} \) = \( \frac{0.2188}{0.7} \) = 0.3125 in.

Weld 41, actual weld leg = 0.3125 in.

Weld 43 \( t_{\text{min}} = \) smaller of 0.75, \( t \), or \( t_n = \) smaller of 0.75, 0.3125, or 0.7500 = 0.3125 in.

Weld 43 Leg min. = \( \frac{\text{smaller of } 0.25 \text{ or } (t_{\text{min}} \times 0.7) + \text{ca}}{0.7} \) = \( \frac{0.2188}{0.7} \) = 0.3125 in.

Weld 43, actual weld leg = 0.3125 in.

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

- Nozzle wall in shear = 0.70 \* \( S_n = 0.70 \times 17100 \) = 11970 PSI
- Upper fillet, Weld 41, in shear = 0.49 \* Material Stress = 0.49 \* 17100 = 8379 PSI
- Vessel groove weld, in tension = 0.74 \* Material Stress = 0.74 \* 17100 = 12654 PSI
- Inner fillet, Weld 43, in shear = 0.49 \* Material Stress = 0.49 \* 17100 = 8379 PSI

**Strength of Connection Elements**

- Nozzle wall in shear = \( \frac{1}{2} \times \pi \times \text{mean nozzle diameter} \times t_n \times \text{Nozzle wall in shear unit stress} = \frac{1}{2} \times \pi \times 16.7500 \times 0.7500 \times 11970 = 236100 \text{ lb.} \)
- Upper fillet in shear = \( \frac{1}{2} \times \pi \times \text{Nozzle OD} \times \text{weld leg} \times \text{upper fillet in shear unit stress} = \frac{1}{2} \times \pi \times 17.5000 \times 0.3125 \times 8379 = 71900 \text{ lb.} \)
- Groove Weld in Tension = \( \frac{1}{2} \times \pi \times \text{Nozzle OD} \times \text{groove depth} \times \text{groove weld tension unit stress} = \frac{1}{2} \times \pi \times 17.5000 \times 0.3125 \times 12654 = 108600 \text{ lb.} \)
- Inner fillet in shear = \( \frac{1}{2} \times \pi \times \text{Nozzle OD} \times \text{weld leg} \times \text{inner fillet in shear unit stress} = \frac{1}{2} \times \pi \times 17.5000 \times 0.3125 \times 8379 = 71900 \text{ lb.} \)

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

\[ W = [A - A1 + 2 \text{tn fr1(E1t - Fr1)}] \times Sv = [3.0505 - 1.9633 + 2 \times 0.7500 \times 0.8550 \times (1.00 \times 0.3125 - 1.0000 \times 0.1881)] \times 20000 = 24900 \text{ lb.} \]

\[ W1-1 = (A2 + A5 + A41 + A42) \times Sv = (0.9528 + 0.0000 + 0.0835 + 0.0000) \times 20000 = 20700 \text{ lb.} \]

\[ W2-2 = (A2 + A3 + A41 + A43 + 2 \text{tn t fr1}) \times Sv = (0.9528 + 1.0020 + 0.0835 + 0.0835 + 2 \times 0.7500 \times 0.3125 \times 0.8550) \times 20000 = 50500 \text{ lb.} \]

\[ W3-3 = (A2 + A3 + A5 + A41 + A42 + A43 + 2 \text{tn t fr1}) \times Sv = (0.9528 + 1.0020 + 0.0000 + 0.0835 + 0.0000 + 0.0835 + 2 \times 0.7500 \times 0.3125 \times 0.8550) \times 20000 = 50500 \text{ lb.} \]

**Check Strength Paths**

- **Path 1-1** = Upper fillet in shear + Nozzle wall in shear = 71900 + 236100 = 308000 lb.
- **Path 2-2** = Upper fillet in shear + Groove weld in tension + Inner fillet in shear = 71900 + 108600 + 71900 = 252400 lb.
- **Path 3-3** = Upper fillet in shear + Inner fillet in shear + Groove weld in tension = 71900 + 71900 + 108600 = 252400 lb.
Nozzle Design Information

- Design Pressure: 75.00 PSI
- Static Head: 3.50 PSI
- Nozzle Material: SA-105
- Joint Efficiency ($E_1$): 1.00
- External Projection: 1.1875 in.
- Internal Projection: 0.0000 in.
- Inside Corrosion Allowance: 0.0000 in.
- External Corrosion Allowance: 0.0000 in.
- Nozzle ID (new): 1.6750 in.
- Nozzle ID (corroded): 1.6750 in.
- Outer "h" Limit: 0.7388 in.
- Internal "h" Limit: 0.7388 in.
- OD, Limit of Reinforcement: 3.3500 in.

- Allowable Stress at Design Temperature ($S_n$): 20000 PSI
- Allowable Stress at Ambient Temperature: 20000 PSI
- Nozzle Path: None
- Nozzle Wall Thickness (new): 0.2955 in.
- Nozzle Wall Thickness (corroded): 0.2955 in.
- Upper Weld Leg Size (Weld 41): 0.3125 in.
- Internal Weld Leg Size (Weld 43): 0.0000 in.
- Outside Groove Weld Depth: 0.3125 in.

Minimum Design Metal Temperature

- Min. Temp. Curve: A
- Pressure at MDMT: 75.00 PSI
- Minimum Design Metal Temperature: -20 °F
- Computed Minimum Temperature: -122 °F

Host Component: Shell 1 - Shell 1

- Material: SA-516 Gr 70
- Material Stress ($S_v$): 20000 PSI
- Shell wall thickness (new): 0.3125 in.
- Shell wall thickness (corroded): 0.3125 in.

Nozzle Detail Information

- Upper Weld Leg Size (Weld 41): 0.3125 in.
- Nozzle Wall Thickness ($t_n$): 0.2955 in.
- Outside Groove Weld Depth: 0.3125 in.

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.
### Required Shell Thickness per Paragraph UG-37(a)

\[
tr = \frac{PRo}{SE + 0.4P} = \frac{78.50 \times 48.0000}{20000 \times 1 + 0.4 \times 78.50} = 0.1881 \text{ in.}
\]

### Nozzle Required Thickness Calculations

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

\[
trn = \frac{PRn}{SE - 0.6P} = \frac{78.50 \times 0.8375}{20000 \times 1 - 0.6 \times 78.50} = 0.0033 \text{ in.}
\]

### Strength Reduction Factors

\[
fr1 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{20000}{20000}, 1.0000 \right) = 1.0000
\]
\[
fr2 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{20000}{20000}, 1.0000 \right) = 1.0000
\]
\[
fr3 = \min \left( \frac{Sn}{Sv}, 1.0000 \right) = \min \left( \frac{20000}{20000}, 1.0000 \right) = 1.0000
\]

### UG-45 Thickness Calculations

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

\[
t = \frac{PRn}{SE - 0.6P} + \text{Ca} + \text{ext. Ca} = \frac{78.50 \times 0.8375}{20000 \times 1 - 0.6 \times 78.50} + 0.0000 + 0.0000 = 0.0033 \text{ in.}
\]

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

\[
t = \frac{PRo}{SE + 0.4P} + \text{Ca} + \text{ext. Ca} = \frac{78.50 \times 48.0000}{20000 \times 1 + 0.4 \times 78.50} + 0.0000 + 0.0000 = 0.1881 \text{ in.}
\]

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

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

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

\[
t = \text{Smallest of UG-45(b)(1) or UG-45(b)(4)} = 0.1347 \text{ in.}
\]

Wall thickness = \( t = 0.2955 \) is greater than or equal to UG-45 value of 0.1347
Nozzle Weld Strength Calculations

Attachment Weld Strength per Paragraph UW-16

Weld 41 \( t_{min} \) = smaller of 0.75, \( t \), or \( t_n \) = smaller of 0.75, 0.3125, or 0.2955 = 0.2955 in.

\[
Weld 41 \text{ Leg min.} = \frac{\text{smaller of} \ 0.25 \ \text{or} \ (t_{min} \cdot 0.7) + \text{ext. CA}}{0.7} = \frac{0.2068}{0.7} = 0.2955 \text{ in.}
\]

Weld 41, actual weld leg = 0.3125 in.

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

Nozzle wall in shear = 0.70 * \( S_n \) = 0.70 * 20000 = 14000 PSI

Upper fillet, Weld 41, in shear = 0.49 * Material Stress = 0.49 * 20000 = 9800 PSI

Vessel groove weld, in tension = 0.74 * Material Stress = 0.74 * 20000 = 14800 PSI

Strength of Connection Elements

Nozzle wall in shear = \( \frac{1}{2} \pi \times \text{mean nozzle diameter} \times t_n \times \text{Nozzle wall in shear unit stress} = \frac{1}{2} \pi \times 1.9705 \times 0.2955 \times 14000 = 12800 \text{ lb.} \)

Upper fillet in shear = \( \frac{1}{2} \pi \times \text{Nozzle OD} \times \text{weld leg} \times \text{upper fillet in shear unit stress} = \frac{1}{2} \pi \times 2.2660 \times 0.3125 \times 9800 = 10900 \text{ lb.} \)

Groove Weld in Tension = \( \frac{1}{2} \pi \times \text{Nozzle OD} \times \text{groove depth} \times \text{groove weld tension unit stress} = \frac{1}{2} \pi \times 2.2660 \times 0.3125 \times 14800 = 16500 \text{ lb.} \)

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

\[
W = [A - A1 + 2 \ t_{fr1}(E1t - Ftr)] \ Sv = [0.3151 - 0.2084 + 2 \times 0.2955 \times 1.0000 \times (1.00 \times 0.3125 - 1.0000 \times 0.1881)] \times 20000 = 3600 \text{ lb.}
\]

W1-1 = (A2 + A5 + A41 + A42) * Sv = (0.4317 + 0.0000 + 0.0977 + 0.0000) * 20000 = 10600 lb.

W2-2 = (A2 + A3 + A41 + A43 + 2 \ t_{fr1}) \ Sv = (0.4317 + 0.0000 + 0.0977 + 0.0000 + 2 \times 0.2955 \times 0.3125 \times 1.0000) \times 20000 = 14300 lb.

W3-3 = (A2 + A3 + A5 + A41 + A42 + 2 \ t_{fr1}) \ Sv = (0.4317 + 0.0000 + 0.0977 + 0.0000 + 0.0000 + 2 \times 0.2955 \times 0.3125 \times 1.0000) \times 20000 = 14300 lb.

Check Strength Paths

Path 1-1 = Upper fillet in shear + Nozzle wall in shear = 10900 + 12800 = 23700 lb.

Path 2-2 = Upper fillet in shear + Groove weld in tension + Inner fillet in shear = 10900 + 16500 + 0 = 27400 lb.

Path 3-3 = Upper fillet in shear + Inner fillet in shear + Groove weld in tension = 10900 + 0 + 16500 = 27400 lb.
### Saddle Design Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Temperature:</td>
<td>150 °F</td>
</tr>
<tr>
<td>Material:</td>
<td>SA-36 Plate</td>
</tr>
<tr>
<td>Condition:</td>
<td></td>
</tr>
<tr>
<td>Length (d):</td>
<td>68.2500 in.</td>
</tr>
<tr>
<td>Top Width (b'):</td>
<td>10.0000 in.</td>
</tr>
<tr>
<td>Bottom Width (b_b):</td>
<td>10.0000 in.</td>
</tr>
<tr>
<td>Outside Stiffener Thickness (t_so):</td>
<td>0.5000 in.</td>
</tr>
<tr>
<td>Inside Stiffener Thickness (t_si):</td>
<td>0.5000 in.</td>
</tr>
<tr>
<td>Saddle Angle of contact (θ):</td>
<td>150.0 °</td>
</tr>
<tr>
<td>Dist. from saddle centerline to tang. line (A):</td>
<td>13.5000 in.</td>
</tr>
<tr>
<td>Support Design Condition:</td>
<td>Shell stiffened by heads (A/R &lt;= 1/2)</td>
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</table>

### Wear Plate Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
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<td>Design Temperature:</td>
<td>150 °F</td>
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<tr>
<td>Material:</td>
<td>SA-36 Plate</td>
</tr>
<tr>
<td>Condition:</td>
<td></td>
</tr>
<tr>
<td>Extension (j_w):</td>
<td>10.2500 in.</td>
</tr>
<tr>
<td>Width (b_w):</td>
<td>12.0000 in.</td>
</tr>
<tr>
<td>Thickness (t_wp):</td>
<td>0.3750 in.</td>
</tr>
</tbody>
</table>

### Base Plate Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Temperature:</td>
<td>150 °F</td>
</tr>
<tr>
<td>Material:</td>
<td>SA-36 Plate</td>
</tr>
<tr>
<td>Condition:</td>
<td></td>
</tr>
<tr>
<td>Width (b_b):</td>
<td>12.0000 in.</td>
</tr>
<tr>
<td>Length (m):</td>
<td>70.0000 in.</td>
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</table>

### Anchor Bolt Information

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<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Material:</td>
<td>SA-193 Gr B7 &lt;=2.5&quot;</td>
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<tr>
<td>Condition:</td>
<td></td>
</tr>
<tr>
<td>Size:</td>
<td>1&quot;</td>
</tr>
<tr>
<td>Quantity:</td>
<td>2</td>
</tr>
<tr>
<td>Root Area:</td>
<td>0.5510 sq. in.</td>
</tr>
</tbody>
</table>
### 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>B - 6&quot; Pipe</td>
<td>ASME Flange 1</td>
<td>Slip-On 6</td>
<td>SA-105</td>
<td>150</td>
<td>1.1</td>
<td>272.50</td>
<td></td>
</tr>
<tr>
<td>C - 6&quot; Pipe</td>
<td>ASME Flange 2</td>
<td>Slip-On 6</td>
<td>SA-105</td>
<td>150</td>
<td>1.1</td>
<td>272.50</td>
<td></td>
</tr>
</tbody>
</table>
Zick Analysis

Test Condition

Saddle Support Loads

\[ Q_L = \frac{F_L h}{L - 2A} = \frac{0 \times 66.000}{123.0000 - 2 \times 13.5000} = 0 \text{ lb.} \]

\[ Q_T = \frac{1.5 F_T h}{d} = \frac{1.5 \times 0 \times 66.000}{68.2500} = 0 \text{ lb.} \]

\[ Q_W = \frac{W}{2} = \frac{45063}{2} = 22532 \text{ lb.} \]

\[ Q_N = Q_W = 22532 \text{ lb.} \]

Saddle Load for Vessel Stress Analysis

\[ Q = Q_N = 22532 \text{ lb.} \]

Saddle Load for Support Stress Analysis

\[ Q_S = Q_N = 22532 \text{ lb.} \]
Zick Calculations

Longitudinal Stress Due to Internal Pressure

\[ \sigma_p = \frac{PR}{2t} = \frac{75.00 \times 47.8438}{2 \times 0.3125} = 5741 \text{ PSI} \]

Longitudinal Compressive Stress Due to External Pressure

\[ \sigma_{pe} = 0 \text{ PSI} \]

Longitudinal Bending Stress in the Shell at the Midpoint

\[ Z_1 = \pi R^2 t = 3.1416 \times 47.8438^2 \times 0.3125 \]

\[ S_1 = \frac{K_1 Q L}{4 Z_1} = \frac{0.53213 \times 22532 \times 123.0000}{4 \times 2247} = 164 \text{ PSI} \]

Longitudinal Bending Stress in the Shell in the Plane of the Saddle

\[ S_1' = \frac{K_1' Q L}{4 Z_1} = \frac{0.04938 \times 22532 \times 123.0000}{4 \times 2247} = 15 \text{ PSI} \]

Saddle Plane Tangential Shear Stress

\[ t_e = t + t_{wp} = 0.3125 + 0.3750 = 0.6875 \text{ in.} \]

\[ S_2 = \frac{K_2 Q}{R t_e} = \frac{0.48517 \times 22532}{47.8438 \times 0.6875} = 332 \text{ PSI} \]

\[ S_{2w} = \frac{K_{2w} Q}{R t} = \frac{0.38022 \times 22532}{47.8438 \times 0.3125} = 573 \text{ PSI} \]

\[ S_{2H} = \frac{K_2 Q}{R t_H} = \frac{0.48517 \times 22532}{47.8438 \times 0.2820} = 810 \text{ PSI} \]

Circumferential Stress at the Horn of the Saddle

\[ t_e^2 = t^2 + t_{wp}^2 = 0.3125^2 + 0.3750^2 \]

\[ S_3 = -\left( \frac{Q}{4 t_e (b + 1.56 \sqrt{R t})} \right) \cdot \left( \frac{12 K_3 Q R}{L t_e^2} \right) \]

\[ = -\left[ \frac{22532}{4 \times 0.6875 \times (10.0000 + 1.56 \times \sqrt{47.8438 \times 0.3125})} \right] \cdot \left[ \frac{12 \times 0.00792 \times 22532 \times 47.8438}{123.0000 \times 0.2383} \right] \]

\[ = -4007 \text{ PSI} \]

Circumferential Stress at End of the Wear Plate

\[ S_{3w} = -\left( \frac{Q}{4 t (b_w + 1.56 \sqrt{R t})} \right) \cdot \left( \frac{12 K_{3w} Q R}{L t^2} \right) \]

\[ = -\left[ \frac{22532}{4 \times 0.3125 \times (12.0000 + 1.56 \times \sqrt{47.8438 \times 0.3125})} \right] \cdot \left[ \frac{12 \times 0.00631 \times 22532 \times 47.8438}{123.0000 \times 0.3125^2} \right] \]

\[ = -7795 \text{ PSI} \]

Additional Stresses in Head Used as a Stiffener

\[ S_4 = \frac{K_4 Q}{R t_H} = \frac{0.29525 \times 22532}{47.8438 \times 0.2820} = 493 \text{ PSI} \]
Ring Compression in the Shell Over the Saddle

\[ t_s = t + t_{wp} = 0.3125 + 0.3750 \]
\[ S_5 = \frac{K_5 Q}{t_e (b + 1.56 \sqrt{R t})} = \frac{0.67330 \times 22532}{0.6875 \times (0.5000 + 1.56 \times 47.8438 \times 0.3125)} = 3378 \text{ PSI} \]

Maximum Splitting Force

\[ F_s = K_8 Q_s = 0.25937 \times 22532 = 5844 \text{ lb.} \]
Vessel Stress Ratio Calculations

Any ratio greater than 1 represents an overstressed condition

\[ R_{1t} = \frac{S_1 + S_p}{S_{Shell} E} = \frac{164 + 5741}{20000 	imes 0.70} = 0.4218 \]

\[ R_{1C} = \frac{-S_1}{-\text{Min}(S_{Shell}, B_{Shell})} = \frac{-164}{-\text{Min}(20000, 11484)} = 0.0143 \]

\[ R_{1t}' = \frac{S_1' + S_p}{S_{Shell} E} = \frac{15 + 5741}{20000 	imes 0.70} = 0.4112 \]

\[ R_{1C}' = \frac{-S_1'}{-\text{Min}(S_{Shell}, B_{Shell})} = \frac{-15}{-\text{Min}(20000, 11484)} = 0.0013 \]

\[ R_2 = \frac{S_2}{0.8 S_{Shell}} = \frac{332}{0.8 	imes 20000} = 0.0208 \]

\[ R_{2W} = \frac{S_{2W}}{0.8 S_{Shell}} = \frac{573}{0.8 	imes 20000} = 0.0358 \]

\[ R_{2H} = \frac{S_{2H}}{0.8 S_{Head}} = \frac{810}{0.8 	imes 20000} = 0.0506 \]

\[ R_3 = \frac{S_3}{- (1.25 S_{Shell})} = \frac{-4007}{- (1.25 	imes 20000)} = 0.1603 \]

\[ R_{3W} = \frac{S_{3W}}{- (1.25 S_{Shell})} = \frac{-7795}{- (1.25 	imes 20000)} = 0.3118 \]

\[ R_4 = \frac{S_4 + S_{pH}}{1.25 S_{Head}} = \frac{493 + 15637}{1.25 	imes 20000} = 0.6452 \]

\[ R_5 = \frac{S_5}{0.5 Y_{Shell}} = \frac{3378}{0.5 	imes 35700} = 0.1892 \]
### 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>Shell 1</td>
<td>SA-516 Gr 70</td>
<td>B</td>
<td>75.00 PSI</td>
<td>-20 °F</td>
</tr>
<tr>
<td>F - 12x16&quot; MWY</td>
<td>SA-106 Gr B</td>
<td>B</td>
<td>75.00 PSI</td>
<td>-125 °F</td>
</tr>
<tr>
<td>G - 1-1/2&quot; 3000# Cplg</td>
<td>SA-105</td>
<td>A</td>
<td>75.00 PSI</td>
<td>-122 °F</td>
</tr>
<tr>
<td>A - 3/4&quot; 3000# Cplg</td>
<td>SA-105</td>
<td>A</td>
<td>75.00 PSI</td>
<td>-122 °F</td>
</tr>
<tr>
<td>Right Side Head</td>
<td>SA-516 Gr 70</td>
<td>B</td>
<td>75.00 PSI</td>
<td>-20 °F</td>
</tr>
<tr>
<td>E - 12x16&quot; MWY</td>
<td>SA-106 Gr B</td>
<td>B</td>
<td>75.00 PSI</td>
<td>-125 °F</td>
</tr>
<tr>
<td>C - 6&quot; Pipe</td>
<td>SA-106 Gr B</td>
<td>B</td>
<td>3.50 PSI</td>
<td>-155 °F</td>
</tr>
<tr>
<td>Left Side Head</td>
<td>SA-516 Gr 70</td>
<td>B</td>
<td>75.00 PSI</td>
<td>-20 °F</td>
</tr>
<tr>
<td>B - 6&quot; Pipe</td>
<td>SA-106 Gr B</td>
<td>B</td>
<td>3.50 PSI</td>
<td>-155 °F</td>
</tr>
<tr>
<td>D - 12x16&quot; MWY</td>
<td>SA-106 Gr B</td>
<td>B</td>
<td>75.00 PSI</td>
<td>-125 °F</td>
</tr>
</tbody>
</table>

*Component with highest MDMT: Shell 1.  
Computed MDMT = -20 °F  
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</th>
<th>Component MAWP Hot &amp; Corroded</th>
<th>Vessel MAWP Hot &amp; Corroded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell 1</td>
<td>75.00 PSI</td>
<td>3.50 PSI</td>
<td>87.88 PSI</td>
<td>91.38 PSI</td>
<td>87.88 PSI</td>
</tr>
<tr>
<td>F - 12x16” MWY</td>
<td>75.00 PSI</td>
<td>3.50 PSI</td>
<td>88.39 PSI</td>
<td>91.89 PSI</td>
<td>88.39 PSI</td>
</tr>
<tr>
<td>G - 1-1/2” 3000# Cplg</td>
<td>75.00 PSI</td>
<td>3.50 PSI</td>
<td>127.06 PSI</td>
<td>130.56 PSI</td>
<td>127.06 PSI</td>
</tr>
<tr>
<td>A - 3/4” 3000# Cplg</td>
<td>75.00 PSI</td>
<td>3.50 PSI</td>
<td>127.06 PSI</td>
<td>130.56 PSI</td>
<td>127.06 PSI</td>
</tr>
<tr>
<td>Right Side Head</td>
<td>75.00 PSI</td>
<td>3.50 PSI</td>
<td>87.81 PSI</td>
<td>91.31 PSI</td>
<td>87.81 PSI</td>
</tr>
<tr>
<td>E - 12x16” MWY</td>
<td>75.00 PSI</td>
<td>3.50 PSI</td>
<td>88.86 PSI</td>
<td>92.36 PSI</td>
<td>88.86 PSI</td>
</tr>
<tr>
<td>C - 6” Pipe</td>
<td>75.00 PSI</td>
<td>3.50 PSI</td>
<td>87.81 PSI</td>
<td>91.31 PSI</td>
<td>87.81 PSI</td>
</tr>
<tr>
<td>ASME Flange Class: 150 Gr:1.1</td>
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</tr>
<tr>
<td>Left Side Head</td>
<td>75.00 PSI</td>
<td>3.50 PSI</td>
<td>88.86 PSI</td>
<td>92.36 PSI</td>
<td>88.86 PSI</td>
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<tr>
<td>B - 6” Pipe</td>
<td>75.00 PSI</td>
<td>3.50 PSI</td>
<td>97.69 PSI</td>
<td>101.19 PSI</td>
<td>97.69 PSI</td>
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<td>ASME Flange Class: 150 Gr:1.1</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D - 12x16” MWY</td>
<td>75.00 PSI</td>
<td>3.50 PSI</td>
<td>88.86 PSI</td>
<td>92.36 PSI</td>
<td>88.86 PSI</td>
</tr>
</tbody>
</table>

NC = Not Calculated  Inc = Incomplete

### Summary

Component with the lowest vessel MAWP(New & Cold): **Right Side Head**

The lowest vessel MAWP(New & Cold): **87.81 PSI**

Component with the lowest vessel MAWP(Hot & Corroded): **Right Side Head**

The lowest vessel MAWP(Hot & Corroded): **87.81 PSI**

Pressures are exclusive of any external loads.

Flange pressures listed here do not consider external loadings.
<table>
<thead>
<tr>
<th></th>
<th>Dry Weight</th>
<th>Flooded Weight</th>
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</thead>
<tbody>
<tr>
<td>Shell</td>
<td>3190.24 lb.</td>
<td>34198.36 lb.</td>
</tr>
<tr>
<td>Head</td>
<td>1844.99 lb.</td>
<td>10820.08 lb.</td>
</tr>
<tr>
<td>Nozzle</td>
<td>141.78 lb.</td>
<td>141.78 lb.</td>
</tr>
<tr>
<td>ASME Flange</td>
<td>38.00 lb.</td>
<td>38.00 lb.</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>5215.01 lb.</strong></td>
<td><strong>45198.23 lb.</strong></td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell</td>
<td>3711.74 Gal.</td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>1076.15 Gal.</td>
<td></td>
</tr>
<tr>
<td>Nozzle</td>
<td>7.47 Gal.</td>
<td></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>4795.36 Gal.</strong></td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell</td>
<td>251.33 Sq. Ft.</td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>144.88 Sq. Ft.</td>
<td></td>
</tr>
<tr>
<td>Nozzle</td>
<td>14.58 Sq. Ft.</td>
<td></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>410.78 Sq. Ft.</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Hydrostatic Test Information Par. UG-99(b)**

Gauge at Top

Calculated Test Pressure: **97.50 PSI**

This calculation assumes one chamber.

This calculation is limited by the lowest component pressure per chamber.
# Table of Contents

Shell 1 1  
Right Side Head 2  
Left Side Head 3  
A - 3/4" 3000# Cplg 4  
B - 6" Pipe 7  
C - 6" Pipe 11  
D - 12x16" MWY 15  
E - 12x16" MWY 19  
F - 12x16" MWY 23  
G - 1-1/2" 3000# Cplg 27  
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