Pressure Vessel Engineering Ltd
120 Randall Drive Suite B Waterloo, Ontario N2V 1C6

Date Printed: 3/21/2012

VESSEL DESCRIPTION

Design Calcs Sample

Vessel designed with DesignCalcs, Version: 2012.4
Vessel is ASME Code Stamped

Job No: Design Calcs Sample
Vessel Number: 1

NAMEPLATE INFORMATION

Vessel MAWP: 200.00 PSI at 300 °F
MDMT: -20 °F at 200.00 PSI

Serial Number(s): _____

National Board Number(s): _____
Year Built: 2008
Radiography: NONE
Postweld Heat Treated: NONE
Construction Type: W

Notes

Design Calcs Version 2012.4
Built to ASME VIII-I 2007 Edition, 2008 Addenda

Signatures

_____ Date: ____/____/____

Pressure Vessel Engineering Ltd
120 Randall Drive Suite B Waterloo, Ontario N2V 1C6

Date Printed: 3/21/2012

Project Description

UG-22 Loadings Considered

Internal Press:	Yes
External Press:	No
Vessel Weight:	Yes
Weight of Attachments:	No
Attachment of Internals:	No
Attachment of Externals:	No
Cyclic or Dynamic Reactions:	No
Wind Loading:	No
Seismic Loading:	Yes
Fluid Impact Shock Reactions:	No
Temperature Gradients:	No
Differential Thermal Expansion:	No
Abnormal Pressures:	No
Hydrotest Loads:	Yes

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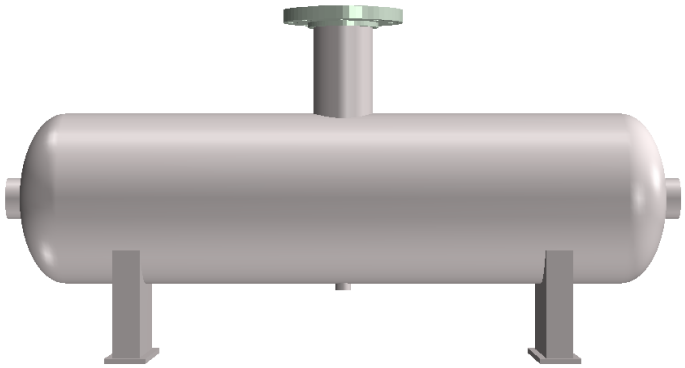

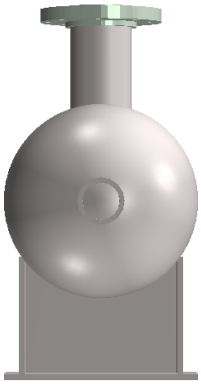

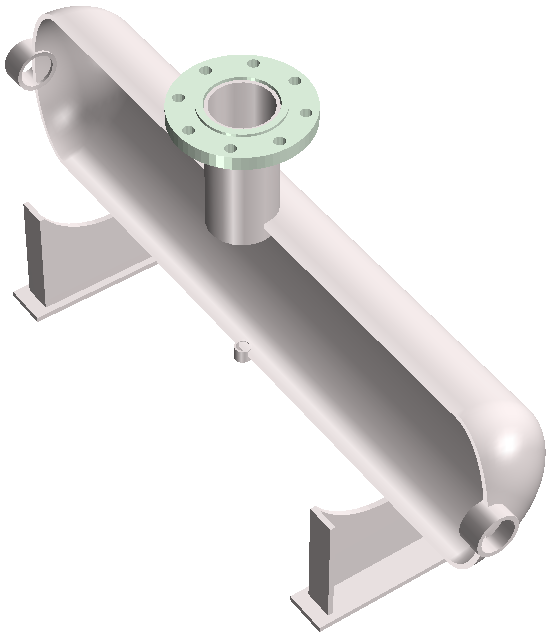

Pressure Vessel Engineering Ltd

Shell

Job No: Design Calcs Sample
Number: 1

Vessel Number: 1
Mark Number: S1

Date Printed: 3/21/2012

Cylindrical Shell Design Information

Design Pressure:	200.00	PSI	Design Temperature:	300	°F
Static Head:	0.50	PSI	Long. Joint Efficiency:	85	%
Shell Material:	SA-106 Gr. B		Factor B Chart:	CS-2	
			Material Stress (hot):	17100	PSI
Shell Length:	36.0000	in.	Material Stress (cold):	17100	PSI
			Compressive Stress:	17247	PSI
Corrosion Allowance:	0.0000	in.	Actual Circumferential Stress:	4489	PSI
External Corrosion Allowance:	0.0000	in.	Actual Longitudinal Stress:	2562	PSI
Outside Diameter (new):	12.7500	in.			
Outside Diameter (corroded):	12.7500	in.	Specific Gravity:	1.00	
Shell Surface Area:	10.01	Sq. Ft.	Weight of Fluid:	147.26	lb.
Shell Estimated Volume:	17.63	Gal.	Total Flooded Shell Weight:	294.22	lb.
Circ. Joint Efficiency:	70	%	Shell Weight:	146.96	lb.

Minimum Design Metal Temperature Data

Minimum Design Metal Temperature: -20 °F
Material is exempt from impact testing per UG-20(f), 1 through 5

Design Thickness Calculations

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

$$t = \frac{PR}{2SE + 0.4P} = \frac{200.50 * 6.0000}{2 * 17100 * 0.70 + 0.4 * 200.50}$$

= Greater Of ($0.0501_{(Calculated)}$, $0.0625_{(Minimum\ Allowed)}$) + 0.0000 (corrosion) + 0.0000 (ext. corrosion) + 0.0469 (12 1/2% for pipe)

= minimum of **0.1094** in.

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

$$t = \frac{PR_o}{SE + 0.4P} = \frac{200.50 * 6.3750}{17100 * 0.85 + 0.4 * 200.50}$$ = 0.0875 + 0.0000 (corrosion) + 0.0000 (ext. corrosion) + 0.0469 (12 1/2% for pipe)

= minimum of **0.1344** in.

External loads do not control design.

Pipe Selected: Size = **12 in.**, Schedule = **STD**, Diameter = **12.7500** in., Wall = **0.3750** in.

Pressure Vessel Engineering Ltd

Head, Left

Job No: Design Calcs Sample
Number: 1

Vessel Number: 1
Mark Number: H1

Date Printed: 3/21/2012

Ellipsoidal Head Design Information

Design Pressure:	200.00	PSI	Design Temperature:	300	°F
Static Head:	0.50	PSI	Joint Efficiency:	85	%
Head Material:	SA-234 Gr. WPB		Factor B Chart:	CS-2	
			Material Stress (hot):	17100	PSI
Corrosion Allowance:	0.0000	in.	Material Stress (cold):	17100	PSI
External Corrosion Allowance:	0.0000	in.	Actual Head Stress:	4371	PSI
Head Location:	Left		Straight Flange :	2.8130	in.
Outside Diameter :	12.7500	in.	Head Depth (ho) :	3.3750	in.
12.5 % pipe undertolerance:	0.0469	in.			
$K = \frac{1}{6}[2 + (D/2h)^2]$:	1.00				
Head Surface Area:	1.92	Sq. Ft.	Specific Gravity:	1.00	
Head Estimated Volume:	2.36	Gal.	Weight of Fluid:	19.65	lb.
Head Weight:	29.01	lb.	Total Flooded Head Weight:	48.66	lb.

Minimum Design Metal Temperature Data

Minimum Design Metal Temperature: -20 °F
Material is exempt from impact testing per UG-20(f), 1 through 5

Design Thickness Calculations

Design Thickness Calculations per Appendix 1-4(c)

$$\mathbf{t} = \frac{PD_oK}{2SE + 2P(K - 0.1)} = \frac{200.50 * 12.7500 * 1.00}{2 * 17100 * 0.85 + 2 * 200.50 * (1.00 - 0.1)}$$

$= 0.0869 + 0.0000_{(corrosion)} + 0.0000_{(ext.\ corrosion)} + 0.0469_{(12.5\ \%)}$ = minimum of **0.1338** in.

Nominal Head Thickness Selected = **0.3750** in.
Minimum Thickness after forming, t_s (uncorroded) = **0.3281** in.

Pipe Cap
Size: 12 Schedule: STD

Pressure Vessel Engineering Ltd

Head, Right

Job No: Design Calcs Sample
Number: 2

Vessel Number: 1
Mark Number: H2

Date Printed: 3/21/2012

Ellipsoidal Head Design Information

Design Pressure:	200.00	PSI	Design Temperature:	300	°F
Static Head:	0.50	PSI	Joint Efficiency:	85	%
Head Material:	SA-234 Gr. WPB		Factor B Chart:	CS-2	
			Material Stress (hot):	17100	PSI
Corrosion Allowance:	0.0000	in.	Material Stress (cold):	17100	PSI
External Corrosion Allowance:	0.0000	in.	Actual Head Stress:	4371	PSI
Head Location:	Right		Straight Flange :	2.8130	in.
Outside Diameter :	12.7500	in.	Head Depth (ho) :	3.3750	in.
12.5 % pipe undertolerance:	0.0469	in.			
$K = \frac{1}{6}[2 + (D/2h)^2]$:	1.00				

Head Surface Area:	1.92	Sq. Ft.	Specific Gravity:	1.00	
Head Estimated Volume:	2.36	Gal.	Weight of Fluid:	19.65	lb.
Head Weight:	29.01	lb.	Total Flooded Head Weight:	48.66	lb.

Minimum Design Metal Temperature Data

Minimum Design Metal Temperature: -20 °F
Material is exempt from impact testing per UG-20(f), 1 through 5

Design Thickness Calculations

Design Thickness Calculations per Appendix 1-4(c)

$$\mathbf{t} = \frac{PD_oK}{2SE + 2P(K - 0.1)} = \frac{200.50 * 12.7500 * 1.00}{2 * 17100 * 0.85 + 2 * 200.50 * (1.00 - 0.1)}$$

$= 0.0869 + 0.0000_{(corrosion)} + 0.0000_{(ext.\ corrosion)} + 0.0469_{(12.5\ \%)}$ = minimum of **0.1338** in.

Nominal Head Thickness Selected = **0.3750** in.
Minimum Thickness after forming, t_s (uncorroded) = **0.3281** in.

Pipe Cap
Size: 12 Schedule: STD

Pressure Vessel Engineering Ltd

N1 - Vent, 4" Sch STD Pipe

Job No: Design Calcs Sample
Number: 1
ID Number: 1

Vessel Number: 1
Mark Number: N1

Date Printed: 3/21/2012

Nozzle Design Information

Design Pressure:	200.00	PSI	Design Temperature:	300	°F
Static Head:	0.00	PSI	Nozzle Efficiency (E):	100	%
Nozzle Material:	SA-106 Gr. B		Joint Efficiency (E_1):	1.00	
			Factor B Chart:	CS-2	
External Projection:	7.7500	in.	Allowable Stress at Design Temperature (S_n):	17100	PSI
Internal Projection:	1.0000	in.	Allowable Stress at Ambient Temperature:	17100	PSI
Inside Corrosion Allowance:	0.0000	in.	Correction Factor (F):	1.00	
External Corrosion Allowance:	0.0000	in.	Nozzle Path:	None	
Nozzle Pipe Size:	4		Nozzle Pipe Schedule:	STD	
Nozzle ID (new):	4.0260	in.	Nozzle Wall Thickness(new):	0.2370	in.
Nozzle ID (corroded):	4.0260	in.	Nozzle Wall Thickness(corroded):	0.2370	in.
			Upper Weld Leg Size(Weld 41):	0.2500	in.
			Internal Weld Leg Size(Weld 43):	0.2500	in.
			Outside Groove Weld Depth:	0.3750	in.

Minimum Design Metal Temperature

Minimum Design Metal Temperature: -20 °F
Material is exempt from impact testing per UG-20(f), 1 through 5

Host Component: Shell 1 - Shell

Material:	SA-106 Gr. B		Shell wall thickness(new):	0.3750	in.
Material Stress(S_v):	17100	PSI	Shell wall thickness - 12½% for pipe (corroded):	0.3281	in.

Nozzle Detail Information

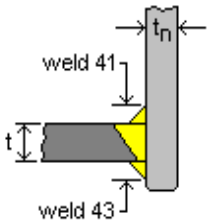

Fig. UW-16.1 (c)

Upper Weld Leg Size(Weld 41): 0.2500 in.

Internal Weld Leg Size(Weld 43): 0.2500 in.

Nozzle Wall Thickness(t_n): 0.2370 in.

Outside Groove Weld Depth: 0.3750 in.

Nozzle passes through the vessel, attached by a groove weld.
Pipe Size: 4 Schedule: STD
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)

$$\mathbf{tr} = \frac{PRo}{SE + 0.4P} = \frac{200.00 * 6.3750}{17100 * 1 + 0.4 * 200.00}$$ = **0.0742** in.

Nozzle Required Thickness Calculations

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

$$\mathbf{trn} = \frac{PRn}{SE - 0.6P} = \frac{200.00 * 2.0130}{17100 * 1 - 0.6 * 200.00}$$ = **0.0237** in.

Strength Reduction Factors

fr1 = $\min\left(\frac{Sn}{Sv}, 1.0000\right) = \min\left(\frac{17100}{17100}, 1.0000\right) = 1.0000$ **fr2** = $\min\left(\frac{Sn}{Sv}, 1.0000\right) = \min\left(\frac{17100}{17100}, 1.0000\right) = 1.0000$

UG-45 Thickness Calculations

Nozzle Thickness for Pressure Loading (plus corrosion)

$$t_a = \frac{PRn}{SE - 0.6P} + Ca + \text{ext. } Ca = \frac{200.00 * 2.0130}{17100 * 1.00 - 0.6 * 200.00} + 0.0000 + 0.0000$$ = **0.0237** in.

Nozzle Thickness for Internal Pressure (plus corrosion) Based on Host

$$t_{b1} = \frac{PRo}{SE + 0.4P} + Ca + \text{ext. } Ca = \frac{200.00 * 6.3750}{17100 * 1 + 0.4 * 200.00} + 0.0000 + 0.0000$$ = **0.0742** in.

Minimum Thickness (plus corrosion) per Table UG-45

t_{b3} = minimum thickness (Table UG-45) + Ca + ext. Ca = **0.2070** in.

Nozzle Minimum Thickness Based on Host and Table UG-45

$t_b = \min[t_{b3}, \max(t_{b1}, t_{b2})]$ = **0.0742** in.

$t_{UG\text{-}45} = \max(t_a, t_b)$ = **0.0742** in.

Wall thickness = tn * 0.875(pipe) = **0.2074** is greater than or equal to UG-45 value of **0.0742**

Limits of Reinforcement (UG-40)

L_{par} = max(d, R_n + t + t_n) = max(4.0260, 2.0130 + 0.3281 + 0.2370) = **4.0260** in.
L_{noro} = min(2.5 t, 2.5 t_n + t_e) = min(2.5 * 0.3281, 2.5 * 0.2370 + 0.0000) = **0.5925** in.
L_{nori} = min(2.5 t, 2.5 t_i) = min(2.5 * 0.3281, 2.5 * 0.2370) = **0.5925** in.

Nozzle Reinforcement Calculations (Internal Pressure)

A = max{C [d t_r F + 2 t_n t_r F (1 - f_{r1})], 0} = max{1.0000 * [4.0260 * 0.0742 * 1.00 + 2 * 0.2370 * 0.0742 * 1.00 * (1 - 1.0000)], 0}
= **0.2987** sq. in.

A1 = max[(2 L_{par} - d) (E_1 t - F t_r) - 2 t_n (E_1 t - F t_r) (1 - f_{r1}), 0] =
max[(2 * 4.0260 - 4.0260) * (1.0000 * 0.3281 - 1.00 * 0.0742) - 2 * 0.2370 * (1.0000 * 0.3281 - 1.00 * 0.0742) * (1 - 1.0000), 0]
= **1.0222** sq. in.

A2 = max{2 min(h_o, L_{noro}) [min(t_n, L_{par} - 0.5 d) - t_{rn}] f_{r2}, 0} =
max{2 * min(7.7500, 0.5925) * [min(0.2370, 4.0260 - 0.5 * 4.0260) - 0.0237] * 1.0000, 0} = **0.2528** sq. in.

A3 = max{2 min(h, L_{nori}) min(t_i, L_{par} - 0.5 d) f_{r2}, 0} =
max{2 * min(1.0000, 0.5925) * min(0.2370, 4.0260 - 0.5 * 4.0260) * 1.0000, 0} = **0.2808** sq. in.

A41 = f_{r2} [L_{41}^2 - (L_{41} - $L_{41pareff}$)^2 - (L_{41} - $L_{41noreff}$)^2] =
1.0000 * [0.2500^2 - (0.2500 - 0.2500)^2 - (0.2500 - 0.2500)^2] = **0.0625** sq. in.

A42 = f_{r4} $L_{42pareff}$ $L_{42noreff}$ =
0.0000 * 0.0000 * 0.0000 = **0.0000** sq. in.

A43 = f_{r2} [L_{43}^2 - (L_{43} - $L_{43pareff}$)^2 - (L_{43} - $L_{43noreff}$)^2] =
1.0000 * [0.2500^2 - (0.2500 - 0.2500)^2 - (0.2500 - 0.2500)^2] = **0.0625** sq. in.

A5
= **0.0000** sq. in.

Area Available (Internal Pressure) = A1 + A2 + A3 + A41 + A42 + A43 + A5 = 1.6808 sq. in., which is **>=** A (0.2987)

Pressure Vessel Engineering Ltd

N2 - Inlet - 2" coupling, 3000#

Job No: Design Calcs Sample Number: 2
ID Number: 2

Vessel Number: 1
Mark Number: N2

Date Printed: 3/21/2012

Nozzle Design Information

Design Pressure:	200.00	PSI	Design Temperature:	300	°F
Static Head:	0.50	PSI	Nozzle Efficiency (E):	100	%
Nozzle Material:	SA-105		Joint Efficiency (E_1):	1.00	
			Factor B Chart:	CS-2	
External Projection:	1.0000	in.	Allowable Stress at Design Temperature (S_n):	20000	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 ID (new):	2.4060	in.	Nozzle Wall Thickness(new):	0.3125	in.
Nozzle ID (corroded):	2.4060	in.	Nozzle Wall Thickness(corroded):	0.3125	in.
			Upper Weld Leg Size(Weld 41):	0.3125	in.
			Internal Weld Leg Size(Weld 43):	0.0000	in.
			Outside Groove Weld Depth:	0.3750	in.

Minimum Design Metal Temperature

Minimum Design Metal Temperature: -20 °F
Material is exempt from impact testing per UG-20(f), 1 through 5

Host Component: Head 1 - Head, Left

Material:	SA-234 Gr. WPB		Head wall thickness(new):	0.3750	in.
Material Stress(S_v):	17100	PSI	Head wall thickness - 12½% for pipe:	0.3281	in.

Nozzle Detail Information

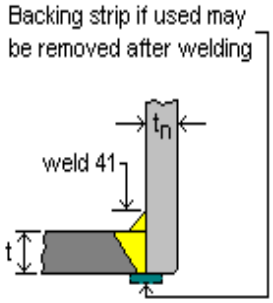

Fig. UW-16.1 (c)

Upper Weld Leg Size(Weld 41): 0.3125 in.

Nozzle Wall Thickness(t_n): 0.3125 in.

Outside Groove Weld Depth: 0.3750 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 Head Thickness per Paragraph UG-37(a)

$$\mathbf{tr} = \frac{P\ K1\ Do}{(2SE + 0.8P)} = \frac{200.50 * 0.9000 * 12.7500}{(2 * 17100 * 1 + 0.8 * 200.50)}$$ = **0.0670** in.

Nozzle Required Thickness Calculations

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

$$\mathbf{trn} = \frac{PRn}{SE - 0.6P} = \frac{200.50 * 1.2030}{20000 * 1 - 0.6 * 200.50}$$ = **0.0121** in.

Strength Reduction Factors

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

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

UG-45 Thickness Calculations

Nozzle Thickness for Pressure Loading (plus corrosion)

$$t_a = \frac{PRn}{SE - 0.6P} + Ca + ext.\ Ca = \frac{200.50 * 1.2030}{20000 * 1.00 - 0.6 * 200.50} + 0.0000 + 0.0000$$ = **0.0121** in.

Nozzle Thickness for Internal Pressure (plus corrosion) Based on Host

$$t_{b1} = \frac{P\ K\ Do}{(2SE + 2P(K - 0.1))} + Ca + ext.\ Ca = \frac{200.50 * 1.0000 * 12.7500}{(2 * 17100 * 1 + 2 * 200.50 * (1.0000 - 0.1))} + 0.0000 + 0.0000$$ = **0.0740** in.

Minimum Thickness (plus corrosion) per Table UG-45

t_{b3} = minimum thickness (Table UG-45) + Ca + ext. Ca = **0.1890** in.

Nozzle Minimum Thickness Based on Host and Table UG-45

$t_b = \min[t_{b3}, \max(t_{b1}, t_{b2})]$ = **0.0740** in.

$t_{UG\text{-}45} = \max(t_a, t_b)$ = **0.0740** in.

Wall thickness = tn = **0.3125** is greater than or equal to UG-45 value of **0.0740**

Pressure Vessel Engineering Ltd

N3 - Outlet - 2" Coupling, 3000#

Job No: Design Calcs Sample Number: 3
ID Number: 3

Vessel Number: 1
Mark Number: N3

Date Printed: 3/21/2012

Nozzle Design Information

Design Pressure:	200.00	PSI	Design Temperature:	300	°F
Static Head:	0.50	PSI	Nozzle Efficiency (E):	100	%
Nozzle Material:	SA-105		Joint Efficiency (E_1):	1.00	
			Factor B Chart:	CS-2	
External Projection:	1.0000	in.	Allowable Stress at Design Temperature (S_n):	20000	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 ID (new):	2.4060	in.	Nozzle Wall Thickness(new):	0.3125	in.
Nozzle ID (corroded):	2.4060	in.	Nozzle Wall Thickness(corroded):	0.3125	in.
			Upper Weld Leg Size(Weld 41):	0.3125	in.
			Internal Weld Leg Size(Weld 43):	0.0000	in.
			Outside Groove Weld Depth:	0.3750	in.

Minimum Design Metal Temperature

Minimum Design Metal Temperature: -20 °F
Material is exempt from impact testing per UG-20(f), 1 through 5

Host Component: Head 2 - Head, Right

Material:	SA-234 Gr. WPB		Head wall thickness(new):	0.3750	in.
Material Stress(S_v):	17100	PSI	Head wall thickness - 12½% for pipe:	0.3281	in.

Nozzle Detail Information

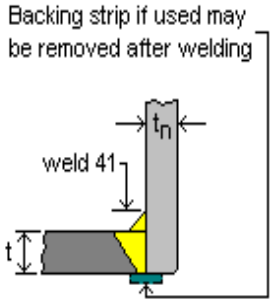

Fig. UW-16.1 (c)

Upper Weld Leg Size(Weld 41): 0.3125 in.

Nozzle Wall Thickness(t_n): 0.3125 in.

Outside Groove Weld Depth: 0.3750 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 Head Thickness per Paragraph UG-37(a)

$$\mathbf{tr} = \frac{P\ K1\ Do}{(2SE + 0.8P)} = \frac{200.50 * 0.9000 * 12.7500}{(2 * 17100 * 1 + 0.8 * 200.50)}$$ = **0.0670** in.

Nozzle Required Thickness Calculations

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

$$\mathbf{trn} = \frac{PRn}{SE - 0.6P} = \frac{200.50 * 1.2030}{20000 * 1 - 0.6 * 200.50}$$ = **0.0121** in.

Strength Reduction Factors

fr1 = $\min\left(\frac{Sn}{Sv}, 1.0000\right) = \min\left(\frac{20000}{17100}, 1.0000\right) = 1.0000$ **fr2** = $\min\left(\frac{Sn}{Sv}, 1.0000\right) = \min\left(\frac{20000}{17100}, 1.0000\right) = 1.0000$

UG-45 Thickness Calculations

Nozzle Thickness for Pressure Loading (plus corrosion)

$$t_a = \frac{PRn}{SE - 0.6P} + Ca + ext.\ Ca = \frac{200.50 * 1.2030}{20000 * 1.00 - 0.6 * 200.50} + 0.0000 + 0.0000$$ = **0.0121** in.

Nozzle Thickness for Internal Pressure (plus corrosion) Based on Host

$$t_{b1} = \frac{P\ K\ Do}{(2SE + 2P(K - 0.1))} + Ca + ext.\ Ca = \frac{200.50 * 1.0000 * 12.7500}{(2 * 17100 * 1 + 2 * 200.50 * (1.0000 - 0.1))} + 0.0000 + 0.0000$$ = **0.0740** in.

Minimum Thickness (plus corrosion) per Table UG-45

t_{b3} = minimum thickness (Table UG-45) + Ca + ext. Ca = **0.1890** in.

Nozzle Minimum Thickness Based on Host and Table UG-45

$t_b = \min[t_{b3}, \max(t_{b1}, t_{b2})]$ = **0.0740** in.

$t_{UG\text{-}45} = \max(t_a, t_b)$ = **0.0740** in.

Wall thickness = tn = **0.3125** is greater than or equal to UG-45 value of **0.0740**

Pressure Vessel Engineering Ltd

N4 - Drain - 1/2" Coupling, 3000#

Job No: Design Calcs Sample Number: 4 ID Number: 4

Vessel Number: 1 Mark Number: N4

Date Printed: 3/21/2012

Nozzle Design Information

Design Pressure:	200.00 PSI		Design Temperature:	300 °F	
Static Head:	0.50 PSI		Nozzle Efficiency (E):	100 %	
Nozzle Material:	SA-105		Joint Efficiency (E_1):	1.00	
			Factor B Chart:	CS-2	
External Projection:	0.5000 in.		Allowable Stress at Design Temperature (S_n):	20000 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 ID (new):	0.8550 in.		Nozzle Wall Thickness(new):	0.1425 in.	
Nozzle ID (corroded):	0.8550 in.		Nozzle Wall Thickness(corroded):	0.1425 in.	
			Upper Weld Leg Size(Weld 41):	0.2500 in.	
			Internal Weld Leg Size(Weld 43):	0.0000 in.	
			Outside Groove Weld Depth:	0.3750 in.	

Minimum Design Metal Temperature

Minimum Design Metal Temperature: -20 °F
Material is exempt from impact testing per UG-20(f), 1 through 5

Host Component: Shell 1 - Shell

Material:	SA-106 Gr. B		Shell wall thickness(new):	0.3750	in.
Material Stress(S_v):	17100	PSI	Shell wall thickness - 12½% for pipe (corroded):	0.3281	in.

Nozzle Detail Information

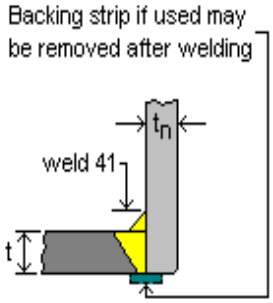

Fig. UW-16.1 (c)

Upper Weld Leg Size(Weld 41): 0.2500 in.

Nozzle Wall Thickness(t_n): 0.1425 in.

Outside Groove Weld Depth: 0.3750 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)

$$\mathbf{tr} = \frac{PRo}{SE + 0.4P} = \frac{200.50 * 6.3750}{17100 * 1 + 0.4 * 200.50}$$ = **0.0744** in.

Nozzle Required Thickness Calculations

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

$$\mathbf{trn} = \frac{PRn}{SE - 0.6P} = \frac{200.50 * 0.4275}{20000 * 1 - 0.6 * 200.50}$$ = **0.0043** in.

Strength Reduction Factors

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

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

UG-45 Thickness Calculations

Nozzle Thickness for Pressure Loading (plus corrosion)

$$t_a = \frac{PRn}{SE - 0.6P} + Ca + \text{ext. } Ca = \frac{200.50 * 0.4275}{20000 * 1.00 - 0.6 * 200.50} + 0.0000 + 0.0000$$ = **0.0043** in.

Nozzle Thickness for Internal Pressure (plus corrosion) Based on Host

$$t_{b1} = \frac{PRo}{SE + 0.4P} + Ca + \text{ext. } Ca = \frac{200.50 * 6.3750}{17100 * 1 + 0.4 * 200.50} + 0.0000 + 0.0000$$ = **0.0744** in.

Minimum Thickness (plus corrosion) per Table UG-45

t_{b3} = minimum thickness (Table UG-45) + Ca + ext. Ca = **0.1160** in.

Nozzle Minimum Thickness Based on Host and Table UG-45

$t_b = \min[t_{b3}, \max(t_{b1}, t_{b2})]$ = **0.0744** in.

$t_{UG\text{-}45} = \max(t_a, t_b)$ = **0.0744** in.

Wall thickness = tn = **0.1425** is greater than or equal to UG-45 value of **0.0744**

Pressure Vessel Engineering Ltd

Saddle

Job No: Design Calcs Sample
Number: 1

Vessel Number: 1
Mark Number: SDL1

Date Printed: 3/21/2012

Saddle Design Information

Design Temperature:	300	°F	Support Type:	Type II	
Material:	SA/CSA-G40.21 Gr. 38W		Stiffener Quantity:	2	
Condition:			Material Stress (hot):	17100	PSI
Length (d):	11.0418	in.	Material Stress (cold):	17100	PSI
Top Width (b'):	2.0000	in.	Yield Strength:	33600	PSI
Bottom Width ($b_{b'}$):	2.0000	in.	Density:	0.2800	lb/in.^3
Outside Stiffener Thickness (t_{so}):	0.3750	in.	Web Plate Thickness (t_w):	0.3750	in.
Inside Stiffener Thickness (t_{si}):	0.3750	in.	Vessel Centerline Height (h):	12.0000	in.
Saddle Angle of contact (n):	120.0	°	Elevation above grade (g):	0.0000	in.
Dist. from saddle centerline to tang. line (A):	5.0000	in.			
Support Design Condition:	Shell unstiffened (A/R > 1/2)				

Base Plate Information

Design Temperature:	300	°F	Ultimate 28 Day Concrete Strength:	3000.00	PSI
Material:	SA/CSA-G40.21 Gr. 38W		Yield Strength:	33600	PSI
Condition:			Length (m):	13.0000	in.
Width (b_b):	3.0000	in.	Thickness (t_b):	0.3750	in.

Anchor Bolt Information

Material:	SA-307 Gr. B		Material Stress (hot):	7000	PSI
Condition:			Material Stress (cold):	7000	PSI
Size:	1/2"		Number of Threads per in. :	13.0000	
Quantity:	2		Root Area:	0.1260	sq. in.

ASME Flange Design Information

Host	Description	Type	Size (in.)	Material	ASME Class	Material Group	MAP (PSI)
N1 - Vent, 4" Sch STD	ASME Flange 1	Slip On	4		150	1.1	230.00

Zick Analysis

Operating Pressurized Condition - Sustained Loads

Saddle Support Loads

$$\mathbf{Q}_L = \frac{F_L h}{L - 2A} = \frac{0 * 12.0000}{41.6260 - 2 * 5.0000}$$ = **0** lb.

$$\mathbf{Q}_T = \frac{1.5\ F_T\ h}{d} = \frac{1.5\ * 0 * 12.0000}{11.0418}$$ = **0** lb.

$$\mathbf{Q}_W = \frac{W}{2} = \frac{227}{2}$$ = **114** lb.

$\mathbf{Q}_N = Q_W = 114$ = **114** lb.

Saddle Load for Vessel Stress Analysis

$\mathbf{Q} = Q_N = 114$ = **114** lb.

Saddle Load for Support Stress Analysis

$\mathbf{Q}_S = Q_N = 114$ = **114** lb.

Zick Calculations

Longitudinal Stress Due to Internal Pressure

$$S_p = \frac{P\,R}{2\,t} = \frac{200.50 * 6.1875}{2 * 0.3750}$$ = **1654** PSI

Longitudinal Compressive Stress Due to External Pressure

$$S_{pe} = \frac{-P_e\,R}{2\,t} = \frac{-0.00 * 6.1875}{2 * 0.3750}$$ = **0** PSI

Longitudinal Bending Stress in the Shell at the Midpoint

$Z_1 = \pi R^2 t = 3.1416 * 6.1875^2 * 0.3750$ = **45** in.³

$$S_1 = \frac{K_1\,Q\,L}{4\,Z_1} = \frac{0.44999 * 114 * 41.6260}{4 * 45}$$ = **12** PSI

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

$$S_1' = \frac{K_1'\,Q\,L}{4\,Z_1} = \frac{0.66538 * 114 * 41.6260}{4 * 45}$$ = **18** PSI

Saddle Plane Tangential Shear Stress

$$S_2 = \left[\frac{K_2\,Q}{R\,t}\right] \left[\frac{L - 2A}{L + \frac{4}{3}H}\right] = \left[\frac{1.17074 * 114}{6.1875 * 0.3750}\right] \left[\frac{41.6260 - 2 * 5.0000}{41.6260 + \frac{4}{3} * 3.3750}\right]$$ = **39** PSI

Circumferential Stress at the Horn of the Saddle

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

$$= -\left[\frac{114}{4 * 0.3750 * (2.0000 + 1.56 * \sqrt{6.1875 * 0.3750})}\right] - \left[\frac{12 * 0.03764 * 114 * 6.1875}{41.6260 * 0.3750^2}\right]$$

= **-72** PSI

Ring Compression in the Shell Over the Saddle

$$S_5 = \frac{K_5\,Q}{t\,(b + 1.56\sqrt{R\,t})} = \frac{0.76027 * 114}{0.3750 * (0.3750 + 1.56 * \sqrt{6.1875 * 0.3750})}$$ = **84** PSI

Maximum Splitting Force

$F_s = K_8 Q_s = 0.20352 * 114$ = **23** lb.

Vessel Stress Ratio Calculations

Any ratio greater than 1 represents an overstressed condition

$$\mathbf{R_{1t}} = \frac{S_1 + S_p}{S_{Shell}\, E} = \frac{12 + 1654}{17100 * 0.70} \quad \mathbf{= 0.1392}$$

$$\mathbf{R_{1C}} = \frac{-S_1}{-\,\mathrm{Min}(S_{Shell}, B_{Shell})} = \frac{-12}{-\mathrm{Min}(17100,17247)} \quad \mathbf{= 0.0007}$$

$$\mathbf{R_{1t}'} = \frac{S_1' + S_p}{S_{Shell}\, E} = \frac{18 + 1654}{17100 * 0.70} \quad \mathbf{= 0.1397}$$

$$\mathbf{R_{1C}'} = \frac{-S_1'}{-\,\mathrm{Min}(S_{Shell}, B_{Shell})} = \frac{-18}{-\mathrm{Min}(17100,17247)} \quad \mathbf{= 0.0011}$$

$$\mathbf{R_2} = \frac{S_2}{0.8\, S_{Shell}} = \frac{39}{0.8 * 17100} \quad \mathbf{= 0.0029}$$

$$\mathbf{R_3} = \frac{S_3}{-\,(1.25\, S_{Shell})} = \frac{-72}{-\,(1.25 * 17100)} \quad \mathbf{= 0.0034}$$

$$\mathbf{R_5} = \frac{S_5}{0.5\, Y_{Shell}} = \frac{84}{0.5 * 31000} \quad \mathbf{= 0.0054}$$

MDMT Report by Components

Design MDMT is -20 °F

Component	Material	Curve	Pressure	MDMT
Shell	SA-106 Gr. B			Exempt per UG-20(f), 1-5
N1 - Vent, 4" Sch STD Pipe	SA-106 Gr. B			Exempt per UG-20(f), 1-5
N4 - Drain - 1/2" Coupling, 3000#	SA-105			Exempt per UG-20(f), 1-5
Head, Left	SA-234 Gr. WPB			Exempt per UG-20(f), 1-5
N2 - Inlet - 2" coupling, 3000#	SA-105			Exempt per UG-20(f), 1-5
Head, Right	SA-234 Gr. WPB			Exempt per UG-20(f), 1-5
N3 - Outlet - 2" Coupling, 3000#	SA-105			Exempt per UG-20(f), 1-5

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

Component	Design Pressure	Static Head	Vessel MAWP New & Cold UG-98(a)	Component MAWP Hot & Corroded UG-98(b)	Vessel MAWP Hot & Corroded UG-98(a)
Shell	200.00 PSI	0.50 PSI	647.66 PSI	647.66 PSI	647.66 PSI
N1 - Vent, 4" Sch STD Pipe	200.00 PSI	0.00 PSI	647.66 PSI	647.66 PSI	647.66 PSI
ASME Flange Class: 150 Gr:1.1	200.00 PSI	0.00 PSI	285.00 PSI	230.00 PSI	230.00 PSI
N4 - Drain - 1/2" Coupling, 3000#	200.00 PSI	0.50 PSI	898.21 PSI	898.71 PSI	898.21 PSI
Head, Left	200.00 PSI	0.50 PSI	783.90 PSI	784.40 PSI	783.90 PSI
N2 - Inlet - 2" coupling, 3000#	200.00 PSI	0.50 PSI	975.13 PSI	975.63 PSI	975.13 PSI
Head, Right	200.00 PSI	0.50 PSI	783.90 PSI	784.40 PSI	783.90 PSI
N3 - Outlet - 2" Coupling, 3000#	200.00 PSI	0.50 PSI	975.13 PSI	975.63 PSI	975.13 PSI

NC = Not Calculated Inc = Incomplete

Summary

Component with the lowest vessel MAWP(New & Cold) : **ASME Flange Class: 150 Gr:1.1**
The lowest vessel MAWP(New & Cold) : **285.00** PSI

Component with the lowest vessel MAWP(Hot & Corroded) : **ASME Flange Class: 150 Gr:1.1**
The lowest vessel MAWP(Hot & Corroded) : **230.00** PSI

Pressures are exclusive of any external loads.

Flange pressures listed here do not consider external loadings

Summary Information

	Dry Weight	Flooded Weight
Shell	146.96 lb.	294.22 lb.
Head	58.02 lb.	97.33 lb.
Nozzle	8.63 lb.	8.63 lb.
ASME Flange	13.00 lb.	13.00 lb.
	0.00 lb.	0.00 lb.
	0.00 lb.	0.00 lb.
	0.00 lb.	0.00 lb.
	0.00 lb.	0.00 lb.
	0.00 lb.	0.00 lb.
Totals	226.60 lb.	413.18 lb.

	Volume
Shell	17.63 Gal.
Head	4.71 Gal.
Nozzle	0.60 Gal.
	0.00 Gal.
	0.00 Gal.
Totals	22.94 Gal.

	Area
Shell	10.01 Sq. Ft.
Head	3.84 Sq. Ft.
Nozzle	1.34 Sq. Ft.
	0.00 Sq. Ft.
	0.00 Sq. Ft.
Totals	15.19 Sq. Ft.

Hydrostatic Test Information Par. UG-99(b)
Gauge at Top

Component	Const.	x	STest	/	SDesign	x	Pressure	=	Component Hydro Test Pressure
Head, Left	1.3	x	17100	/	17100	x	200.00	=	**260.00**
Head, Right	1.3	x	17100	/	17100	x	200.00	=	260.00
N1 - Vent, 4" Sch STD	1.3	x	17100	/	17100	x	200.00	=	260.00
N2 - Inlet - 2" coupli	1.3	x	20000	/	20000	x	200.00	=	260.00
N3 - Outlet - 2" Coupl	1.3	x	20000	/	20000	x	200.00	=	260.00
N4 - Drain - 1/2" Coup	1.3	x	20000	/	20000	x	200.00	=	260.00
Shell	1.3	x	17100	/	17100	x	200.00	=	260.00

Calculated Test Pressure: 260.00 PSI

Special Notes:

This calculation assumes one chamber.

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

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