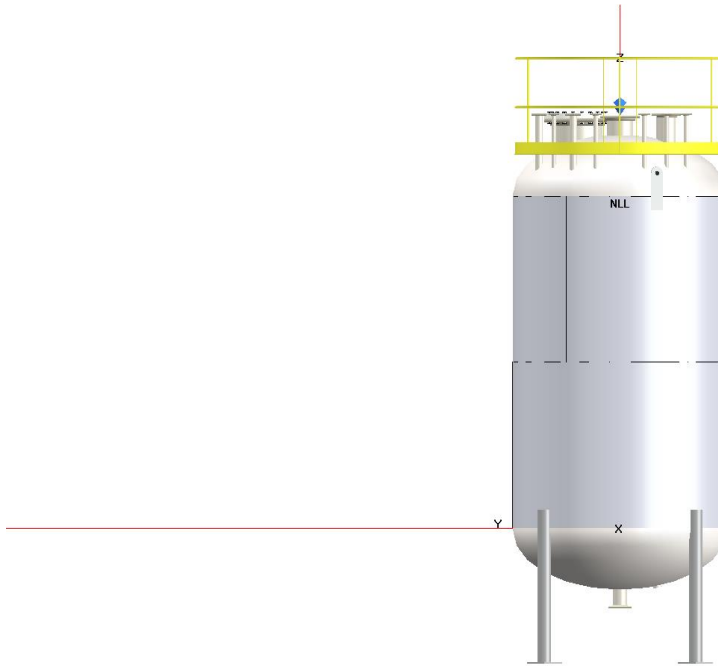


ASHLAND



COMPRESS Pressure Vessel Design Calculations

Item: 102" I.D. T-304/304L S/S SOLVENT RECOVERY TANK
Roben Job No: 14053REVA
Corr. Allow: 1/16" ON ALL
X-Ray SPOT X-RAY LONG SEAMS
Pressure/Temp 15 VAC/100 psig @ -25 TO 450 F
Date: Wednesday, October 22, 2014

(1) REQ'D-----P.O. NO: 4502514375-----EQUIP NO: 72-9106-----6" 130 DEGREE JKT
COIL-----12" AGITATOR-----

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Deficiencies Summary

No deficiencies found.

Nozzle Schedule

Specifications									
Nozzle mark	Identifier	Size	Materials		Impact Tested	Normalized	Fine Grain	Flange	Blind
A	AGITATOR	12.75 OD x 0.625	Nozzle	SA-240 304	No	No	No	NPS 12 Class 150 SO A182 F304	No
			Pad	SA-240 304	No	No	No		
B	FUTURE	NPS 8 Sch 80S (XS)	Nozzle	SA-312 TP304 Wld pipe	No	No	No	NPS 8 Class 150 SO A182 F304	No
			Pad	SA-240 304	No	No	No		
C	FUTURE	NPS 4 Sch 80S (XS)	Nozzle	SA-312 TP304 Wld pipe	No	No	No	NPS 4 Class 150 SO A182 F304	No
D	VENT	NPS 3 Sch 80S (XS)	Nozzle	SA-312 TP304 Wld pipe	No	No	No	NPS 3 Class 150 SO A182 F304	No
			Pad	SA-240 304	No	No	No		
E	RELIEF	NPS 3 Sch 80S (XS)	Nozzle	SA-312 TP304 Wld pipe	No	No	No	NPS 3 Class 150 SO A182 F304	No
			Pad	SA-240 304	No	No	No		
F	CHARGE PORT	NPS 2 Sch 160	Nozzle	SA-312 TP304 Wld pipe	No	No	No	NPS 2 Class 150 SO A182 F304	No
G	CHARGE PORT	NPS 2 Sch 160	Nozzle	SA-312 TP304 Wld pipe	No	No	No	NPS 2 Class 150 SO A182 F304	No
H	CHARGE PORT	NPS 2 Sch 160	Nozzle	SA-312 TP304 Wld pipe	No	No	No	NPS 2 Class 150 SO A182 F304	No
J	CHARGE PORT	NPS 3 Sch 80S (XS)	Nozzle	SA-312 TP304 Wld pipe	No	No	No	NPS 3 Class 150 SO A182 F304	No
			Pad	SA-240 304	No	No	No		
K	CHARGE PORT	NPS 1.5 Sch 160	Nozzle	SA-312 TP304 Wld pipe	No	No	No	NPS 1 1/2 Class 150 SO A182 F304	No
L	CHARGE PORT	NPS 1.5 Sch 160	Nozzle	SA-312 TP304 Wld pipe	No	No	No	NPS 1 1/2 Class 150 SO A182 F304	No
M	MANWAY	24 OD x 0.5	Nozzle	SA-240 304	No	No	No	NPS 24 Class 150 SO A182 F304	NPS 24 Class 150 A182 F304
			Pad	SA-240 304	No	No	No		
P	DRAIN	NPS 6 Sch 80S (XS)	Nozzle	SA-312 TP304 Wld pipe	No	No	No	NPS 6 Class 150 SO A182 F304	No
			Pad	SA-240 304	No	No	No		
Q	THERMOWELL	Studding Outlet NPS 1 Class 150	Nozzle	SA-240 304 (low stress)	No	No	No	N/A	No

Nozzle Summary

Dimensions												
Nozzle mark	OD (in)	t _n (in)	Req t _n (in)	A ₁ ?	A ₂ ?	Shell			Reinforcement Pad		Corr (in)	A _a /A _r (%)
						Nom t (in)	Design t (in)	User t (in)	Width (in)	t _{pad} (in)		
A	12.75	0.625	0.3906	Yes	Yes	0.485*	0.4121		4	0.5	0.0625	100.0
B	8.625	0.5	0.3934	Yes	Yes	0.485*	0.3702		1.5	0.25	0.0625	100.0
C	4.5	0.337	0.3084	Yes	Yes	0.485*	0.3216		N/A	N/A	0.0625	100.0
D	3.5	0.3	0.2874	Yes	Yes	0.485*	0.3876		1	0.25	0.0625	100.0
E	3.5	0.3	0.2874	Yes	Yes	0.485*	0.3763		1	0.25	0.0625	100.0
F	2.375	0.344	0.2254	Yes	Yes	0.485*	N/A		N/A	N/A	0.0625	Exempt
G	2.375	0.344	0.2254	Yes	Yes	0.485*	N/A		N/A	N/A	0.0625	Exempt
H	2.375	0.344	0.2254	Yes	Yes	0.485*	N/A		N/A	N/A	0.0625	Exempt
J	3.5	0.3	0.2874	Yes	Yes	0.485*	0.3763		1	0.25	0.0625	100.0
K	1.9	0.281	0.2164	Yes	Yes	0.485*	N/A		N/A	N/A	0.0625	Exempt
L	1.9	0.281	0.2164	Yes	Yes	0.485*	N/A		N/A	N/A	0.0625	Exempt
M	24	0.5	0.3497	Yes	Yes	0.485*	0.3157		4.25	0.5	0.0625	100.0
P	6.625	0.432	0.3514	Yes	Yes	0.485*	0.3851		1.5	0.25	0.0625	100.0
Q	4.25	1.625	0.2699	Yes	Yes	0.485*	N/A		N/A	N/A	0.0625	Exempt

*Head minimum thickness after forming

Definitions	
t _n	Nozzle thickness
Req t _n	Nozzle thickness required per UG-45/UG-16
Nom t	Vessel wall thickness
Design t	Required vessel wall thickness due to pressure + corrosion allowance per UG-37
User t	Local vessel wall thickness (near opening)
A _a	Area available per UG-37, governing condition
A _r	Area required per UG-37, governing condition
Corr	Corrosion allowance on nozzle wall

Pressure Summary

Component Summary										
Identifier	P Design (psi)	T Design (°F)	MAWP (psi)	MAP (psi)	MAEP (psi)	T _e external (°F)	MDMT (°F)	MDMT Exemption		Impact Tested
TOP HEAD	100	450	125.99	161.51	25.31	450	-320	Note 1		No
Straight Flange on TOP HEAD	100	450	129.69	165.69	16.53	450	-320	Note 2		No
Cylinder #1	100	450	126.83	165.69	16.53	450	-320	Note 2		No
Cylinder #2	100	450	123.72	165.69	16.53	450	-320	Note 2		No
Straight Flange on BTM HEAD	100	450	123.67	165.69	16.53	450	-320	Note 2		No
BTM HEAD	100	450	118.86	161.51	25.31	450	-320	Note 3		No
4 PIPE LEGS	100	450	100	N/A	N/A	N/A	N/A	N/A		N/A
AGITATOR (A)	100	450	144.11	179.38	16.53	450	-55	Nozzle	Note 4	No
								Pad	Note 2	No
FUTURE (B)	100	450	119.92	154.18	16.53	450	-55	Nozzle	Note 4	No
								Pad	Note 2	No
FUTURE (C)	100	450	100.98	134.97	16.53	450	-55	Note 4		No
VENT (D)	100	450	114.06	148.93	16.53	450	-55	Nozzle	Note 4	No
								Pad	Note 2	No
RELIEF (E)	100	450	112.8	147.47	16.53	450	-55	Nozzle	Note 4	No
								Pad	Note 2	No
CHARGE PORT (F)	100	450	111.84	190.01	16.53	450	-55	Note 4		No
CHARGE PORT (G)	100	450	111.84	190.01	16.53	450	-55	Note 4		No
CHARGE PORT (H)	100	450	111.84	190.01	16.53	450	-55	Note 4		No
CHARGE PORT (J)	100	450	112.8	147.47	16.53	450	-55	Nozzle	Note 4	No
								Pad	Note 2	No
CHARGE PORT (K)	100	450	148.23	190.01	16.53	450	-55	Note 4		No
CHARGE PORT (L)	100	450	148.23	190.01	16.53	450	-55	Note 4		No
MANWAY (M)	100	450	100.78	123.75	16.53	450	-55	Nozzle	Note 4	No
								Pad	Note 2	No
DRAIN (P)	100	450	122.6	167.66	16.53	450	-55	Nozzle	Note 4	No
								Pad	Note 2	No
THERMOWELL (Q)	100	450	157.53	211.11	16.53	450	-55	Note 5		No

Chamber Summary	
Design MDMT	-20 °F
Rated MDMT	-55 °F @ 100 psi
MAWP hot & corroded	100 psi @ 450 °F
MAP cold & new	123.75 psi @ 70 °F
MAEP	16.53 psi @ 450 °F

Notes for MDMT Rating		
Note #	Exemption	Details
1.	Straight Flange governs MDMT	
2.	Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320°F	
3.	Straight Flange governs MDMT	
4.	Flange rating governs: Flange rated MDMT per UHA-51(d)(1)(a) = -320°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	
5.	Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320°F	Bolts rated MDMT per Fig UCS-66 note (c) = -55°F

Revision History

Revisions			
No.	Date	Operator	Notes
0	8/18/2014	ahuhn	New vessel created ASME Section VIII Division 1 [COMPRESS 2014 Build 7400]

Settings Summary

COMPRESS 2015 Build 7500	
ASME Section VIII Division 1, 2013 Edition	
Units	U.S. Customary
Datum Line Location	0.00" from bottom seam
Vessel Design Mode	Get Thickness from Pressure
Minimum thickness	0.0625" per UG-16(b)
Design for cold shut down only	No
Design for lethal service (full radiography required)	No
Design nozzles for	Design P, find nozzle MAWP and MAP
Corrosion weight loss	100% of theoretical loss
UG-23 Stress Increase	1.20
Skirt/legs stress increase	1.0
Minimum nozzle projection	6"
Juncture calculations for $\alpha > 30$ only	No
Preheat P-No 1 Materials > 1.25" and \leq 1.50" thick	No
UG-37(a) shell tr calculation considers longitudinal stress	No
Cylindrical shells made from pipe are entered as minimum thickness	No
Nozzles made from pipe are entered as minimum thickness	No
Pipe caps are entered as minimum thickness	No
Butt welds	Tapered per Figure UCS-66.3(a)
Disallow Appendix 1-5, 1-8 calculations under 15 psi	No
Hydro/Pneumatic Test	
Shop Hydrotest at user defined pressure	150 psi
Test liquid specific gravity	1.00
Maximum stress during test	90% of yield
Required Marking - UG-116	
UG-116(e) Radiography	RT3
UG-116(f) Postweld heat treatment	None
Code Cases\Interpretations	
Use Code Case 2547	No
Use Code Case 2695	No
Apply interpretation VIII-1-83-66	Yes
Apply interpretation VIII-1-86-175	Yes

Apply interpretation VIII-1-01-37	Yes
Apply interpretation VIII-1-01-150	No
Apply interpretation VIII-1-07-50	Yes
No UCS-66.1 MDMT reduction	No
No UCS-68(c) MDMT reduction	No
Disallow UG-20(f) exemptions	No
UG-22 Loadings	
UG-22(a) Internal or External Design Pressure	Yes
UG-22(b) Weight of the vessel and normal contents under operating or test conditions	Yes
UG-22(c) Superimposed static reactions from weight of attached equipment (external loads)	Yes
UG-22(d)(2) Vessel supports such as lugs, rings, skirts, saddles and legs	Yes
UG-22(f) Wind reactions	No
UG-22(f) Seismic reactions	Yes
UG-22(j) Test pressure and coincident static head acting during the test:	No
Note: UG-22(b),(c) and (f) loads only considered when supports are present.	

Radiography Summary

UG-116 Radiography							
Component	Longitudinal Seam		Top Circumferential Seam		Bottom Circumferential Seam		Mark
	Category (Fig UW-3)	Radiography / Joint Type	Category (Fig UW-3)	Radiography / Joint Type	Category (Fig UW-3)	Radiography / Joint Type	
TOP HEAD	N/A	Seamless No RT	N/A	N/A	B	Spot UW-11(b) / Type 1	RT3
Cylinder #1	A	Spot UW-11(b) / Type 1	B	Spot UW-11(b) / Type 1	B	Spot UW-11(b) / Type 1	RT3
Cylinder #2	A	Spot UW-11(b) / Type 1	B	Spot UW-11(b) / Type 1	B	Spot UW-11(b) / Type 1	RT3
BTM HEAD	N/A	Seamless No RT	B	Spot UW-11(b) / Type 1	N/A	N/A	RT3
Nozzle	Longitudinal Seam		Nozzle to Vessel Circumferential Seam		Nozzle free end Circumferential Seam		
AGITATOR (A)	A	User Defined (E = 0.85)	D	N/A / Type 7	C	N/A	RT3
MANWAY (M)	A	User Defined (E = 0.85)	D	N/A / Type 7	C	N/A	RT3
FUTURE (C)	A	Welded pipe	D	N/A / Type 7	C	N/A	RT3
FUTURE (B)	A	Welded pipe	D	N/A / Type 7	C	N/A	RT3
CHARGE PORT (H)	A	Welded pipe	D	N/A / Type 7	C	N/A	RT3
VENT (D)	A	Welded pipe	D	N/A / Type 7	C	N/A	RT3
CHARGE PORT (F)	A	Welded pipe	D	N/A / Type 7	C	N/A	RT3
RELIEF (E)	A	Welded pipe	D	N/A / Type 7	C	N/A	RT3
CHARGE PORT (G)	A	Welded pipe	D	N/A / Type 7	C	N/A	RT3
CHARGE PORT (K)	A	Welded pipe	D	N/A / Type 7	C	N/A	RT3
CHARGE PORT (J)	A	Welded pipe	D	N/A / Type 7	C	N/A	RT3
CHARGE PORT (L)	A	Welded pipe	D	N/A / Type 7	C	N/A	RT3
DRAIN (P)	A	Welded pipe	D	N/A / Type 7	C	N/A	RT3
THERMOWELL (Q)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
Nozzle Flange	Longitudinal Seam		Flange Face		Nozzle to Flange Circumferential Seam		
ASME B16.5/16.47 flange attached to AGITATOR (A)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to MANWAY (M)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to FUTURE (C)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to FUTURE (B)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to CHARGE PORT (H)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to VENT (D)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to CHARGE PORT (F)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to RELIEF (E)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to CHARGE PORT (G)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to CHARGE PORT (K)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A

ASME B16.5/16.47 flange attached to CHARGE PORT (J)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to CHARGE PORT (L)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to DRAIN (P)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
UG-116(e) Required Marking: RT3							

Thickness Summary

Component Data								
Component Identifier	Material	Diameter (in)	Length (in)	Nominal t (in)	Design t (in)	Total Corrosion (in)	Joint E	Load
TOP HEAD	SA-240 304	102 ID	25.985	0.485*	0.3978	0.0625	0.85	Internal
Straight Flange on TOP HEAD	SA-240 304	102 ID	1	0.5	0.4849	0.0625	0.85	External
Cylinder #1	SA-240 304	102 ID	72	0.5	0.4849	0.0625	0.85	External
Cylinder #2	SA-240 304	102 ID	72	0.5	0.4849	0.0625	0.85	External
Straight Flange on BTM HEAD	SA-240 304	102 ID	1	0.5	0.4849	0.0625	0.85	External
BTM HEAD	SA-240 304	102 ID	25.985	0.485*	0.4218	0.0625	0.85	Internal
*Head minimum thickness after forming								

Definitions	
Nominal t	Vessel wall nominal thickness
Design t	Required vessel thickness due to governing loading + corrosion
Joint E	Longitudinal seam joint efficiency
Load	
Internal	Circumferential stress due to internal pressure governs
External	External pressure governs
Wind	Combined longitudinal stress of pressure + weight + wind governs
Seismic	Combined longitudinal stress of pressure + weight + seismic governs

Weight Summary

Weight (lb) Contributed by Vessel Elements											
Component	Metal New*	Metal Corroded	Insulation	Insulation Supports	Lining	Piping + Liquid	Operating Liquid		Test Liquid		Surface Area ft ²
							New	Corroded	New	Corroded	
TOP HEAD	1,653.7	1,443	0	0	0	0	0	0	5,549.6	5,580.9	87
Cylinder #1	3,361.8	2,943.4	0	0	0	0	23,369.4	23,426.7	21,237.1	21,289.2	162
Cylinder #2	3,361.8	2,943.4	0	0	0	0	25,484.5	25,547	21,237.1	21,289.2	162
BTM HEAD	1,745.6	1,523.1	0	0	0	0	6,379.7	6,410.5	5,316.4	5,342.1	91
4 PIPE LEGS	800.1	800.1	0	0	0	0	0	0	0	0	44
TOTAL:	10,923	9,653	0	0	0	0	55,233.7	55,384.3	53,340.2	53,501.4	545

*Shells with attached nozzles have weight reduced by material cut out for opening.

Weight (lb) Contributed by Attachments											
Component	Body Flanges		Nozzles & Flanges		Packed Beds	Ladders & Platforms*	Trays	Tray Supports	Rings & Clips	Vertical Loads	Surface Area ft ²
	New	Corroded	New	Corroded							
TOP HEAD	0	0	1,378.3	1,317	0	814.5	0	0	0	4,760*	34
Cylinder #1	0	0	0	0	0	0	0	0	46.9	0	1
Cylinder #2	0	0	0	0	0	0	0	0	0	750	0
BTM HEAD	0	0	46.2	43.3	0	0	0	0	0	0	2
4 PIPE LEGS	0	0	0	0	0	0	0	0	0	0	0
TOTAL:	0	0	1,424.5	1,360.3	0	814.5	0	0	46.9	5,510*	37

*** This number includes vertical loads which are not present in all conditions.
* Platforms and ladders are not included in surface area.

Vessel Totals		
	New	Corroded
Operating Weight (lb)	73,952	72,769
Empty Weight (lb)	18,719	17,385
Test Weight (lb)	72,059	70,886
Surface Area (ft ²)	583	-
Capacity** (US gal)	6,367	6,386

**The vessel capacity does not include volume of nozzle, piping or other attachments.

Vessel Lift Condition	
Vessel Lift Weight, New (lb)	13,144
Center of Gravity from Datum (in)	75.4282

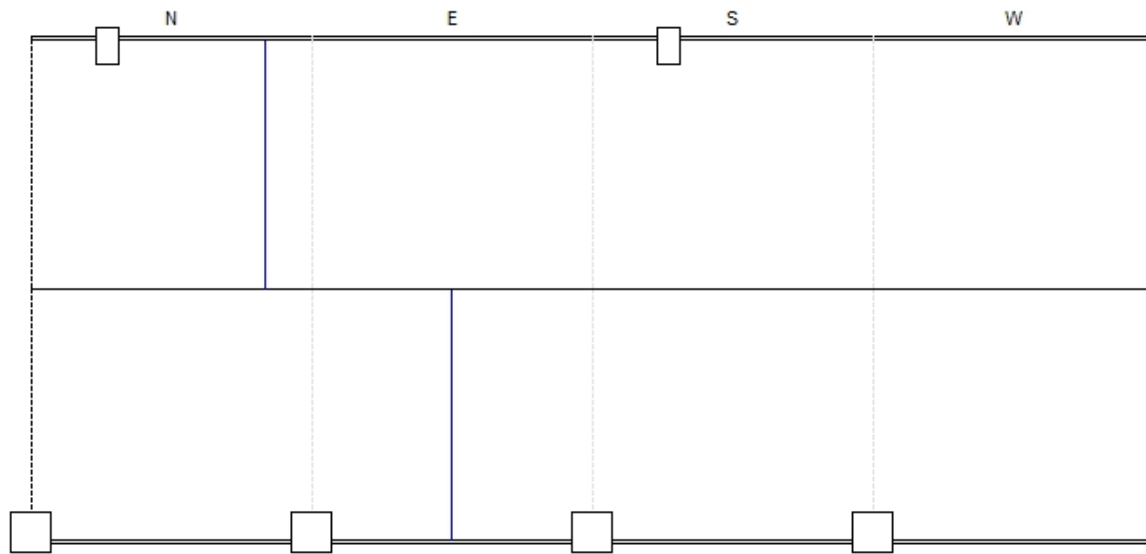
Long Seam Summary

Shell Long Seam Angles	
Component	Seam 1
Cylinder #1	30°
Cylinder #2	90°

Shell Plate Lengths		
Component	Starting Angle	Plate 1
Cylinder #1	30°	322.0132"
Cylinder #2	90°	322.0132"

Notes

- 1) Plate Lengths use the circumference of the vessel based on the mid diameter of the components.
- 2) North is located at 0°



Shell Rollout

Test Report

Horizontal shop test based on user defined pressure

Gauge pressure at 70°F = 150
psi

Horizontal shop test		
Identifier	Local test pressure (psi)	Test liquid static head (psi)
TOP HEAD	153.682	3.682
Straight Flange on TOP HEAD	153.682	3.682
Cylinder #1	153.682	3.682
Cylinder #2	153.682	3.682
Straight Flange on BTM HEAD	153.682	3.682
BTM HEAD	153.682	3.682
AGITATOR (A)	152.049	2.049
CHARGE PORT (F)	150.302	0.302
CHARGE PORT (G)	150.302	0.302
CHARGE PORT (H)	150.723	0.723
CHARGE PORT (J)	150.487	0.487
CHARGE PORT (K)	150.717	0.717
CHARGE PORT (L)	150.458	0.458
DRAIN (P)	151.945	1.945
FUTURE (B)	151.682	1.682
FUTURE (C)	152.134	2.134
MANWAY (M)	152.996	2.996
RELIEF (E)	153.366	3.366
THERMOWELL (Q)	151.859	1.859
VENT (D)	151.081	1.081

(1) The zero degree angular position is assumed to be up, and the test liquid height is assumed to the top-most flange.

The field test condition has not been investigated.

Vacuum Summary

Largest Unsupported Length Le			
Component	Line of Support	Elevation above Datum (in)	Length Le (in)
TOP HEAD	-	170.985	N/A
-	1/3 depth of TOP HEAD	153.5208	N/A
Straight Flange on TOP HEAD Top	-	145	163.0417
Straight Flange on TOP HEAD Bottom	-	144	163.0417
Cylinder #1 Top	-	144	163.0417
Cylinder #1 Bottom	-	72	163.0417
Cylinder #2 Top	-	72	163.0417
Cylinder #2 Bottom	-	0	163.0417
Straight Flange on BTM HEAD Top	-	0	163.0417
Straight Flange on BTM HEAD Bottom	-	-1	163.0417
-	1/3 depth of BTM HEAD	-9.5208	N/A
BTM HEAD	-	-26.985	N/A

Liquid Level bounded by BTM HEAD

ASME Section VIII Division 1, 2013 Edition	
Location from Datum (in)	138.0244
Operating Liquid Specific Gravity	1.2

TOP HEAD

ASME Section VIII Division 1, 2013 Edition				
Component		Ellipsoidal Head		
Material		SA-240 304 (II-D p. 94, In. 8)		
Attached To		Cylinder #1		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Optimize MDMT/ Find MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		100	450	-25
External		15	450	
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Test horizontal		3.68	102	1
Dimensions				
Inner Diameter		102"		
Head Ratio		2		
Minimum Thickness		0.485"		
Corrosion	Inner	0.0625"		
	Outer	0"		
Length L_{sf}		1"		
Nominal Thickness t_{sf}		0.5"		
Weight and Capacity				
		Weight (lb)¹	Capacity (US gal)¹	
New		1,653.66	636.72	
Corroded		1,443.03	639.76	
Radiography				
Category A joints		Seamless No RT		
Head to shell seam		Spot UW-11(b) Type 1		

¹includes straight flange

Results Summary	
Governing condition	internal pressure
Minimum thickness per UG-16	0.0625" + 0.0625" = 0.125"
Design thickness due to internal pressure (t)	0.3978"
Design thickness due to external pressure (t _e)	0.3473"
Maximum allowable working pressure (MAWP)	125.99 psi
Maximum allowable pressure (MAP)	161.51 psi
Maximum allowable external pressure (MAEP)	25.31 psi
Straight Flange governs MDMT	-320 °F

Factor K		
K = (1/6)*[2 + (D / (2*h)) ²]		
Corroded	K = (1/6)*[2 + (102.125 / (2*25.5625)) ²]	0.9984
New	K = (1/6)*[2 + (102 / (2*25.5)) ²]	1

Design thickness for internal pressure, (Corroded at 450 °F) Appendix 1-4(c)

$$\begin{aligned}
 t &= P \cdot D \cdot K / (2 \cdot S \cdot E - 0.2 \cdot P) + \text{Corrosion} \\
 &= 100 \cdot 102.125 \cdot 0.998371 / (2 \cdot 17,900 \cdot 0.85 - 0.2 \cdot 100) + 0.0625 \\
 &= \a href="#">0.3978"
 \end{aligned}$$

Maximum allowable working pressure, (Corroded at 450 °F) Appendix 1-4(c)

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (K \cdot D + 0.2 \cdot t) - P_s \\
 &= 2 \cdot 17,900 \cdot 0.85 \cdot 0.4225 / (0.998371 \cdot 102.125 + 0.2 \cdot 0.4225) - 0 \\
 &= \a href="#">125.99 \text{ psi}
 \end{aligned}$$

Maximum allowable pressure, (New at 70 °F) Appendix 1-4(c)

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (K \cdot D + 0.2 \cdot t) - P_s \\
 &= 2 \cdot 20,000 \cdot 0.85 \cdot 0.485 / (1 \cdot 102 + 0.2 \cdot 0.485) - 0 \\
 &= \a href="#">161.51 \text{ psi}
 \end{aligned}$$

Design thickness for external pressure, (Corroded at 450 °F) UG-33(d)

Equivalent outside spherical radius (R_o)

$$\begin{aligned}
 R_o &= K_o \cdot D_o \\
 &= 0.8916 \cdot 102.97 \\
 &= 91.8081 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (91.8081 / 0.284785) \\
 &= 0.000388
 \end{aligned}$$

From Table HA-1: B = 4,835.6542 psi

$$\begin{aligned}
 P_a &= B / (R_o / t) \\
 &= 4,835.6542 / (91.8081 / 0.2848) \\
 &= 15 \text{ psi}
 \end{aligned}$$

$$t = 0.2848'' + \text{Corrosion} = 0.2848'' + 0.0625'' = 0.3473''$$

Check the external pressure per UG-33(a)(1) Appendix 1-4(c)

$$t = \frac{1.67 \cdot P_e \cdot D \cdot K}{(2 \cdot S \cdot E - 0.2 \cdot 1.67 \cdot P_e)} + \text{Corrosion}$$

$$= \frac{1.67 \cdot 15 \cdot 102.125 \cdot 0.998371}{(2 \cdot 17,900 \cdot 1 - 0.2 \cdot 1.67 \cdot 15)} + 0.0625$$

$$= 0.1339''$$

The head external pressure design thickness (t_e) is [0.3473](#)''.

Maximum Allowable External Pressure, (Corroded at 450 °F) UG-33(d)

Equivalent outside spherical radius (R_o)

$$R_o = K_o \cdot D_o$$

$$= 0.8916 \cdot 102.97$$

$$= 91.8081 \text{ in}$$

$$A = 0.125 / (R_o / t)$$

$$= 0.125 / (91.8081 / 0.4225)$$

$$= 0.000575$$

From Table HA-1: $B = 5,499.4805$ psi

$$P_a = B / (R_o / t)$$

$$= 5,499.4805 / (91.8081 / 0.4225)$$

$$= 25.3085 \text{ psi}$$

Check the Maximum External Pressure, UG-33(a)(1) Appendix 1-4(c)

$$P = \frac{2 \cdot S \cdot E \cdot t}{(K \cdot D + 0.2 \cdot t) \cdot 1.67}$$

$$= \frac{2 \cdot 17,900 \cdot 1 \cdot 0.4225}{((0.998371 \cdot 102.125 + 0.2 \cdot 0.4225) \cdot 1.67)}$$

$$= 88.76 \text{ psi}$$

The maximum allowable external pressure (MAEP) is [25.31](#) psi.

% Forming strain - UHA-44(a)(2)

$$\text{EFE} = (75 \cdot t / R_f) \cdot (1 - R_f / R_o)$$

$$= (75 \cdot 0.5 / 17.59) \cdot (1 - 17.59 / \infty)$$

$$= 2.1319\%$$

Straight Flange on TOP HEAD

ASME Section VIII Division 1, 2013 Edition				
Component		Cylinder		
Material		SA-240 304 (II-D p. 94, ln. 8)		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Optimize MDMT/ Find MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		100	450	-25
External		15	450	
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Test horizontal		3.68	102	1
Dimensions				
Inner Diameter		102"		
Length		1"		
Nominal Thickness		0.5"		
Corrosion	Inner	0.0625"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)	Capacity (US gal)	
New		46.69	35.37	
Corroded		40.88	35.46	
Radiography				
Longitudinal seam		Seamless No RT		
Bottom Circumferential seam		Spot UW-11(b) Type 1		

Results Summary	
Governing condition	External pressure
Minimum thickness per UG-16	0.0625" + 0.0625" = 0.125"
Design thickness due to internal pressure (t)	0.3995"
Design thickness due to external pressure (t _e)	0.4849"
Design thickness due to combined loadings + corrosion	0.2012"
Maximum allowable working pressure (MAWP)	129.69 psi
Maximum allowable pressure (MAP)	165.69 psi
Maximum allowable external pressure (MAEP)	16.53 psi
Rated MDMT	-320 °F

UHA-51 Material Toughness Requirements
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.

Design thickness, (at 450 °F) UG-27(c)(1)

$$\begin{aligned}
 t &= P \cdot R / (S \cdot E - 0.60 \cdot P) + \text{Corrosion} \\
 &= 100 \cdot 51.0625 / (17,900 \cdot 0.85 - 0.60 \cdot 100) + 0.0625 \\
 &= \a href="#">0.3995"
 \end{aligned}$$

Maximum allowable working pressure, (at 450 °F) UG-27(c)(1)

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R + 0.60 \cdot t) - P_s \\
 &= 17,900 \cdot 0.85 \cdot 0.4375 / (51.0625 + 0.60 \cdot 0.4375) - 0 \\
 &= \a href="#">129.69 \text{ psi}
 \end{aligned}$$

Maximum allowable pressure, (at 70 °F) UG-27(c)(1)

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R + 0.60 \cdot t) \\
 &= 20,000 \cdot 0.85 \cdot 0.5 / (51 + 0.60 \cdot 0.5) \\
 &= \a href="#">165.69 \text{ psi}
 \end{aligned}$$

External Pressure, (Corroded & at 450 °F) UG-28(c)

$$\begin{aligned}
 L / D_o &= 163.0417 / 103 = 1.5829 \\
 D_o / t &= 103 / 0.4224 = 243.8726 \\
 \text{From table G: } A &= 0.000218 \\
 \text{From table HA-1: } B &= 2,743.5664 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\
 &= 4 \cdot 2,743.57 / (3 \cdot (103 / 0.4224)) \\
 &= 15 \text{ psi}
 \end{aligned}$$

Design thickness for external pressure P_a = 15 psi

$$t_a = t + \text{Corrosion} = 0.4224 + 0.0625 = \a href="#">0.4849"$$

Maximum Allowable External Pressure, (Corroded & at 450 °F) UG-28(c)

$L / D_o = 163.0417 / 103 = 1.5829$
 $D_o / t = 103 / 0.4375 = 235.4286$
 From table G: $A = 0.000232$
 From table HA-1: $B = 2,919.0141 \text{ psi}$

$P_a = 4 * B / (3 * (D_o / t))$
 $= 4 * 2,919.01 / (3 * (103 / 0.4375))$
 $= 16.53 \text{ psi}$

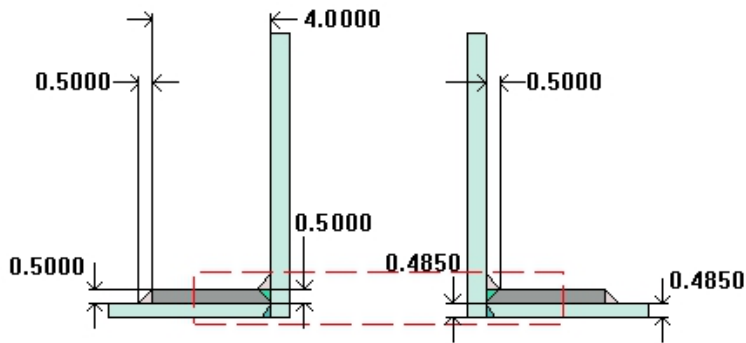
% Forming strain - UHA-44(a)(2)

$EFE = (50 * t / R_f) * (1 - R_f / R_o)$
 $= (50 * 0.5 / 51.25) * (1 - 51.25 / \infty)$
 $= 0.4878\%$

Thickness Required Due to Pressure + External Loads								
Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S _t	S _c					
Operating, Hot & Corroded	100	17,900	6,603	450	0.0625	Seismic	0.1387	0.1376
Operating, Hot & New	100	17,900	6,861	450	0	Seismic	0.1385	0.1373
Hot Shut Down, Corroded	0	17,900	6,603	450	0.0625	Seismic	0.0023	0.0049
Hot Shut Down, New	0	17,900	6,861	450	0	Seismic	0.0023	0.0048
Empty, Corroded	0	20,000	9,181	70	0.0625	Seismic	0.0018	0.0034
Empty, New	0	20,000	9,706	70	0	Seismic	0.0017	0.0033
Vacuum	-15	17,900	6,603	450	0.0625	Seismic	0.0506	0.0532
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0	17,900	6,603	450	0.0625	Weight	0.0035	0.0043

AGITATOR (A)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Location and Orientation

Located on	TOP HEAD
Orientation	0°
End of nozzle to datum line	179"
Calculated as hillside	No
Distance to head center, R	0"
Passes through a Category A joint	No

Nozzle

Access opening	No
Material specification	SA-240 304 (II-D p. 94, ln. 8)
Inside diameter, new	11.5"
Nominal wall thickness	0.625"
Corrosion allowance	0.0625"
Projection available outside vessel, L _{pr}	7.59"
Projection available outside vessel to flange face, L _f	8.215"
Local vessel minimum thickness	0.485"
User input radial limit of reinforcement	9"
Liquid static head included	0 psi
Longitudinal joint efficiency	0.85

Reinforcing Pad

Material specification	SA-240 304 (II-D p. 94, ln. 8)
Diameter, D _p	20.75"

Thickness, t_e	0.5"
Is split	No
Welds	
Inner Fillet, Leg ₄₁	0.5"
Outer Fillet, Leg ₄₂	0.5"
Nozzle to vessel groove weld	0.485"
Pad groove weld	0.5"

ASME B16.5-2009 Flange	
Description	NPS 12 Class 150 SO A182 F304
Bolt Material	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 352, In. 31)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
Consider External Loads on Flange MAWP Rating	No
MAWP rating	180 psi @ 450°F
MAP rating	275 psi @ 70°F
Hydrotest rating	425 psi @ 70°F
External fillet weld leg (UW-21)	0.75" (0.75 in min)
Internal fillet weld leg (UW-21)	0.3393" (0.3393 in min)
PWHT performed	No
Impact Tested	No
Gasket	
Description	GARLOCK BLUEGARD 3200 NON ASBESTOS
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UHA-51 Material Toughness Requirements Nozzle
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320°F
Material is exempt from impact testing at the Design MDMT of -25°F.

UHA-51 Material Toughness Requirements Pad

Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F

Material is exempt from impact testing at the Design MDMT of -25 °F.

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
2.9826	5.0522	1.0578	1.1194	--	2.625	0.25	0.3475	0.625

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
37,795.81	71,499.76	277,870.96	33,020.35	332,557.88	80,007.85	255,024.55

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.25	0.35	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.2113	0.35	weld size is adequate

WRC 107												
Load Case	P (psi)	P _r (lb _f)	M ₁ (lb _f -in)	V ₂ (lb _f)	M ₂ (lb _f -in)	V ₁ (lb _f)	M _t (lb _f -in)	Max Comb Stress (psi)	Allow Comb Stress (psi)	Max Local Primary Stress (psi)	Allow Local Primary Stress (psi)	Over stressed
Load case 1	100	4,760	0	0	101,004	0	27,420	22,832	53,700	12,973	26,850	No
Load case 1 (Hot Shut Down)	0	4,760	0	0	101,004	0	27,420	-18,828	53,700	-3,817	26,850	No

% Forming strain - UHA-44(a)(2)

$$\begin{aligned}
 \text{EFE} &= (50 \cdot t / R_f) \cdot (1 - R_f / R_o) \\
 &= (50 \cdot 0.625 / 6.0625) \cdot (1 - 6.0625 / \infty) \\
 &= 5.1546\%
 \end{aligned}$$

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 144.11 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
4.2993	4.2998	0.3358	1.089	--	2.625	0.25	0.3906	0.625

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
72,006.82	70,955.6	277,870.96	32,476.19	332,557.88	79,463.69	255,024.55

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.25	0.35	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.2113	0.35	weld size is adequate

WRC 107												
Load Case	P (psi)	P _r (lb _f)	M ₁ (lb _f -in)	V ₂ (lb _f)	M ₂ (lb _f -in)	V ₁ (lb _f)	M _t (lb _f -in)	Max Comb Stress (psi)	Allow Comb Stress (psi)	Max Local Primary Stress (psi)	Allow Local Primary Stress (psi)	Over stressed
Load case 1	144.11	4,760	0	0	101,004	0	27,420	27,651	53,700	17,792	26,850	No

Reinforcement Calculations for MAP

Available reinforcement per UG-37 governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 179.38 psi @ 70 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
4.7386	4.739	0.4742	1.3898	--	2.625	0.25	0.3281	0.625

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
87,111.25	85,296	326,362.39	44,921	390,098.63	97,421	303,469.21

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.25	0.35	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.2425	0.35	weld size is adequate

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.6553	4.866	0.8779	1.1131	--	2.625	0.25	0.1258	0.625

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.25	0.35	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.2113	0.35	weld size is adequate

Reinforcement Calculations for MAEP

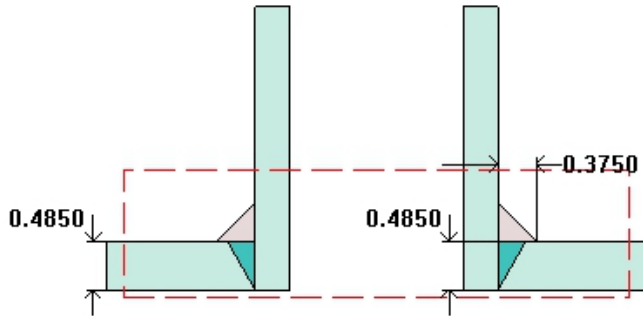
UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For $P_e = 16.53$ psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.7751	4.7317	0.7466	1.1101	--	2.625	0.25	0.126	0.625

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.25	0.35	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.2113	0.35	weld size is adequate

CHARGE PORT (F)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Location and Orientation

Located on	TOP HEAD
Orientation	15°
End of nozzle to datum line	180"
Calculated as hillside	Yes
Distance to head center, R	45"
Passes through a Category A joint	No

Nozzle

Description	NPS 2 Sch 160
Access opening	No
Material specification	SA-312 TP304 Wld pipe (II-D p. 94, ln. 21)
Inside diameter, new	1.687"
Nominal wall thickness	0.344"
Corrosion allowance	0.0625"
Opening chord length	2.4713"
Projection available outside vessel, L_{pr}	21.0086"
Projection available outside vessel to flange face, L_f	21.3526"
Local vessel minimum thickness	0.485"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Welds

Inner Fillet, Leg₄₁	0.375"
---------------------------------------	--------

Nozzle to vessel groove weld	0.485"
------------------------------	--------

ASME B16.5-2009 Flange	
Description	NPS 2 Class 150 SO A182 F304
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 352, ln. 31)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	180 psi @ 450 °F
MAP rating	275 psi @ 70 °F
Hydrotest rating	425 psi @ 70 °F
External fillet weld leg (UW-21)	0.31" (0.31 in min)
Internal fillet weld leg (UW-21)	0.3393" (0.3393 in min)
PWHT performed	No
Impact Tested	No
Gasket	
Description	COAST RUBBER PTFE ROLL TEFLON
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 100 \cdot 0.906 / (17,000 \cdot 1 - 0.6 \cdot 100) =$	0.0053"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0053 \cdot 1 / (0.301 - 0.0625) =$	0.0224
Impact test exempt per UHA-51(g) (coincident ratio = 0.0224)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1973	0.301

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.197	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 111.84 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1973	0.301

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.197	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 190.01 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.301

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.2408	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.125	0.301

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.197	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 16.53 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.125	0.301

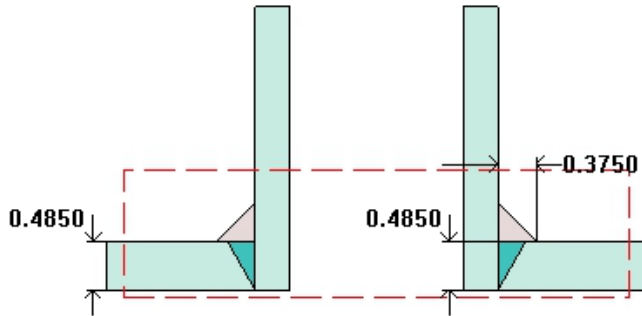
UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.197	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

CHARGE PORT (G)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Location and Orientation

Located on	TOP HEAD
Orientation	345°
End of nozzle to datum line	180"
Calculated as hillside	Yes
Distance to head center, R	45"
Passes through a Category A joint	No

Nozzle

Description	NPS 2 Sch 160
Access opening	No
Material specification	SA-312 TP304 Wld pipe (II-D p. 94, ln. 21)
Inside diameter, new	1.687"
Nominal wall thickness	0.344"
Corrosion allowance	0.0625"
Opening chord length	2.4713"
Projection available outside vessel, L _{pr}	21.0086"
Projection available outside vessel to flange face, L _f	21.3526"
Local vessel minimum thickness	0.485"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Welds

Inner Fillet, Leg ₄₁	0.375"
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Nozzle to vessel groove weld	0.485"
------------------------------	--------

ASME B16.5-2009 Flange	
Description	NPS 2 Class 150 SO A182 F304
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 352, ln. 31)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	180 psi @ 450 °F
MAP rating	275 psi @ 70 °F
Hydrotest rating	425 psi @ 70 °F
External fillet weld leg (UW-21)	0.31" (0.31 in min)
Internal fillet weld leg (UW-21)	0.3393" (0.3393 in min)
PWHT performed	No
Impact Tested	No
Gasket	
Description	COAST RUBBER PTFE ROLL TEFLON
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 100 \cdot 0.906 / (17,000 \cdot 1 - 0.6 \cdot 100) =$	0.0053"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0053 \cdot 1 / (0.301 - 0.0625) =$	0.0224
Impact test exempt per UHA-51(g) (coincident ratio = 0.0224)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1973	0.301

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.197	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 111.84 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1973	0.301

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.197	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 190.01 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.301

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.2408	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.125	0.301

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.197	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 16.53 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.125	0.301

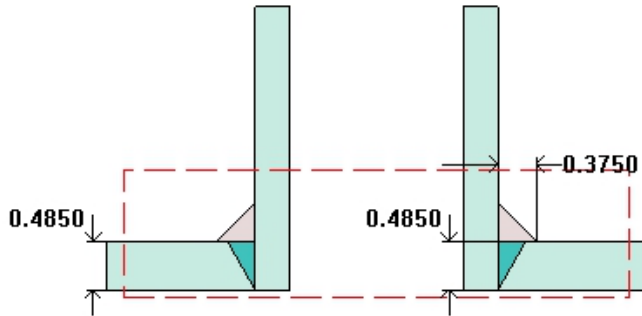
UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.197	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

CHARGE PORT (H)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Location and Orientation

Located on	TOP HEAD
Orientation	315°
End of nozzle to datum line	180"
Calculated as hillside	Yes
Distance to head center, R	45"
Passes through a Category A joint	No

Nozzle

Description	NPS 2 Sch 160
Access opening	No
Material specification	SA-312 TP304 Wld pipe (II-D p. 94, ln. 21)
Inside diameter, new	1.687"
Nominal wall thickness	0.344"
Corrosion allowance	0.0625"
Opening chord length	2.4713"
Projection available outside vessel, L _{pr}	21.0086"
Projection available outside vessel to flange face, L _f	21.3526"
Local vessel minimum thickness	0.485"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Welds

Inner Fillet, Leg ₄₁	0.375"
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Nozzle to vessel groove weld	0.485"
------------------------------	--------

ASME B16.5-2009 Flange	
Description	NPS 2 Class 150 SO A182 F304
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 352, ln. 31)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	180 psi @ 450 °F
MAP rating	275 psi @ 70 °F
Hydrotest rating	425 psi @ 70 °F
External fillet weld leg (UW-21)	0.31" (0.31 in min)
Internal fillet weld leg (UW-21)	0.3393" (0.3393 in min)
PWHT performed	No
Impact Tested	No
Gasket	
Description	COAST RUBBER PTFE ROLL TEFLON
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 100 \cdot 0.906 / (17,000 \cdot 1 - 0.6 \cdot 100) =$	0.0053"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0053 \cdot 1 / (0.301 - 0.0625) =$	0.0224
Impact test exempt per UHA-51(g) (coincident ratio = 0.0224)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1973	0.301

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.197	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 111.84 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1973	0.301

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.197	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 190.01 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.301

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.2408	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.125	0.301

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.197	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 16.53 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.125	0.301

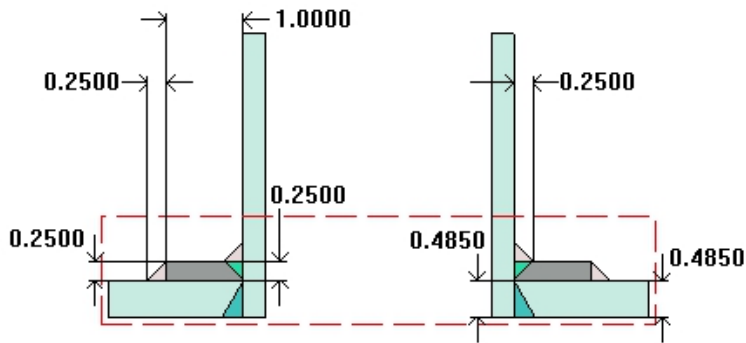
UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.197	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

CHARGE PORT (J)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Location and Orientation

Located on	TOP HEAD
Orientation	30°
End of nozzle to datum line	180"
Calculated as hillside	Yes
Distance to head center, R	45"
Passes through a Category A joint	No

Nozzle

Description	NPS 3 Sch 80S (XS)
Access opening	No
Material specification	SA-312 TP304 Wld pipe (II-D p. 94, ln. 21)
Inside diameter, new	2.9"
Nominal wall thickness	0.3"
Corrosion allowance	0.0625"
Opening chord length	4.1363"
Projection available outside vessel, L_{pr}	20.6029"
Projection available outside vessel to flange face, L_f	20.9029"
Local vessel minimum thickness	0.485"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Reinforcing Pad

Material specification	SA-240 304 (II-D p. 94, ln. 8)
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Diameter, D_p	6.7302"
Thickness, t_e	0.25"
Is split	No
Welds	
Inner Fillet, Leg_{41}	0.25"
Outer Fillet, Leg_{42}	0.25"
Nozzle to vessel groove weld	0.485"
Pad groove weld	0.25"

ASME B16.5-2009 Flange	
Description	NPS 3 Class 150 SO A182 F304
Bolt Material	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 352, ln. 31)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	180 psi @ 450 °F
MAP rating	275 psi @ 70 °F
Hydrotest rating	425 psi @ 70 °F
External fillet weld leg (UW-21)	0.3325" (0.3325 in min)
Internal fillet weld leg (UW-21)	0.3" (0.3 in min)
PWHT performed	No
Impact Tested	No
Gasket	
Description	COAST RUBBER PTFE ROLL TEFLON
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 100 * 1.5125 / (17,000 * 1 - 0.6 * 100) =$	0.0089"
Stress ratio = $t_r * E^* / (t_n - c) = 0.0089 * 1 / (0.2625 - 0.0625) =$	0.0446
Impact test exempt per UHA-51(g) (coincident ratio = 0.0446)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.	

UHA-51 Material Toughness Requirements Pad

Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F

Material is exempt from impact testing at the Design MDMT of -25 °F.

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.1991	1.5029	0.5591	0.3282	--	0.5	0.1156	0.2515	0.2625

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
12,448.94	16,894.02	36,131.43	9,875.86	59,210.81	19,944.61	53,949.26

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.1662	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 112.8 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.3527	1.3529	0.4107	0.3266	--	0.5	0.1156	0.2515	0.2625

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
17,591	16,865.38	36,131.43	9,847.22	59,210.81	19,915.97	53,949.26

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.1662	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAP

Available reinforcement per UG-37 governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 147.47 psi @ 70 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.5294	1.5295	0.4221	0.4918	--	0.5	0.1156	0.189	0.2625

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
23,254.54	22,148	43,845.62	15,845	71,254.07	27,095	65,363.96

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.5992	1.4769	0.5597	0.3016	--	0.5	0.1156	0.125	0.2625

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.1662	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAEP

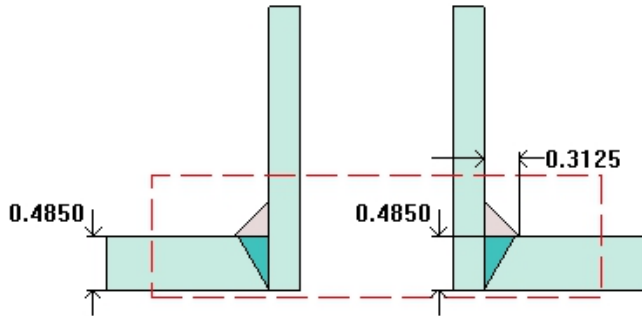
UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 16.53 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.6423	1.3914	0.4758	0.3	--	0.5	0.1156	0.125	0.2625

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.1662	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

CHARGE PORT (K)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Location and Orientation

Located on	TOP HEAD
Orientation	45°
End of nozzle to datum line	180"
Calculated as hillside	Yes
Distance to head center, R	45"
Passes through a Category A joint	No

Nozzle

Description	NPS 1.5 Sch 160
Access opening	No
Material specification	SA-312 TP304 Wld pipe (II-D p. 94, ln. 21)
Inside diameter, new	1.338"
Nominal wall thickness	0.281"
Corrosion allowance	0.0625"
Opening chord length	1.9943"
Projection available outside vessel, L_{pr}	21.2677"
Projection available outside vessel to flange face, L_f	21.5487"
Local vessel minimum thickness	0.485"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Welds

Inner Fillet, Leg₄₁	0.3125"
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Nozzle to vessel groove weld	0.485"
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ASME B16.5-2009 Flange	
Description	NPS 1.5 Class 150 SO A182 F304
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 352, ln. 31)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	180 psi @ 450 °F
MAP rating	275 psi @ 70 °F
Hydrotest rating	425 psi @ 70 °F
External fillet weld leg (UW-21)	0.305" (0.305 in min)
Internal fillet weld leg (UW-21)	0.281" (0.281 in min)
PWHT performed	No
Impact Tested	No
Gasket	
Description	COAST RUBBER PTFE ROLL TEFLON
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 100 \cdot 0.7315 / (17,000 \cdot 1 - 0.6 \cdot 100) =$	0.0043"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0043 \cdot 1 / (0.2459 - 0.0625) =$	0.0236
Impact test exempt per UHA-51(g) (coincident ratio = 0.0236)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1894	0.2459

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.153	0.2188	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 148.23 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1894	0.2459

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.153	0.2188	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 190.01 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1269	0.2459

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1967	0.2188	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.125	0.2459

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.153	0.2188	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 16.53 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.125	0.2459

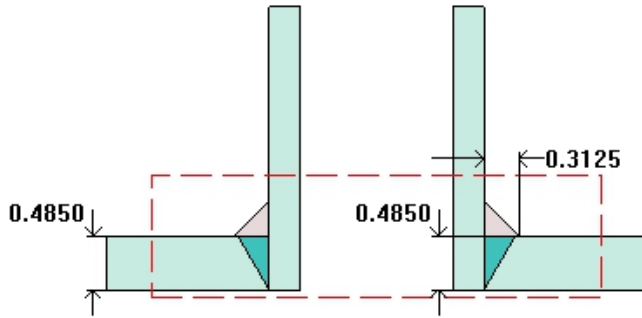
UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.153	0.2188	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

CHARGE PORT (L)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Location and Orientation

Located on	TOP HEAD
Orientation	330°
End of nozzle to datum line	180"
Calculated as hillside	Yes
Distance to head center, R	45"
Passes through a Category A joint	No

Nozzle

Description	NPS 1.5 Sch 160
Access opening	No
Material specification	SA-312 TP304 Wld pipe (II-D p. 94, ln. 21)
Inside diameter, new	1.338"
Nominal wall thickness	0.281"
Corrosion allowance	0.0625"
Opening chord length	1.9943"
Projection available outside vessel, L_{pr}	21.2677"
Projection available outside vessel to flange face, L_f	21.5487"
Local vessel minimum thickness	0.485"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Welds

Inner Fillet, Leg₄₁	0.3125"
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Nozzle to vessel groove weld	0.485"
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ASME B16.5-2009 Flange	
Description	NPS 1.5 Class 150 SO A182 F304
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 352, ln. 31)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	180 psi @ 450 °F
MAP rating	275 psi @ 70 °F
Hydrotest rating	425 psi @ 70 °F
External fillet weld leg (UW-21)	0.305" (0.305 in min)
Internal fillet weld leg (UW-21)	0.281" (0.281 in min)
PWHT performed	No
Impact Tested	No
Gasket	
Description	COAST RUBBER PTFE ROLL TEFLON
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 100 \cdot 0.7315 / (17,000 \cdot 1 - 0.6 \cdot 100) =$	0.0043"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0043 \cdot 1 / (0.2459 - 0.0625) =$	0.0236
Impact test exempt per UHA-51(g) (coincident ratio = 0.0236)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1894	0.2459

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.153	0.2188	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 148.23 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1894	0.2459

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.153	0.2188	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 190.01 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1269	0.2459

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1967	0.2188	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.125	0.2459

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.153	0.2188	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 16.53 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.125	0.2459

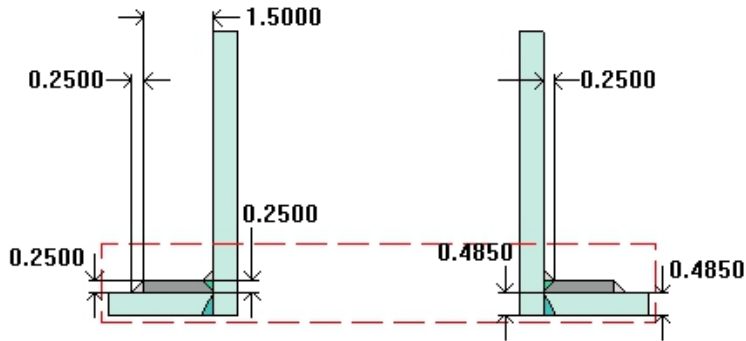
UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.153	0.2188	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

FUTURE (B)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Location and Orientation

Located on	TOP HEAD
Orientation	290°
End of nozzle to datum line	180"
Calculated as hillside	Yes
Distance to head center, R	24"
Passes through a Category A joint	No

Nozzle

Description	NPS 8 Sch 80S (XS)
Access opening	No
Material specification	SA-312 TP304 Wld pipe (II-D p. 94, ln. 21)
Inside diameter, new	7.625"
Nominal wall thickness	0.5"
Corrosion allowance	0.0625"
Opening chord length	8.0228"
Projection available outside vessel, L_{pr}	10.4899"
Projection available outside vessel to flange face, L_f	10.9899"
Local vessel minimum thickness	0.485"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Reinforcing Pad

Material specification	SA-240 304 (II-D p. 94, ln. 8)
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Diameter, D_p	11.9227"
Thickness, t_e	0.25"
Is split	No
Welds	
Inner Fillet, Leg_{41}	0.25"
Outer Fillet, Leg_{42}	0.25"
Nozzle to vessel groove weld	0.485"
Pad groove weld	0.25"

ASME B16.5-2009 Flange	
Description	NPS 8 Class 150 SO A182 F304
Bolt Material	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 352, ln. 31)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	180 psi @ 450°F
MAP rating	275 psi @ 70°F
Hydrotest rating	425 psi @ 70°F
External fillet weld leg (UW-21)	0.485" (0.485 in min)
Internal fillet weld leg (UW-21)	0.3393" (0.3393 in min)
PWHT performed	No
Impact Tested	No
Gasket	
Description	COAST RUBBER PTFE ROLL TEFLON
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 100 \cdot 3.875 / (17,000 \cdot 1 - 0.6 \cdot 100) =$	0.0229"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0229 \cdot 1 / (0.4375 - 0.0625) =$	0.061
Impact test exempt per UHA-51(g) (coincident ratio = 0.061)	
Rated MDMT =	-320°F
Material is exempt from impact testing at the Design MDMT of -25°F.	

UHA-51 Material Toughness Requirements Pad

Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F

Material is exempt from impact testing at the Design MDMT of -25 °F.

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
2.0923	2.9208	1.3093	0.7459	--	0.75	0.1156	0.3443	0.4375

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
16,222.03	28,845.85	100,933.58	19,921.6	145,912.35	34,465.35	116,887.28

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 119.92 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
2.5093	2.5094	0.9058	0.738	--	0.75	0.1156	0.3443	0.4375

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
30,229.39	28,704.44	100,933.58	19,780.19	145,912.35	34,323.94	116,887.28

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAP

Available reinforcement per UG-37 governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 154.18 psi @ 70 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
2.8484	2.8488	1.0134	0.9698	--	0.75	0.1156	0.2818	0.4375

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
38,925.68	36,708	121,822.11	28,703	175,590.39	44,953	143,132.32

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.1612	2.6742	1.0866	0.722	--	0.75	0.1156	0.125	0.4375

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAEP

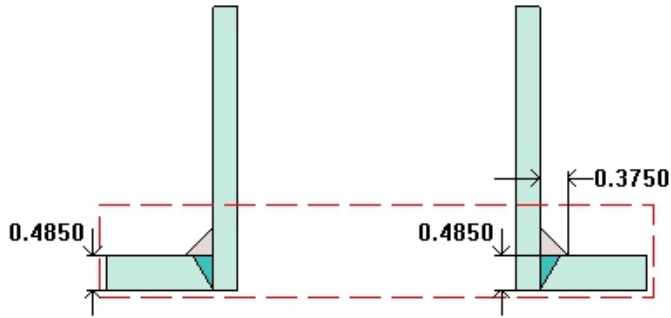
UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 16.53 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.2452	2.5095	0.9241	0.7198	--	0.75	0.1156	0.125	0.4375

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

FUTURE (C)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Location and Orientation

Located on	TOP HEAD
Orientation	255°
End of nozzle to datum line	180"
Calculated as hillside	Yes
Distance to head center, R	24"
Passes through a Category A joint	No

Nozzle

Description	NPS 4 Sch 80S (XS)
Access opening	No
Material specification	SA-312 TP304 Wld pipe (II-D p. 94, ln. 21)
Inside diameter, new	3.826"
Nominal wall thickness	0.337"
Corrosion allowance	0.0625"
Opening chord length	4.0891"
Projection available outside vessel, L _{pr}	11.1106"
Projection available outside vessel to flange face, L _f	11.4476"
Local vessel minimum thickness	0.485"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Welds

Inner Fillet, Leg ₄₁	0.375"
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Nozzle to vessel groove weld	0.485"
------------------------------	--------

ASME B16.5-2009 Flange	
Description	NPS 4 Class 150 SO A182 F304
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 352, ln. 31)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	180 psi @ 450 °F
MAP rating	275 psi @ 70 °F
Hydrotest rating	425 psi @ 70 °F
External fillet weld leg (UW-21)	0.37" (0.37 in min)
Internal fillet weld leg (UW-21)	0.337" (0.337 in min)
PWHT performed	No
Impact Tested	No
Gasket	
Description	COAST RUBBER PTFE ROLL TEFLON
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 100 * 1.9755 / (17,000 * 1 - 0.6 * 100) =$	0.0117"
Stress ratio = $t_r * E^* / (t_n - c) = 0.0117 * 1 / (0.2949 - 0.0625) =$	0.0502
Impact test exempt per UHA-51(g) (coincident ratio = 0.0502)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.0704	1.0912	0.6648	0.307	--	--	0.1194	0.2699	0.2949

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(1)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1922	0.2625	weld size is adequate

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100.98 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.0809	1.081	0.6547	0.3069	--	--	0.1194	0.2699	0.2949

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(1)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1922	0.2625	weld size is adequate

Reinforcement Calculations for MAP

Available reinforcement per UG-37 governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 134.97 psi @ 70 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.2588	1.2589	0.6754	0.464	--	--	0.1195	0.2074	0.2949

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(1)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.2359	0.2625	weld size is adequate

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.5941	0.9638	0.5517	0.2927	--	--	0.1194	0.125	0.2949

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1922	0.2625	weld size is adequate

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)	UG-45 Summary (in)

For $P_e = 16.53$ psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.637	0.8803	0.4692	0.2917	--	--	0.1194	0.125	0.2949

UG-41 Weld Failure Path Analysis Summary

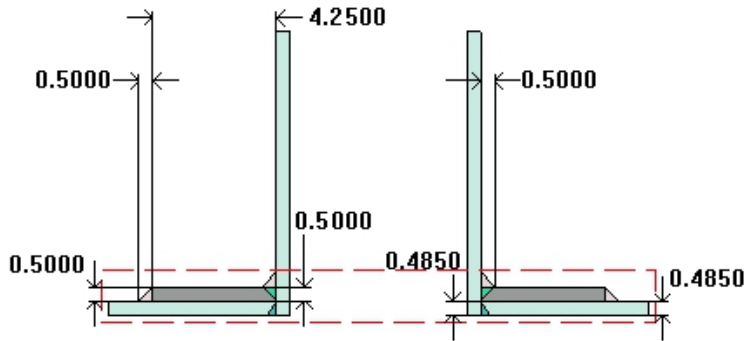
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary

Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1922	0.2625	weld size is adequate

MANWAY (M)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Location and Orientation

Located on	TOP HEAD
Orientation	135°
End of nozzle to datum line	178"
Calculated as hillside	Yes
Distance to head center, R	29"
Passes through a Category A joint	No

Nozzle

Access opening	No
Material specification	SA-240 304 (II-D p. 94, ln. 8)
Inside diameter, new	23"
Nominal wall thickness	0.5"
Corrosion allowance	0.0625"
Opening chord length	24.6309"
Projection available outside vessel, L _{pr}	7.9724"
Projection available outside vessel to flange face, L _f	8.4724"
Local vessel minimum thickness	0.485"
User input radial limit of reinforcement	18"
Liquid static head included	0 psi
Longitudinal joint efficiency	0.85

Reinforcing Pad

Material specification	SA-240 304 (II-D p. 94, ln. 8)
------------------------	--------------------------------

Diameter, D_p	34.038"
Thickness, t_e	0.5"
Is split	No
Welds	
Inner Fillet, Leg ₄₁	0.5"
Outer Fillet, Leg ₄₂	0.5"
Nozzle to vessel groove weld	0.485"
Pad groove weld	0.5"

ASME B16.5-2009 Flange	
Description	NPS 24 Class 150 SO A182 F304
Bolt Material	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 352, ln. 31)
Blind included	Yes
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	180 psi @ 450 °F
MAP rating	275 psi @ 70 °F
Hydrotest rating	425 psi @ 70 °F
External fillet weld leg (UW-21)	0.6125" (0.6125 in min)
Internal fillet weld leg (UW-21)	0.3393" (0.3393 in min)
PWHT performed	No
Impact Tested	No
Gasket	
Description	COAST RUBBER PTFE ROLL TEFLON
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.

UHA-51 Material Toughness Requirements Pad
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
7.0188	7.101	1.5637	0.7873	--	4.25	0.5	0.3475	0.5

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
99,800.89	99,117.67	437,373.04	25,185.08	625,991.3	105,735.08	445,459.13

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.25	0.35	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.2113	0.35	weld size is adequate

% Forming strain - UHA-44(a)(2)

$$\begin{aligned}
 EFE &= (50 \cdot t / R_f) \cdot (1 - R_f / R_o) \\
 &= (50 \cdot 0.5 / 11.75) \cdot (1 - 11.75 / \infty) \\
 &= 2.1277\%
 \end{aligned}$$

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100.78 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
7.0737	7.0747	1.5384	0.7863	--	4.25	0.5	0.3497	0.5

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
101,202.03	99,099.77	437,373.04	25,167.18	625,991.3	105,717.18	445,459.13

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.25	0.35	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.2113	0.35	weld size is adequate

Reinforcement Calculations for MAP

Available reinforcement per UG-37 governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 123.75 psi @ 70 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
7.7356	7.7359	1.9465	1.0394	--	4.25	0.5	0.3157	0.5

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
119,166.19	115,788	520,383.14	35,488	734,303.3	125,488	532,591.37

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.25	0.35	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.2425	0.35	weld size is adequate

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For $P_e = 15 \text{ psi @ } 450 \text{ }^\circ\text{F}$ The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
3.5073	7.0915	1.5656	0.7759	--	4.25	0.5	0.1327	0.5

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.25	0.35	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.2113	0.35	weld size is adequate

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For $P_e = 16.53 \text{ psi @ } 450 \text{ }^\circ\text{F}$ The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
3.761	6.8512	1.3315	0.7697	--	4.25	0.5	0.1357	0.5

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.25	0.35	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.2113	0.35	weld size is adequate

Platform/Ladder #1

Platform	
Distance from Base to Datum	162"
Attached To	TOP HEAD
Start Angle	0.00 degrees
End Angle	360.00 degrees
Shell Clearance, L_c	-18"
Width, W	30" (2.50 ft)
Projected Length, L	24" (2.00 ft)
Wind Force Coefficient, C_f	2.00
Floor Grating	
Unit Weight	10.00 psf
Area	6774.19 in ² (47.04 ft ²)
Railing	
Height, h	42" (3.50 ft)
Length	320.05" (26.67 ft)
Unit Weight	12.00 lb/ft
Ladder	
Distance from Start to Datum	146"
Angle	0.00 degrees
Unit Weight	18.00 lb/ft
Length	16" (1.33 ft)
Weight	
Platform & Railing Weight	790.48 lb
Ladder Weight	24.00 lb
Total Weight	814.48 lb
Included in Vessel Lift Weight	No
Present When Vessel is Empty	Yes
Present During Hydrotest	Yes

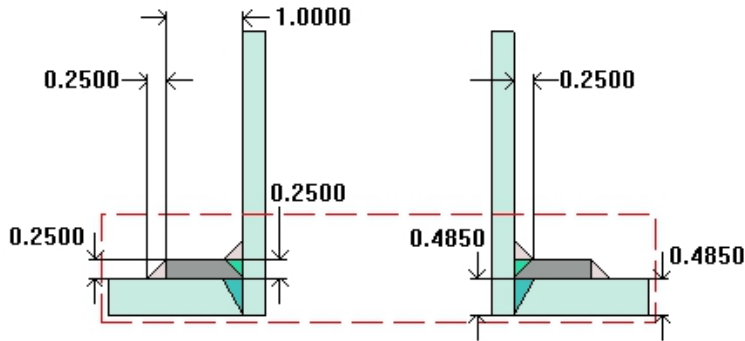
Platform Wind Shear Calculation

Local wind pressure: $P_w = 0$ psf

Wind shear: $V_p = P_w * C_f * A_e = 0.00$ lbf

RELIEF (E)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Location and Orientation

Located on	TOP HEAD
Orientation	205°
End of nozzle to datum line	180"
Calculated as hillside	Yes
Distance to head center, R	45"
Passes through a Category A joint	No

Nozzle

Description	NPS 3 Sch 80S (XS)
Access opening	No
Material specification	SA-312 TP304 Wld pipe (II-D p. 94, ln. 21)
Inside diameter, new	2.9"
Nominal wall thickness	0.3"
Corrosion allowance	0.0625"
Opening chord length	4.1363"
Projection available outside vessel, L _{pr}	20.6029"
Projection available outside vessel to flange face, L _f	20.9029"
Local vessel minimum thickness	0.485"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Reinforcing Pad

Material specification	SA-240 304 (II-D p. 94, ln. 8)
------------------------	--------------------------------

Diameter, D_p	6.7302"
Thickness, t_e	0.25"
Is split	No
Welds	
Inner Fillet, Leg_{41}	0.25"
Outer Fillet, Leg_{42}	0.25"
Nozzle to vessel groove weld	0.485"
Pad groove weld	0.25"

ASME B16.5-2009 Flange	
Description	NPS 3 Class 150 SO A182 F304
Bolt Material	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 352, ln. 31)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	180 psi @ 450 °F
MAP rating	275 psi @ 70 °F
Hydrotest rating	425 psi @ 70 °F
External fillet weld leg (UW-21)	0.3325" (0.3325 in min)
Internal fillet weld leg (UW-21)	0.3" (0.3 in min)
PWHT performed	No
Impact Tested	No
Gasket	
Description	COAST RUBBER PTFE ROLL TEFLON
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 100 * 1.5125 / (17,000 * 1 - 0.6 * 100) =$	0.0089"
Stress ratio = $t_r * E^* / (t_n - c) = 0.0089 * 1 / (0.2625 - 0.0625) =$	0.0446
Impact test exempt per UHA-51(g) (coincident ratio = 0.0446)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.	

UHA-51 Material Toughness Requirements Pad

Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F

Material is exempt from impact testing at the Design MDMT of -25 °F.

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.1991	1.5029	0.5591	0.3282	--	0.5	0.1156	0.2515	0.2625

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
12,448.94	16,894.02	36,131.43	9,875.86	59,210.81	19,944.61	53,949.26

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.1662	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 112.8 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.3527	1.3529	0.4107	0.3266	--	0.5	0.1156	0.2515	0.2625

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
17,591	16,865.38	36,131.43	9,847.22	59,210.81	19,915.97	53,949.26

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.1662	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAP

Available reinforcement per UG-37 governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 147.47 psi @ 70 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.5294	1.5295	0.4221	0.4918	--	0.5	0.1156	0.189	0.2625

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
23,254.54	22,148	43,845.62	15,845	71,254.07	27,095	65,363.96

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.5992	1.4769	0.5597	0.3016	--	0.5	0.1156	0.125	0.2625

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.1662	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAEP

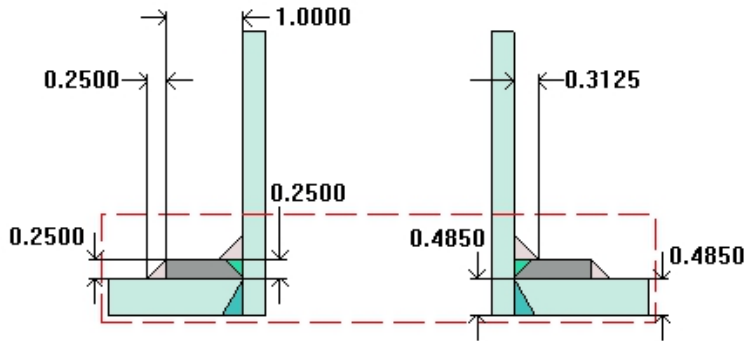
UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 16.53 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.6423	1.3914	0.4758	0.3	--	0.5	0.1156	0.125	0.2625

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.1662	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

VENT (D)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Location and Orientation

Located on	TOP HEAD
Orientation	60°
End of nozzle to datum line	180"
Calculated as hillside	Yes
Distance to head center, R	45"
Passes through a Category A joint	No

Nozzle

Description	NPS 3 Sch 80S (XS)
Access opening	No
Material specification	SA-312 TP304 Wld pipe (II-D p. 94, ln. 21)
Inside diameter, new	2.9"
Nominal wall thickness	0.3"
Corrosion allowance	0.0625"
Opening chord length	4.1363"
Projection available outside vessel, L_{pr}	20.6029"
Projection available outside vessel to flange face, L_f	20.9029"
Local vessel minimum thickness	0.485"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Reinforcing Pad

Material specification	SA-240 304 (II-D p. 94, ln. 8)
-------------------------------	--------------------------------

Diameter, D_p	6.7302"
Thickness, t_e	0.25"
Is split	No
Welds	
Inner Fillet, Leg_{41}	0.3125"
Outer Fillet, Leg_{42}	0.25"
Nozzle to vessel groove weld	0.485"
Pad groove weld	0.25"

ASME B16.5-2009 Flange	
Description	NPS 3 Class 150 SO A182 F304
Bolt Material	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 352, ln. 31)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	180 psi @ 450 °F
MAP rating	275 psi @ 70 °F
Hydrotest rating	425 psi @ 70 °F
External fillet weld leg (UW-21)	0.3325" (0.3325 in min)
Internal fillet weld leg (UW-21)	0.3" (0.3 in min)
PWHT performed	No
Impact Tested	No
Gasket	
Description	COAST RUBBER PTFE ROLL TEFLON
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 100 * 1.5125 / (17,000 * 1 - 0.6 * 100) =$	0.0089"
Stress ratio = $t_r * E^* / (t_n - c) = 0.0089 * 1 / (0.2625 - 0.0625) =$	0.0446
Impact test exempt per UHA-51(g) (coincident ratio = 0.0446)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.	

UHA-51 Material Toughness Requirements Pad

Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F

Material is exempt from impact testing at the Design MDMT of -25 °F.

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.1991	1.5327	0.5591	0.3282	--	0.5	0.1454	0.2515	0.2625

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
12,448.94	17,427.44	36,131.43	10,409.28	61,770.03	20,478.03	53,949.26

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.1662	0.2188	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 114.06 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.3678	1.3679	0.3961	0.3264	--	0.5	0.1454	0.2515	0.2625

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
18,096.83	17,395.22	36,131.43	10,377.06	61,770.03	20,445.81	53,949.26

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.1662	0.2188	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAP

Available reinforcement per UG-37 governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 148.93 psi @ 70 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.5445	1.5448	0.4077	0.4916	--	0.5	0.1455	0.189	0.2625

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
23,806.24	22,742	43,845.62	16,439	74,116.36	27,689	65,363.96

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.175	0.2188	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.5992	1.5067	0.5597	0.3016	--	0.5	0.1454	0.125	0.2625

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.1662	0.2188	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 16.53 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.6423	1.4212	0.4758	0.3	--	0.5	0.1454	0.125	0.2625

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.1662	0.2188	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Cylinder #1

ASME Section VIII Division 1, 2013 Edition				
Component		Cylinder		
Material		SA-240 304 (II-D p. 94, ln. 8)		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Optimize MDMT/ Find MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		100	450	-25
External		15	450	
Static Liquid Head				
Condition		P _s (psi)	H _s (in)	SG
Operating		2.86	66.0244	1.2
Test horizontal		3.68	102	1
Dimensions				
Inner Diameter		102"		
Length		72"		
Nominal Thickness		0.5"		
Corrosion	Inner	0.0625"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)	Capacity (US gal)	
New		3,361.82	2,546.89	
Corroded		2,943.38	2,553.14	
Radiography				
Longitudinal seam		Spot UW-11(b) Type 1		
Top Circumferential seam		Spot UW-11(b) Type 1		
Bottom Circumferential seam		Spot UW-11(b) Type 1		

Results Summary	
Governing condition	External pressure
Minimum thickness per UG-16	0.0625" + 0.0625" = 0.125"
Design thickness due to internal pressure (t)	0.4092"
Design thickness due to external pressure (t _e)	0.4849"
Design thickness due to combined loadings + corrosion	0.2023"
Maximum allowable working pressure (MAWP)	126.83 psi
Maximum allowable pressure (MAP)	165.69 psi
Maximum allowable external pressure (MAEP)	16.53 psi
Rated MDMT	-320 °F

UHA-51 Material Toughness Requirements
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.

Design thickness, (at 450 °F) UG-27(c)(1)

$$\begin{aligned}
 t &= P \cdot R / (S \cdot E - 0.60 \cdot P) + \text{Corrosion} \\
 &= 102.86 \cdot 51.0625 / (17,900 \cdot 0.85 - 0.60 \cdot 102.86) + 0.0625 \\
 &= \a href="#">0.4092"
 \end{aligned}$$

Maximum allowable working pressure, (at 450 °F) UG-27(c)(1)

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R + 0.60 \cdot t) - P_s \\
 &= 17,900 \cdot 0.85 \cdot 0.4375 / (51.0625 + 0.60 \cdot 0.4375) - 2.86 \\
 &= \a href="#">126.83 \text{ psi}
 \end{aligned}$$

Maximum allowable pressure, (at 70 °F) UG-27(c)(1)

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R + 0.60 \cdot t) \\
 &= 20,000 \cdot 0.85 \cdot 0.5 / (51 + 0.60 \cdot 0.5) \\
 &= \a href="#">165.69 \text{ psi}
 \end{aligned}$$

External Pressure, (Corroded & at 450 °F) UG-28(c)

$$\begin{aligned}
 L / D_o &= 163.0417 / 103 = 1.5829 \\
 D_o / t &= 103 / 0.4224 = 243.8726 \\
 \text{From table G: } A &= 0.000218 \\
 \text{From table HA-1: } B &= 2,743.5664 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\
 &= 4 \cdot 2,743.57 / (3 \cdot (103 / 0.4224)) \\
 &= 15 \text{ psi}
 \end{aligned}$$

Design thickness for external pressure P_a = 15 psi

$$t_a = t + \text{Corrosion} = 0.4224 + 0.0625 = \a href="#">0.4849"$$

Maximum Allowable External Pressure, (Corroded & at 450 °F) UG-28(c)

$$\begin{aligned}L / D_o &= 163.0417 / 103 = 1.5829 \\D_o / t &= 103 / 0.4375 = 235.4286 \\ \text{From table G: } A &= 0.000232 \\ \text{From table HA-1: } B &= 2,919.0141 \text{ psi}\end{aligned}$$

$$\begin{aligned}P_a &= 4*B / (3*(D_o / t)) \\ &= 4*2,919.01 / (3*(103 / 0.4375)) \\ &= \underline{16.53} \text{ psi}\end{aligned}$$

% Forming strain - UHA-44(a)(2)

$$\begin{aligned}\text{EFE} &= (50*t / R_f)*(1 - R_f / R_o) \\ &= (50*0.5 / 51.25)*(1 - 51.25 / \infty) \\ &= 0.4878\%\end{aligned}$$

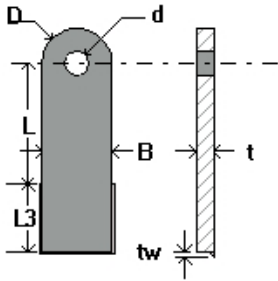
External Pressure + Weight + Seismic Loading Check (Bergman, ASME paper 54-A-104)

$$\begin{aligned}P_v &= (1 + V\text{Accel})*W / (2*\pi*R_m) + M / (\pi*R_m^2) \\ &= 1.20*11,324.8 / (2*\pi*51.2813) + 312,917 / (\pi*51.2813^2) \\ &= 80.0524 \text{ lb/in} \\ \alpha &= P_v / (P_e*D_o) \\ &= 80.0524 / (15*103) \\ &= 0.0518 \\ n &= 5 \\ m &= 1.23 / (L / D_o)^2 \\ &= 1.23 / (163.0417 / 103)^2 \\ &= 0.4909 \\ \text{Ratio } P_e &= (n^2 - 1 + m + m*\alpha) / (n^2 - 1 + m) \\ &= (5^2 - 1 + 0.4909 + 0.4909*0.0518) / (5^2 - 1 + 0.4909) \\ &= 1.001 \\ \text{Ratio } P_e * P_e &\leq \text{MAEP} \\ (1.001 * 15 &= 15.02) \leq 16.53 \\ \text{Cylinder design thickness is satisfactory.}\end{aligned}$$

Thickness Required Due to Pressure + External Loads								
Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S _t	S _c					
Operating, Hot & Corroded	100	17,900	6,603	450	0.0625	Seismic	0.1398	0.1353
Operating, Hot & New	100	17,900	6,861	450	0	Seismic	0.1396	0.1349
Hot Shut Down, Corroded	0	17,900	6,603	450	0.0625	Seismic	0.0001	0.0101
Hot Shut Down, New	0	17,900	6,861	450	0	Seismic	0.0001	0.0101
Empty, Corroded	0	20,000	9,181	70	0.0625	Seismic	0.0014	0.0056
Empty, New	0	20,000	9,706	70	0	Seismic	0.0015	0.0056
Vacuum	-15	17,900	6,603	450	0.0625	Seismic	0.048	0.0584
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0	17,900	6,603	450	0.0625	Weight	0.0049	0.0057

Ear lug

Minimum report

Geometry Inputs	
	
Attached To	Cylinder #1
Material	A 240 304
Distance of Lift Point From Datum	154"
Angular Position	160° and 340°
Length, L	10"
Width, B	6"
Thickness, t	0.75"
Hole Diameter, d	2"
Pin Diameter, Dp	1.5"
Diameter at Pin, D	6"
Load Angle from Vertical, ϕ	0°
Has Brace Plate	No
Welds	
Size, t_w	0.25"
Weld Length, L_3	6"

Intermediate Values	
Load Factor	1.5000
Vessel Weight (new, incl. Load Factor), W	19,716.5 lb
Lug Weight (new), W_{lug}	46.9 lb (Qty=2)
Allowable Stress, Tensile, σ_t	19,980 psi
Allowable Stress, Shear, σ_s	13,320 psi
Allowable Stress, Bearing, σ_p	29,970 psi
Allowable Stress, Bending, σ_b	22,201 psi
Allowable Stress, Weld Shear, $\tau_{allowable}$	13,320 psi
Allowable Stress set to 1/3 Sy per ASME B30.20	No

Summary Values	
Required Lift Pin Diameter, d_{reqd}	0.6864"
Required Lug Thickness, t_{reqd}	0.2193"
Lug Stress Ratio, σ_{ratio}	0.11
Weld Shear Stress Ratio, τ_{ratio}	0.23
Lug Design	Acceptable
Local Stresses WRC 107	Acceptable
Maximum Out of Plane Lift Angle - Weak Axis Bending	7.22°

COMPRESS recommends a spreader beam be used to prevent weak axis bending of the top lugs. No consideration is given for any bracing plate from the lug to the vessel.

Cylinder #2

ASME Section VIII Division 1, 2013 Edition				
Component		Cylinder		
Material		SA-240 304 (II-D p. 94, ln. 8)		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Optimize MDMT/ Find MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		100	450	-20
External		15	450	
Static Liquid Head				
Condition		P _s (psi)	H _s (in)	SG
Operating		5.98	138.0244	1.2
Test horizontal		3.68	102	1
Dimensions				
Inner Diameter		102"		
Length		72"		
Nominal Thickness		0.5"		
Corrosion	Inner	0.0625"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		Capacity (US gal)
New		3,361.82		2,546.89
Corroded		2,943.38		2,553.14
Radiography				
Longitudinal seam		Spot UW-11(b) Type 1		
Top Circumferential seam		Spot UW-11(b) Type 1		
Bottom Circumferential seam		Spot UW-11(b) Type 1		

Results Summary	
Governing condition	External pressure
Minimum thickness per UG-16	0.0625" + 0.0625" = 0.125"
Design thickness due to internal pressure (t)	0.4197"
Design thickness due to external pressure (t _e)	0.4849"
Design thickness due to combined loadings + corrosion	0.1912"
Maximum allowable working pressure (MAWP)	123.72 psi
Maximum allowable pressure (MAP)	165.69 psi
Maximum allowable external pressure (MAEP)	16.53 psi
Rated MDMT	-320 °F

UHA-51 Material Toughness Requirements
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.

Design thickness, (at 450 °F) UG-27(c)(1)

$$\begin{aligned}
 t &= P \cdot R / (S \cdot E - 0.60 \cdot P) + \text{Corrosion} \\
 &= 105.98 \cdot 51.0625 / (17,900 \cdot 0.85 - 0.60 \cdot 105.98) + 0.0625 \\
 &= \a href="#">0.4197"
 \end{aligned}$$

Maximum allowable working pressure, (at 450 °F) UG-27(c)(1)

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R + 0.60 \cdot t) - P_s \\
 &= 17,900 \cdot 0.85 \cdot 0.4375 / (51.0625 + 0.60 \cdot 0.4375) - 5.98 \\
 &= \a href="#">123.72 \text{ psi}
 \end{aligned}$$

Maximum allowable pressure, (at 70 °F) UG-27(c)(1)

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R + 0.60 \cdot t) \\
 &= 20,000 \cdot 0.85 \cdot 0.5 / (51 + 0.60 \cdot 0.5) \\
 &= \a href="#">165.69 \text{ psi}
 \end{aligned}$$

External Pressure, (Corroded & at 450 °F) UG-28(c)

$$\begin{aligned}
 L / D_o &= 163.0417 / 103 = 1.5829 \\
 D_o / t &= 103 / 0.4224 = 243.8726 \\
 \text{From table G: } A &= 0.000218 \\
 \text{From table HA-1: } B &= 2,743.5664 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\
 &= 4 \cdot 2,743.57 / (3 \cdot (103 / 0.4224)) \\
 &= 15 \text{ psi}
 \end{aligned}$$

Design thickness for external pressure P_a = 15 psi

$$t_a = t + \text{Corrosion} = 0.4224 + 0.0625 = \a href="#">0.4849"$$

Maximum Allowable External Pressure, (Corroded & at 450 °F) UG-28(c)

$$\begin{aligned}L / D_o &= 163.0417 / 103 = 1.5829 \\D_o / t &= 103 / 0.4375 = 235.4286 \\ \text{From table G: } A &= 0.000232 \\ \text{From table HA-1: } B &= 2,919.0141 \text{ psi}\end{aligned}$$

$$\begin{aligned}P_a &= 4*B / (3*(D_o / t)) \\ &= 4*2,919.01 / (3*(103 / 0.4375)) \\ &= \underline{16.53} \text{ psi}\end{aligned}$$

% Forming strain - UHA-44(a)(2)

$$\begin{aligned}\text{EFE} &= (50*t / R_f)*(1 - R_f / R_o) \\ &= (50*0.5 / 51.25)*(1 - 51.25 / \infty) \\ &= 0.4878\%\end{aligned}$$

External Pressure + Weight + Seismic Loading Check (Bergman, ASME paper 54-A-104)

$$\begin{aligned}P_v &= (1 + V\text{Accel})*W / (2*\pi*R_m) + M / (\pi*R_m^2) \\ &= 1.20*14,977.3 / (2*\pi*51.2813) + 792,883 / (\pi*51.2813^2) \\ &= 151.7511 \text{ lb/in} \\ \alpha &= P_v / (P_e*D_o) \\ &= 151.7511 / (15*103) \\ &= 0.0982 \\ n &= 5 \\ m &= 1.23 / (L / D_o)^2 \\ &= 1.23 / (163.0417 / 103)^2 \\ &= 0.4909 \\ \text{Ratio } P_e &= (n^2 - 1 + m + m*\alpha) / (n^2 - 1 + m) \\ &= (5^2 - 1 + 0.4909 + 0.4909*0.0982) / (5^2 - 1 + 0.4909) \\ &= 1.002 \\ \text{Ratio } P_e * P_e &\leq \text{MAEP} \\ (1.002 * 15) &= 15.03 \leq 16.53 \\ \text{Cylinder design thickness is satisfactory.}\end{aligned}$$

External Pressure + Weight + Seismic Loading Check at Bottom Seam(Bergman, ASME paper 54-A-104)

$$\begin{aligned}P_v &= W / (2*\pi*R_m) + M / (\pi*R_m^2) \\ &= -56,982.6 / (2*\pi*51.2813) + 6,210 / (\pi*51.2813^2) \\ &= -176.0978 \text{ lb/in} \\ \alpha &= P_v / (P_e*D_o) \\ &= -176.0978 / (15*103) \\ &= -0.114 \\ n &= 5 \\ m &= 1.23 / (L / D_o)^2 \\ &= 1.23 / (163.0417 / 103)^2 \\ &= 0.4909 \\ \text{Ratio } P_e &= (n^2 - 1 + m + m*\alpha) / (n^2 - 1 + m) \\ &= (5^2 - 1 + 0.4909 + 0.4909*-0.114) / (5^2 - 1 + 0.4909) \\ &= 1\end{aligned}$$

$$\text{Ratio } P_e * P_e \leq \text{MAEP}$$

$$(1 * 15 = 15) \leq 16.53$$

Cylinder design thickness is satisfactory.

Thickness Required Due to Pressure + External Loads									
Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Location	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S _t	S _c						
Operating, Hot & Corroded	100	17,900	6,603	450	0.0625	Top	Seismic	0.1211	0.1117
						Bottom	Seismic	0.1287	0.1269
Operating, Hot & New	100	17,900	6,861	450	0	Top	Seismic	0.1208	0.1113
						Bottom	Seismic	0.1285	0.1268
Hot Shut Down, Corroded	0	17,900	6,603	450	0.0625	Top	Seismic	0.0023	0.0192
						Bottom	Seismic	0.0099	0.0082
Hot Shut Down, New	0	17,900	6,861	450	0	Top	Seismic	0.0022	0.0192
						Bottom	Seismic	0.0099	0.0082
Empty, Corroded	0	20,000	9,181	70	0.0625	Top	Seismic	0.0011	0.0082
						Bottom	Seismic	0.0003	0.0002
Empty, New	0	20,000	9,706	70	0	Top	Seismic	0.0011	0.0083
						Bottom	Seismic	0.0003	0.0002
Vacuum	-15	17,900	6,603	450	0.0625	Top	Seismic	0.0421	0.0675
						Bottom	Seismic	0.0214	0.0261
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0	17,900	6,603	450	0.0625	Top	Weight	0.0066	0.0075
						Bottom	Weight	0.0099	0.0099

4 PIPE LEGS

Inputs	
Leg material	SA 312 304
Leg description	6 inch sch 80 pipe
Number of legs, N	4
Overall length	67"
Base to girth seam length	59"
Bolt circle	96"
Foundation allowable bearing stress	1,658 psi
User defined leg eccentricity	0
Effective length coefficient, K	1.2
Coefficient, C_m	0.85
Leg yield stress, F_y	30,000 psi
Leg elastic modulus, E	28,000,000 psi
Anchor Bolts	
Anchor bolt size	0.75" series 8 threaded
Anchor bolt material	SA 325
Anchor bolts/leg	4
Anchor bolt allowable stress, S_b	20,000 psi
Anchor bolt corrosion allowance	0"
Anchor bolt hole clearance	0.375"
Welds	
Leg to shell fillet weld	0.375" (0.326" required)
Legs braced	No

Note: The support attachment point is assumed to be 1 in up from the cylinder circumferential seam.

Conditions Investigated (Only Governing Condition Reported)

Weight operating corroded
Weight operating new
Weight empty corroded
Weight empty new
Weight vacuum corroded
Seismic operating corroded
Seismic operating new
Seismic empty corroded
Seismic empty new
Seismic vacuum corroded

Governing Condition : Seismic operating new, Moment = 66,725.4 lb _f -ft								
Force attack angle °	Leg position °	Axial end load (1) lb _f	Shear resisted lb _f	Axial f _a psi	Bending f _{bx} psi	Bending f _{by} psi	Ratio H ₁₋₁	Ratio H ₁₋₂
0	0	10,514.3	2,112.9	1,252	10,023	0	0.5093	0.5758
	90	21,945.7	2,112.9	2,613	0	10,023	0.5952	0.6514
	180	<u>29,719.5</u>	2,112.9	<u>3,538</u>	<u>10,023</u>	<u>0</u>	<u>0.6537</u>	<u>0.7028</u>
	270	21,945.7	2,112.9	2,613	0	10,023	0.5952	0.6514

(1) Axial end load includes consideration of seismic vertical acceleration.

Leg Calculations (AISC manual ninth edition)

Axial end load, P₁ (Based on vessel total bending moment acting at leg attachment elevation)

$$\begin{aligned}
 P_1 &= W_t / N + 48 * M_t / (N * D) + V_v / N \\
 &= 73,152.36 / 4 + 48 * 66,725.4 / (4 * 103) + 14,630.47 / 4 \\
 &= \underline{29,719.54} \text{ lb}_f
 \end{aligned}$$

Allowable axial compressive stress, F_a (AISC chapter E)

$$\begin{aligned}
 C_c &= \text{Sqr}(2 * \pi^2 * E / F_y) \\
 &= \text{Sqr}(2 * \pi^2 * 28,000,000 / 30,000) \\
 &= 135.7323
 \end{aligned}$$

$$K * l / r = 1.2 * 58 / 2.1958 = 31.6972$$

$$\begin{aligned}
 F_a &= 1 * (1 - (K * l / r)^2 / (2 * C_c^2)) * F_y / (5 / 3 + 3 * (K * l / r) / (8 * C_c) - (K * l / r)^3 / (8 * C_c^3)) \\
 &= 1 * (1 - (31.6972)^2 / (2 * 135.7323^2)) * 30,000 / (5 / 3 + 3 * (31.6972) / (8 * 135.7323) - (31.6972)^3 / (8 * 135.7323^3)) \\
 &= 16,650 \text{ psi}
 \end{aligned}$$

Allowable axial compression and bending (AISC chapter H)

$$\begin{aligned}
 F'_{ex} &= 1 * 12 * \pi^2 * E / (23 * (K * l / r)^2) \\
 &= 1 * 12 * \pi^2 * 28,000,000 / (23 * (31.6972)^2) \\
 &= 143,505 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 F'_{ey} &= 1 * 12 * \pi^2 * E / (23 * (K * l / r)^2) \\
 &= 1 * 12 * \pi^2 * 28,000,000 / (23 * (31.6972)^2) \\
 &= 143,505 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 F_b &= 1 * 0.66 * F_y \\
 &= 1 * 0.66 * 30,000 \\
 &= 19,800 \text{ psi}
 \end{aligned}$$

Compressive axial stress

$$\begin{aligned}
 f_a &= P_1 / A \\
 &= 29,719.54 / 8.4 \\
 &= \underline{3,538} \text{ psi}
 \end{aligned}$$

Bending stresses

$$f_{bx} = F * \cos(\alpha) * L / (I_x / C_x) + P_1 * E_{cc} / (I_x / C_x)$$

$$= 2,112.93 \cdot \cos(0) \cdot 58 / (40.5 / 3.3125) + 29,719.54 \cdot 0 / (40.5 / 3.3125)$$

$$= 10.023 \text{ psi}$$

$$f_{by} = F \cdot \sin(\alpha) \cdot L / (I_y / C_y)$$

$$= 2,112.93 \cdot \sin(0) \cdot 58 / (40.5 / 3.31)$$

$$= 0 \text{ psi}$$

AISC equation H₁₋₁

$$H_{1-1} = f_a / F_a + C_{mx} \cdot f_{bx} / ((1 - f_a / F'_{ex}) \cdot F_{bx}) + C_{my} \cdot f_{by} / ((1 - f_a / F'_{ey}) \cdot F_{by})$$

$$= 3,538 / 16,650 + 0.85 \cdot 10,023 / ((1 - 3,538 / 143,505) \cdot 19,800) + 0.85 \cdot 0 / ((1 - 3,538 / 143,505) \cdot 19,800)$$

$$= 0.6537$$

AISC equation H₁₋₂

$$H_{1-2} = f_a / (0.6 \cdot 1 \cdot F_y) + f_{bx} / F_{bx} + f_{by} / F_{by}$$

$$= 3,538 / (0.6 \cdot 1 \cdot 30,000) + 10,023 / 19,800 + 0 / 19,800$$

$$= 0.7028$$

4, 6 inch sch 80 pipe legs are adequate.

Anchor bolts - Seismic empty corroded condition governs

Tensile loading per leg (4 bolts per leg)

$$R = 48 \cdot M / (N \cdot BC) - W / N$$

$$= 48 \cdot 33,501.2 / (4 \cdot 96) - 17,384.65 / 4$$

$$= -158.52 \text{ lb}_f$$

There is no net uplift (R is negative).

0.75" series 8 threaded bolts are satisfactory.

Check the leg to vessel fillet weld, Bednar 10.3, Seismic operating new governs

Note: continuous welding is assumed for all support leg fillet welds.

$$Z_w = (2 \cdot b \cdot d + d^2) / 3$$

$$= (2 \cdot 6.625 \cdot 9 + 9^2) / 3$$

$$= 66.75 \text{ in}^2$$

$$J_w = (b + 2 \cdot d)^3 / 12 - d^2 \cdot (b + d)^2 / (b + 2 \cdot d)$$

$$= (6.625 + 2 \cdot 9)^3 / 12 - 9^2 \cdot (6.625 + 9)^2 / (6.625 + 2 \cdot 9)$$

$$= 441.3025 \text{ in}^3$$

$$E = d^2 / (b + 2 \cdot d)$$

$$= 9^2 / (6.625 + 2 \cdot 9)$$

$$= 3.28934 \text{ in}$$

$$\text{Governing weld load } f_x = \cos(0) \cdot 2,112.93 = 2,112.93 \text{ lb}_f$$

$$\text{Governing weld load } f_y = \sin(0) \cdot 2,112.93 = 0 \text{ lb}_f$$

$$f_1 = P_1 / L_{\text{weld}}$$

$$= 29,719.54 / 24.625$$

$$= 1,206.89 \text{ lb}_f/\text{in} \quad (V_L \text{ direct shear})$$

$$f_2 = f_y \cdot L_{\text{leg}} \cdot 0.5 \cdot b / J_w$$

$$= 0 \cdot 58 \cdot 0.5 \cdot 6.625 / 441.3025$$

$$= 0 \text{ lb}_f/\text{in} \quad (V_L \text{ torsion shear})$$

$$\begin{aligned} f_3 &= f_y / L_{\text{weld}} \\ &= 0 / 24.625 \\ &= 0 \text{ lb}_f/\text{in} \quad (V_c \text{ direct shear}) \end{aligned}$$

$$\begin{aligned} f_4 &= f_y * L_{\text{leg}} * E / J_w \\ &= 0 * 58 * 3.2893 / 441.3025 \\ &= 0 \text{ lb}_f/\text{in} \quad (V_c \text{ torsion shear}) \end{aligned}$$

$$\begin{aligned} f_5 &= (f_x * L_{\text{leg}} + P_1 * E_{\text{cc}}) / Z_w \\ &= (2,112.93 * 58 + 29,719.54 * 0) / 66.75 \\ &= 1,835.95 \text{ lb}_f/\text{in} \quad (M_L \text{ bending}) \end{aligned}$$

$$\begin{aligned} f_6 &= f_x / L_{\text{weld}} \\ &= 2,112.93 / 24.625 \\ &= 85.8 \text{ lb}_f/\text{in} \quad (\text{Direct outward radial shear}) \end{aligned}$$

$$\begin{aligned} f &= \text{Sqr}((f_1 + f_2)^2 + (f_3 + f_4)^2 + (f_5 + f_6)^2) \\ &= \text{Sqr}((1,206.89 + 0)^2 + (0 + 0)^2 + (1,835.95 + 85.8)^2) \\ &= 2,269.3 \text{ lb}_f/\text{in} \quad (\text{Resultant shear load}) \end{aligned}$$

Required leg to vessel fillet weld leg size (welded both sides + top)

$$\begin{aligned} t_w &= f / (0.707 * 0.55 * S_a) \\ &= 2,269.3 / (0.707 * 0.55 * 17,900) \\ &= \underline{0.326} \text{ in} \end{aligned}$$

The 0.375 in leg to vessel attachment fillet weld size is adequate.

Base plate thickness check, AISC 3-106

$$\begin{aligned} f_p &= P / (B * N) \\ &= 35,714.4 / (12 * 12) \\ &= 248 \text{ psi} \end{aligned}$$

$$\begin{aligned} t_b &= (N - (d - t_L)) / 2 * \text{Sqr}(3 * f_p / S_b) \\ &= (12 - (6.625 - 0.432)) / 2 * \text{Sqr}(3 * 248 / 24,000) \\ &= \underline{0.5112} \text{ in} \end{aligned}$$

The base plate thickness is adequate.

Check the leg to vessel attachment stresses, WRC 107 (Seismic operating corroded governs)

Applied Loads	
Radial load, P_r	-2,079.11 lb _f
Circumferential moment, M_c	0 lb _f -in
Circumferential shear, V_c	0 lb _f
Longitudinal moment, M_L	120,588.4 lb _f -in
Longitudinal shear, V_L	10,354.4 lb _f
Torsion moment, M_t	0 lb _f -in
Internal pressure, P	105.98 psi
Mean shell radius, R_m	51.2813"
Local shell thickness, T	0.4375"
Design factor	3

Maximum stresses due to the applied loads at the leg edge (includes pressure)

$$\gamma = R_m / T = 51.2813 / 0.4375 = 117.2143$$

$$C_1 = 3.3125, C_2 = 7.1433 \text{ in}$$

$$\text{Local circumferential pressure stress} = P \cdot R_i / T = 12,369 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = P \cdot R_i / (2 \cdot T) = 6,184 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 53,000 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = \pm 3 \cdot S = \pm 53,700 \text{ psi}$$

The maximum combined stress ($P_L + P_b + Q$) is within allowable limits.

$$\text{Maximum local primary membrane stress } (P_L) = 23,376 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = \pm 1.5 \cdot S = \pm 26,850 \text{ psi}$$

The maximum local primary membrane stress (P_L) is within allowable limits.

Stresses at the leg edge per WRC Bulletin 107										
Figure	value	β	A_u	A_l	B_u	B_l	C_u	C_l	D_u	D_l
3C*	10.1287	0.1274	0	0	0	0	939	939	939	939
4C*	16.9143	0.1084	1,567	1,567	1,567	1,567	0	0	0	0
1C	0.0956	0.0867	0	0	0	0	6,231	-6,231	6,231	-6,231
2C-1	0.0612	0.0867	3,989	-3,989	3,989	-3,989	0	0	0	0
3A*	4.2482	0.0835	0	0	0	0	0	0	0	0
1A	0.0851	0.0879	0	0	0	0	0	0	0	0
3B*	12.3732	0.1078	-9,440	-9,440	9,440	9,440	0	0	0	0
1B-1	0.0328	0.0943	-25,635	25,635	25,635	-25,635	0	0	0	0
Pressure stress*			12,369	12,369	12,369	12,369	12,369	12,369	12,369	12,369
Total circumferential stress			-17,150	26,142	53,000	-6,248	19,539	7,077	19,539	7,077
Primary membrane circumferential stress*			4,496	4,496	23,376	23,376	13,308	13,308	13,308	13,308
3C*	11.9319	0.1084	1,106	1,106	1,106	1,106	0	0	0	0
4C*	15.8262	0.1274	0	0	0	0	1,467	1,467	1,467	1,467
1C-1	0.0752	0.1118	4,901	-4,901	4,901	-4,901	0	0	0	0
2C	0.0467	0.1118	0	0	0	0	3,044	-3,044	3,044	-3,044
4A*	6.9623	0.0835	0	0	0	0	0	0	0	0
2A	0.0403	0.1064	0	0	0	0	0	0	0	0
4B*	4.5617	0.1078	-5,194	-5,194	5,194	5,194	0	0	0	0
2B-1	0.0376	0.1142	-24,266	24,266	24,266	-24,266	0	0	0	0
Pressure stress*			6,184	6,184	6,184	6,184	6,184	6,184	6,184	6,184
Total longitudinal stress			-17,269	21,461	41,651	-16,683	10,695	4,607	10,695	4,607
Primary membrane longitudinal stress*			2,096	2,096	12,484	12,484	7,651	7,651	7,651	7,651
Shear from M_t			0	0	0	0	0	0	0	0
Circ shear from V_c			0	0	0	0	0	0	0	0
Long shear from V_L			0	0	0	0	-828	-828	828	828
Total Shear stress			0	0	0	0	-828	-828	828	828
Combined stress (P_L+P_D+Q)			-17,269	26,142	53,000	-16,683	19,616	7,329	19,616	7,329
* denotes primary stress.										

Straight Flange on BTM HEAD

ASME Section VIII Division 1, 2013 Edition				
Component		Cylinder		
Material		SA-240 304 (II-D p. 94, ln. 8)		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Optimize MDMT/ Find MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		100	450	-25
External		15	450	
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Operating		6.02	139.0244	1.2
Test horizontal		3.68	102	1
Dimensions				
Inner Diameter		102"		
Length		1"		
Nominal Thickness		0.5"		
Corrosion	Inner	0.0625"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)	Capacity (US gal)	
New		46.69	35.37	
Corroded		40.88	35.46	
Radiography				
Longitudinal seam		Seamless No RT		
Top Circumferential seam		Spot UW-11(b) Type 1		

Results Summary	
Governing condition	External pressure
Minimum thickness per UG-16	0.0625" + 0.0625" = 0.125"
Design thickness due to internal pressure (t)	0.4199"
Design thickness due to external pressure (t _e)	0.4849"
Design thickness due to combined loadings + corrosion	0.2138"
Maximum allowable working pressure (MAWP)	123.67 psi
Maximum allowable pressure (MAP)	165.69 psi
Maximum allowable external pressure (MAEP)	16.53 psi
Rated MDMT	-320 °F

UHA-51 Material Toughness Requirements
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.

Design thickness, (at 450 °F) UG-27(c)(1)

$$\begin{aligned}
 t &= P \cdot R / (S \cdot E - 0.60 \cdot P) + \text{Corrosion} \\
 &= 106.02 \cdot 51.0625 / (17,900 \cdot 0.85 - 0.60 \cdot 106.02) + 0.0625 \\
 &= \a href="#">0.4199"
 \end{aligned}$$

Maximum allowable working pressure, (at 450 °F) UG-27(c)(1)

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R + 0.60 \cdot t) - P_s \\
 &= 17,900 \cdot 0.85 \cdot 0.4375 / (51.0625 + 0.60 \cdot 0.4375) - 6.02 \\
 &= \a href="#">123.67 \text{ psi}
 \end{aligned}$$

Maximum allowable pressure, (at 70 °F) UG-27(c)(1)

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R + 0.60 \cdot t) \\
 &= 20,000 \cdot 0.85 \cdot 0.5 / (51 + 0.60 \cdot 0.5) \\
 &= \a href="#">165.69 \text{ psi}
 \end{aligned}$$

External Pressure, (Corroded & at 450 °F) UG-28(c)

$$\begin{aligned}
 L / D_o &= 163.0417 / 103 = 1.5829 \\
 D_o / t &= 103 / 0.4224 = 243.8726 \\
 \text{From table G: } A &= 0.000218 \\
 \text{From table HA-1: } B &= 2,743.5664 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\
 &= 4 \cdot 2,743.57 / (3 \cdot (103 / 0.4224)) \\
 &= 15 \text{ psi}
 \end{aligned}$$

Design thickness for external pressure P_a = 15 psi

$$t_a = t + \text{Corrosion} = 0.4224 + 0.0625 = \a href="#">0.4849"$$

Maximum Allowable External Pressure, (Corroded & at 450 °F) UG-28(c)

$L / D_o = 163.0417 / 103 = 1.5829$
 $D_o / t = 103 / 0.4375 = 235.4286$
 From table G: $A = 0.000232$
 From table HA-1: $B = 2,919.0141 \text{ psi}$

$P_a = 4*B / (3*(D_o / t))$
 $= 4*2,919.01 / (3*(103 / 0.4375))$
 $= 16.53 \text{ psi}$

% Forming strain - UHA-44(a)(2)

$EFE = (50*t / R_f) * (1 - R_f / R_o)$
 $= (50*0.5 / 51.25) * (1 - 51.25 / \infty)$
 $= 0.4878\%$

Thickness Required Due to Pressure + External Loads								
Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S _t	S _c					
Operating, Hot & Corroded	100	17,900	6,603	450	0.0625	Seismic	0.1513	0.1493
Operating, Hot & New	100	17,900	6,861	450	0	Seismic	0.1512	0.1492
Hot Shut Down, Corroded	0	17,900	6,603	450	0.0625	Seismic	0.0117	0.0096
Hot Shut Down, New	0	17,900	6,861	450	0	Seismic	0.0117	0.0097
Empty, Corroded	0	20,000	9,181	70	0.0625	Seismic	0.0003	0.0002
Empty, New	0	20,000	9,706	70	0	Seismic	0.0003	0.0003
Vacuum	-15	17,900	6,603	450	0.0625	Seismic	0.0215	0.0261
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0	17,900	6,603	450	0.0625	Weight	0.0116	0.0116

BTM HEAD

ASME Section VIII Division 1, 2013 Edition				
Component		Ellipsoidal Head		
Material		SA-240 304 (II-D p. 94, In. 8)		
Attached To		Cylinder #2		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Optimize MDMT/ Find MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		100	450	-25
External		15	450	
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Operating		7.13	164.5869	1.2
Test horizontal		3.68	102	1
Dimensions				
Inner Diameter		102"		
Head Ratio		2		
Minimum Thickness		0.485"		
Corrosion	Inner	0.0625"		
	Outer	0"		
Length L_{sf}		1"		
Nominal Thickness t_{sf}		0.5"		
Weight and Capacity				
		Weight (lb)¹	Capacity (US gal)¹	
New		1,745.59	636.72	
Corroded		1,523.11	639.76	
Radiography				
Category A joints		Seamless No RT		
Head to shell seam		Spot UW-11(b) Type 1		

¹includes straight flange

Results Summary	
Governing condition	internal pressure
Minimum thickness per UG-16	0.0625" + 0.0625" = 0.125"
Design thickness due to internal pressure (t)	0.4218"
Design thickness due to external pressure (t _e)	0.3473"
Maximum allowable working pressure (MAWP)	118.86 psi
Maximum allowable pressure (MAP)	161.51 psi
Maximum allowable external pressure (MAEP)	25.31 psi
Straight Flange governs MDMT	-320 °F

Factor K		
K = (1/6)*[2 + (D / (2*h)) ²]		
Corroded	K = (1/6)*[2 + (102.125 / (2*25.5625)) ²]	0.9984
New	K = (1/6)*[2 + (102 / (2*25.5)) ²]	1

Design thickness for internal pressure, (Corroded at 450 °F) Appendix 1-4(c)

$$\begin{aligned}
 t &= P \cdot D \cdot K / (2 \cdot S \cdot E - 0.2 \cdot P) + \text{Corrosion} \\
 &= 107.13 \cdot 102.125 \cdot 0.998371 / (2 \cdot 17,900 \cdot 0.85 - 0.2 \cdot 107.13) + 0.0625 \\
 &= \a href="#">0.4217"
 \end{aligned}$$

Maximum allowable working pressure, (Corroded at 450 °F) Appendix 1-4(c)

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (K \cdot D + 0.2 \cdot t) - P_s \\
 &= 2 \cdot 17,900 \cdot 0.85 \cdot 0.4225 / (0.998371 \cdot 102.125 + 0.2 \cdot 0.4225) - 7.13 \\
 &= \a href="#">118.86 \text{ psi}
 \end{aligned}$$

Maximum allowable pressure, (New at 70 °F) Appendix 1-4(c)

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (K \cdot D + 0.2 \cdot t) - P_s \\
 &= 2 \cdot 20,000 \cdot 0.85 \cdot 0.485 / (1 \cdot 102 + 0.2 \cdot 0.485) - 0 \\
 &= \a href="#">161.51 \text{ psi}
 \end{aligned}$$

Design thickness for external pressure, (Corroded at 450 °F) UG-33(d)

Equivalent outside spherical radius (R_o)

$$\begin{aligned}
 R_o &= K_o \cdot D_o \\
 &= 0.8916 \cdot 102.97 \\
 &= 91.8081 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (91.8081 / 0.284785) \\
 &= 0.000388
 \end{aligned}$$

From Table HA-1: B = 4,835.6542 psi

$$\begin{aligned}
 P_a &= B / (R_o / t) \\
 &= 4,835.6542 / (91.8081 / 0.2848) \\
 &= 15 \text{ psi}
 \end{aligned}$$

$$t = 0.2848'' + \text{Corrosion} = 0.2848'' + 0.0625'' = 0.3473''$$

Check the external pressure per UG-33(a)(1) Appendix 1-4(c)

$$\begin{aligned} t &= 1.67 \cdot P_e \cdot D \cdot K / (2 \cdot S \cdot E - 0.2 \cdot 1.67 \cdot P_e) + \text{Corrosion} \\ &= 1.67 \cdot 15 \cdot 102.125 \cdot 0.998371 / (2 \cdot 17,900 \cdot 1 - 0.2 \cdot 1.67 \cdot 15) + 0.0625 \\ &= 0.1339'' \end{aligned}$$

The head external pressure design thickness (t_e) is [0.3473](#)''.

Maximum Allowable External Pressure, (Corroded at 450 °F) UG-33(d)

Equivalent outside spherical radius (R_o)

$$\begin{aligned} R_o &= K_o \cdot D_o \\ &= 0.8916 \cdot 102.97 \\ &= 91.8081 \text{ in} \end{aligned}$$

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (91.8081 / 0.4225) \\ &= 0.000575 \end{aligned}$$

From Table HA-1: $B = 5,499.4805$ psi

$$\begin{aligned} P_a &= B / (R_o / t) \\ &= 5,499.4805 / (91.8081 / 0.4225) \\ &= 25.3085 \text{ psi} \end{aligned}$$

Check the Maximum External Pressure, UG-33(a)(1) Appendix 1-4(c)

$$\begin{aligned} P &= 2 \cdot S \cdot E \cdot t / ((K \cdot D + 0.2 \cdot t) \cdot 1.67) \\ &= 2 \cdot 17,900 \cdot 1 \cdot 0.4225 / ((0.998371 \cdot 102.125 + 0.2 \cdot 0.4225) \cdot 1.67) \\ &= 88.76 \text{ psi} \end{aligned}$$

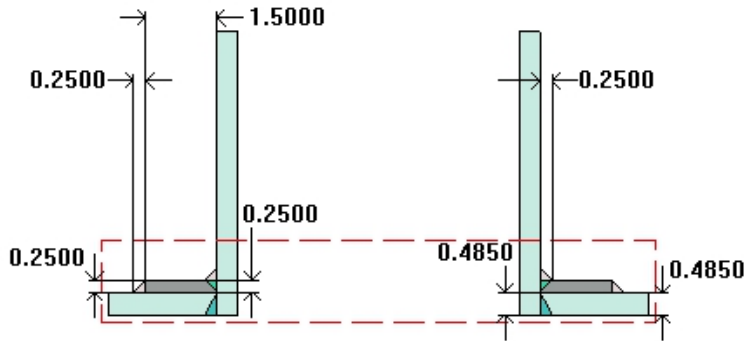
The maximum allowable external pressure (MAEP) is [25.31](#) psi.

% Forming strain - UHA-44(a)(2)

$$\begin{aligned} EFE &= (75 \cdot t / R_f) \cdot (1 - R_f / R_o) \\ &= (75 \cdot 0.5 / 17.59) \cdot (1 - 17.59 / \infty) \\ &= 2.1319\% \end{aligned}$$

DRAIN (P)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Location and Orientation

Located on	BTM HEAD
Orientation	0°
End of nozzle to datum line	-35"
Calculated as hillside	No
Distance to head center, R	0"
Passes through a Category A joint	No

Nozzle

Description	NPS 6 Sch 80S (XS)
Access opening	No
Material specification	SA-312 TP304 Wld pipe (II-D p. 94, ln. 21)
Inside diameter, new	5.761"
Nominal wall thickness	0.432"
Corrosion allowance	0.0625"
Projection available outside vessel, L _{pr}	7.6368"
Projection available outside vessel to flange face, L _f	8.0688"
Local vessel minimum thickness	0.485"
Liquid static head included	7.47 psi
Longitudinal joint efficiency	1

Reinforcing Pad

Material specification	SA-240 304 (II-D p. 94, ln. 8)
Diameter, D _p	9.625"

Thickness, t_e	0.25"
Is split	No
Welds	
Inner Fillet, Leg ₄₁	0.25"
Outer Fillet, Leg ₄₂	0.25"
Nozzle to vessel groove weld	0.485"
Pad groove weld	0.25"

ASME B16.5-2009 Flange	
Description	NPS 6 Class 150 SO A182 F304
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 352, In. 31)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	7.49 psi
MAWP rating	180 psi @ 450 °F
MAP rating	275 psi @ 70 °F
Hydrotest rating	425 psi @ 70 °F
External fillet weld leg (UW-21)	0.42" (0.42 in min)
Internal fillet weld leg (UW-21)	0.432" (0.3393 in min)
PWHT performed	No
Impact Tested	No
Gasket	
Description	COAST RUBBER PTFE ROLL TEFLON
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 107.47 * 2.943 / (17,000 * 1 - 0.6 * 107.47) =$	0.0187"
Stress ratio = $t_r * E^* / (t_n - c) = 0.0187 * 1 / (0.378 - 0.0625) =$	0.0592
Impact test exempt per UHA-51(g) (coincident ratio = 0.0592)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.	

UHA-51 Material Toughness Requirements Pad

Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F

Material is exempt from impact testing at the Design MDMT of -25 °F.

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 107.47 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.6539	2.3439	0.8474	0.6309	--	0.75	0.1156	0.3075	0.378

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
16,083.91	26,787.35	71,783.18	16,989.67	112,077.6	31,533.42	91,391.44

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 130.08 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
2.0019	2.0022	0.5123	0.6243	--	0.75	0.1156	0.3075	0.378

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
27,660.09	26,669.21	71,783.18	16,871.53	112,077.6	31,415.28	91,391.44

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAP

Available reinforcement per UG-37 governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 167.66 psi @ 70 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
2.2685	2.2686	0.5626	0.8404	--	0.75	0.1156	0.245	0.378

UG-41 Weld Failure Path Analysis Summary (lb _f)						
All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength	Weld load W ₃₋₃	Path 3-3 strength
35,584.73	34,120	87,050.74	24,993.68	134,873.78	41,243.68	111,739.38

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.854	2.28	0.7952	0.6192	--	0.75	0.1156	0.125	0.378

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

Reinforcement Calculations for MAEP

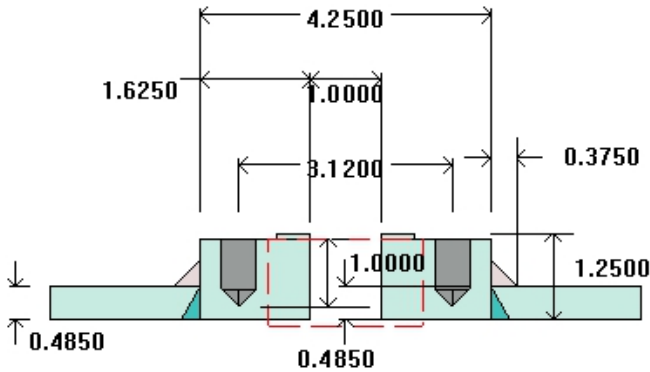
UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 16.53 psi @ 450 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.9158	2.1593	0.6763	0.6174	--	0.75	0.1156	0.125	0.378

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Pad to shell fillet (Leg ₄₂)	0.125	0.175	weld size is adequate

THERMOWELL (Q)

ASME Section VIII Division 1, 2013 Edition



Note: round inside edges per UG-76(c)

Note: Thread engagement shall comply with the requirements of UG-43(g).

Location and Orientation

Located on	BTM HEAD
Orientation	270°
End of nozzle to datum line	-26.0721"
Calculated as hillside	No
Distance to head center, R	18"
Passes through a Category A joint	No

Nozzle

Description	Studding Outlet NPS 1 Class 150
Access opening	No
Material specification	SA-240 304 (low stress) (II-D p. 94, In. 7)
Bolt material specification	SA-193 B7 Bolt <= 2 1/2 (II-D p. 352, In. 31)
Bolt rated MDMT	-55°F
Pad inner diameter	1"
Pad outer diameter, D_p	4.25"
Pad thickness	1.25"
Figure UG-40 thickness, t_e	0.705"
Tapped hole diameter	0.5"
Tapped hole depth	1"
Tapped hole bolt circle	3.12"
Raised face height	0.06"

Raised face outer diameter	2"
Corrosion allowance	0.0625"
Projection available outside vessel, Lpr	0.705"
Local vessel minimum thickness	0.485"
Liquid static head included	7.09 psi
Longitudinal joint efficiency	1
Welds	
Inner Fillet, Leg₄₂	0.375"
Nozzle to vessel groove weld	0.485"

UHA-51 Material Toughness Requirements Pad
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F
Material is exempt from impact testing at the Design MDMT of -25 °F.

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 107.09 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2699	1.625

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Pad to shell fillet (Leg ₄₂)	0.25	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 164.61 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2699	1.625

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Pad to shell fillet (Leg ₄₂)	0.25	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 211.11 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.625

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Pad to shell fillet (Leg ₄₂)	0.25	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.125	1.625

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Pad to shell fillet (Leg ₄₂)	0.25	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 16.53 psi @ 450 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.125	1.625

UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Pad to shell fillet (Leg ₄₂)	0.25	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Seismic Code

Building Code: UBC 1997 building mounted		
Seismic Zone	1	
R _p Factor (Table 16-O), R _p	3.0000	
Soil profile (Table 16-Q)	SD	
Importance Factor, I _p	1.0000	
Component Amplification Factor, a _p	1.0000	
x/h Ratio	1.0000	
Vertical Accelerations Considered	Yes	
Force Multiplier	0.3333	
Minimum Weight Multiplier	0.2000	
Vessel Characteristics		
Height	19.1654 ft	
Weight	Operating, Corroded	72,769 lb
	Empty, Corroded	17,385 lb
	Vacuum, Corroded	72,769 lb
Period of Vibration Calculation		
Fundamental Period, T	Operating, Corroded	0.334 sec (f = 3.0 Hz)
	Empty, Corroded	0.161 sec (f = 6.2 Hz)
	Vacuum, Corroded	0.334 sec (f = 3.0 Hz)

The fundamental period of vibration T (above) is calculated using the Rayleigh method of approximation

$T = 2 * \text{PI} * \text{Sqr}(\{\text{Sum}(W_i * y_i^2)\} / \{g * \text{Sum}(W_i * y_i)\})$, where

W_i is the weight of the ith lumped mass, and
y_i is its deflection when the system is treated as a cantilever beam.

Seismic Shear Reports:

[Operating, Corroded](#)

[Empty, Corroded](#)

[Vacuum, Corroded](#)

[Base Shear Calculations](#)

Seismic Shear Report: Operating, Corroded					
Component	Elevation of Bottom above Base (in)	Elastic Modulus E (10 ⁶ psi)	Inertia I (ft ⁴)	Seismic Shear at Bottom (lb _f)	Bending Moment at Bottom (lb _f -ft)
TOP HEAD	203	26.1	*	1,638	5,127
Cylinder #1	131	26.1	8.9390	5,382	26,076
Cylinder #2 (top)	59	26.1	8.9390	7,771	66,074
4 PIPE LEGS	0	28.0	0.0078	8,316	106,397
Cylinder #2 (bottom)	59	26.1	8.9390	511	518
BTM HEAD	59	26.1	*	490	476
*Moment of Inertia I varies over the length of the component					

Seismic Shear Report: Empty, Corroded					
Component	Elevation of Bottom above Base (in)	Elastic Modulus E (10 ⁶ psi)	Inertia I (ft ⁴)	Seismic Shear at Bottom (lb _f)	Bending Moment at Bottom (lb _f -ft)
TOP HEAD	203	28.3	*	1,289	4,438
Cylinder #1	131	28.3	8.9390	1,625	13,261
Cylinder #2 (top)	59	28.3	8.9390	1,879	23,881
4 PIPE LEGS	0	28.0	0.0078	1,987	33,501
Cylinder #2 (bottom)	59	28.3	8.9390	81	110
BTM HEAD	59	28.3	*	79	103
*Moment of Inertia I varies over the length of the component					

Seismic Shear Report: Vacuum, Corroded					
Component	Elevation of Bottom above Base (in)	Elastic Modulus E (10 ⁶ psi)	Inertia I (ft ⁴)	Seismic Shear at Bottom (lb _f)	Bending Moment at Bottom (lb _f -ft)
TOP HEAD	203	26.1	*	1,638	5,127
Cylinder #1	131	26.1	8.9390	5,382	26,076
Cylinder #2 (top)	59	26.1	8.9390	7,771	66,074
4 PIPE LEGS	0	28.0	0.0078	8,316	106,397
Cylinder #2 (bottom)	59	26.1	8.9390	511	518
BTM HEAD	59	26.1	*	490	476
*Moment of Inertia I varies over the length of the component					

Vertical Acceleration Term, V_{Accel}				
Factor is applied to dead load.				
Compressive Side:		$= 1.0 + V_{Accel}$		
V_{Accel} Term is: greater of (Force Mult * Base Shear / Weight) or (Min. Weight Mult.)				
Force multiplier = 0.3333		Minimum Weight Multiplier = 0.2000		
Condition	Base Shear (lb _f)	Weight (lb)	Force Mult * Shear Weight	V_{Accel}
Operating, Corroded	8,316	72,768.9	0.0381	0.2
Operating, New	8,452	73,952.5	0.0381	0.2
Empty, Corroded	1,987	17,384.7	0.0381	0.2
Empty, New	2,139	18,718.8	0.0381	0.2
Vacuum, Corroded	8,316	72,768.9	0.0381	0.2

Base Shear Calculations

[Operating, Corroded](#)
[Empty, Corroded](#)
[Vacuum, Corroded](#)

Base Shear Calculations: Operating, Corroded

$$V(32-1) = 4 * C_a * I_p * W_p = 4 * 0.1200 * 1.0000 * 72,768.9219 = 34,929.0820$$

$$V(32-2) = a_p * C_a * I_p * (1 + 3 * (x/h)) * W_p / R_p = 1.0000 * 0.1200 * 1.0000 * (1 + 3 * 1.0000) * 72,768.9219 / 3.0000 = 11,643.0273$$

$$V(32-3) = 0.70 * C_a * I_p * W_p = 0.7 * 0.1200 * 1.0000 * 72,768.9219 = 6,112.5894$$

To obtain V, take the greater of V(32-2) and V(32-3).

Then take the lesser of this and V(32-1), and divide by 1.4, giving 8,316.45 lb

Base Shear Calculations: Empty, Corroded

$$V(32-1) = 4 * C_a * I_p * W_p = 4 * 0.1200 * 1.0000 * 17,384.6543 = 8,344.6338$$

$$V(32-2) = a_p * C_a * I_p * (1 + 3 * (x/h)) * W_p / R_p = 1.0000 * 0.1200 * 1.0000 * (1 + 3 * 1.0000) * 17,384.6543 / 3.0000 = 2,781.5447$$

$$V(32-3) = 0.70 * C_a * I_p * W_p = 0.7 * 0.1200 * 1.0000 * 17,384.6543 = 1,460.3110$$

To obtain V, take the greater of V(32-2) and V(32-3).

Then take the lesser of this and V(32-1), and divide by 1.4, giving 1,986.82 lb

Base Shear Calculations: Vacuum, Corroded

$$V(32-1) = 4 * C_a * I_p * W_p = 4 * 0.1200 * 1.0000 * 72,768.9219 = 34,929.0820$$

$$V(32-2) = a_p * C_a * I_p * (1 + 3 * (x/h)) * W_p / R_p = 1.0000 * 0.1200 * 1.0000 * (1 + 3 * 1.0000) * 72,768.9219 / 3.0000 = 11,643.0273$$

$$V(32-3) = 0.70 * C_a * I_p * W_p = 0.7 * 0.1200 * 1.0000 * 72,768.9219 = 6,112.5894$$

To obtain V, take the greater of V(32-2) and V(32-3).

Then take the lesser of this and V(32-1), and divide by 1.4, giving 8,316.45 lb

AGITATOR

ASME Section VIII Division 1, 2013 Edition	
Inputs	
Load Orientation	Vertical Load
Elevation Above Datum	172"
Direction Angle	0.00°
Distance from Center of Vessel	0"
Magnitude of Force	4,760 lb
Loading Conditions	
Present When Operating	Yes
Included in Vessel Lift Weight	No
Present When Vessel is Empty	Yes
Present During Hydrotest	Yes

BAFFLES AND COIL

ASME Section VIII Division 1, 2013 Edition	
Inputs	
Load Orientation	Vertical Load
Elevation Above Datum	70"
Direction Angle	0.00°
Distance from Center of Vessel	0"
Magnitude of Force	750 lb
Loading Conditions	
Present When Operating	Yes
Included in Vessel Lift Weight	Yes
Present When Vessel is Empty	Yes
Present During Hydrotest	Yes