

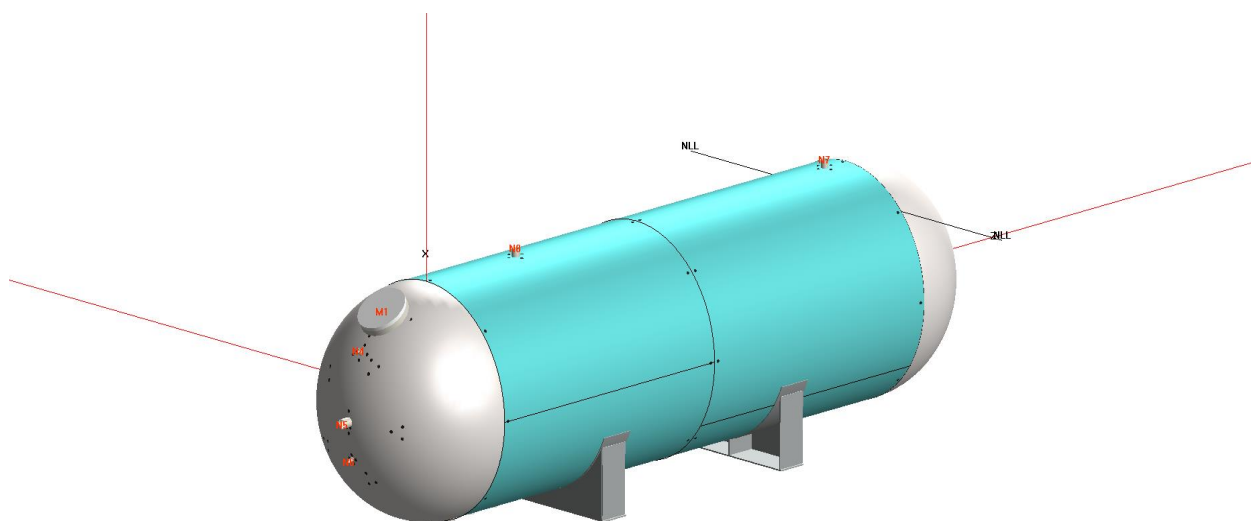
INSPECTRA S.R.L.

Calle Sandía 2500

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Santa Cruz de la Sierra

Bolivia



N. Trabajo 116-18-T-C

Vessel N° GLP-V-09

Número Documento MV-V-09/01

Revisión: 0

Cliente: YPFB TRANSPORTE S.A.

Diseñado por: Ingeniería Inspectra S.R.L.

Fecha: miércoles, abril 10, 2019

VALORIZACIÓN

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Deficiencies Summary

Deficiencies for [Alivio de presión \(N7\)](#)

Nozzle MAWP (173.48 psi) is less than the design pressure (250 psi).
UG-37: Not adequately reinforced (Internal Pressure)

Deficiencies for [Alivio de presión \(N8\)](#)

Nozzle MAWP (167.98 psi) is less than the design pressure (250 psi).
UG-37: Not adequately reinforced (Internal Pressure)
The inner fillet weld ($Leg_{41} = 0.1969$ in) is less than the minimum of 0.31 in.

Deficiencies for [C-01](#)

The nominal thickness (0.29") is less than the design thickness (0.3284").

Deficiencies for [C-02](#)

The nominal thickness (0.3028") is less than the design thickness (0.3284").

Deficiencies for [Compensación \(N3\)](#)

Nozzle MAWP (161.45 psi) is less than the design pressure (250 psi).
Required thickness t_r for the input nozzle pressure exceeds the user defined local vessel wall thickness. (Internal Pressure)
UG-37: Not adequately reinforced (Internal Pressure)
The inner fillet weld ($Leg_{41} = 0.2362$ in) is less than the minimum of 0.31 in.

Deficiencies for [Entrada de Inspección \(M1\)](#)

Nozzle MAWP (243.52 psi) is less than the design pressure (250 psi).
UG-37: Not adequately reinforced (Internal Pressure)
The inner fillet weld ($Leg_{41} = 0.315$ in) is less than the minimum of 0.3202 in.

Deficiencies for [Entrada PVT \(N1\)](#)

Nozzle MAWP (236.08 psi) is less than the design pressure (250 psi).
Required thickness t_r for the input nozzle pressure exceeds the user defined local vessel wall thickness. (Internal Pressure)
UG-37: Not adequately reinforced (Internal Pressure)
The inner fillet weld ($Leg_{41} = 0.2362$ in) is less than the minimum of 0.3571 in.

Deficiencies for [Indicador de Presión \(N4\)](#)

The inner fillet weld ($Leg_{41} = 0.2362$ in) is less than the minimum of 0.317 in.

Deficiencies for [PT \(Cuna 1 v 2\)](#)

The base plate thickness is not adequate.
Anchor bolting is not adequate.

Deficiencies for [Salida \(N2\)](#)

Nozzle MAWP (158.97 psi) is less than the design pressure (250 psi).
Required thickness t_r for the input nozzle pressure exceeds the user defined local vessel wall thickness. (Internal Pressure)
UG-37: Not adequately reinforced (Internal Pressure)
The inner fillet weld ($Leg_{41} = 0.1969$ in) is less than the minimum of 0.31 in.

Deficiencies for [V-01](#)

The nominal thickness (0.538") is less than the design thickness (0.5739").

Deficiencies for [V-02](#)

The nominal thickness (0.572") is less than the design thickness (0.5739").

Deficiencies for [Welded Cover #1](#)

Figure UW-13.2: Weld bevel depth ($b = 1.2016$ in) is less than minimum of 2.3425 in.
The flat head thickness (1.4516") is not sufficient to accommodate the minimum weld bevel b (2.3425") plus the minimum t_p (0.25").

VALORIZACIÓN

Calculation Results Summary, API 510 10th Edition, May 2017 Addendum			
Projected Retirement Date:		Governing Component:	Salida (N2)
Governing CML:	CML 113 on V-01	Projected Thickness at Retirement Date:	0.538"
Target MAWP:	250 psi @ 125 °F	Target MAEP:	N/A

Equipment Information	
Vessel Name:	MV-V-09_01 Rev 0

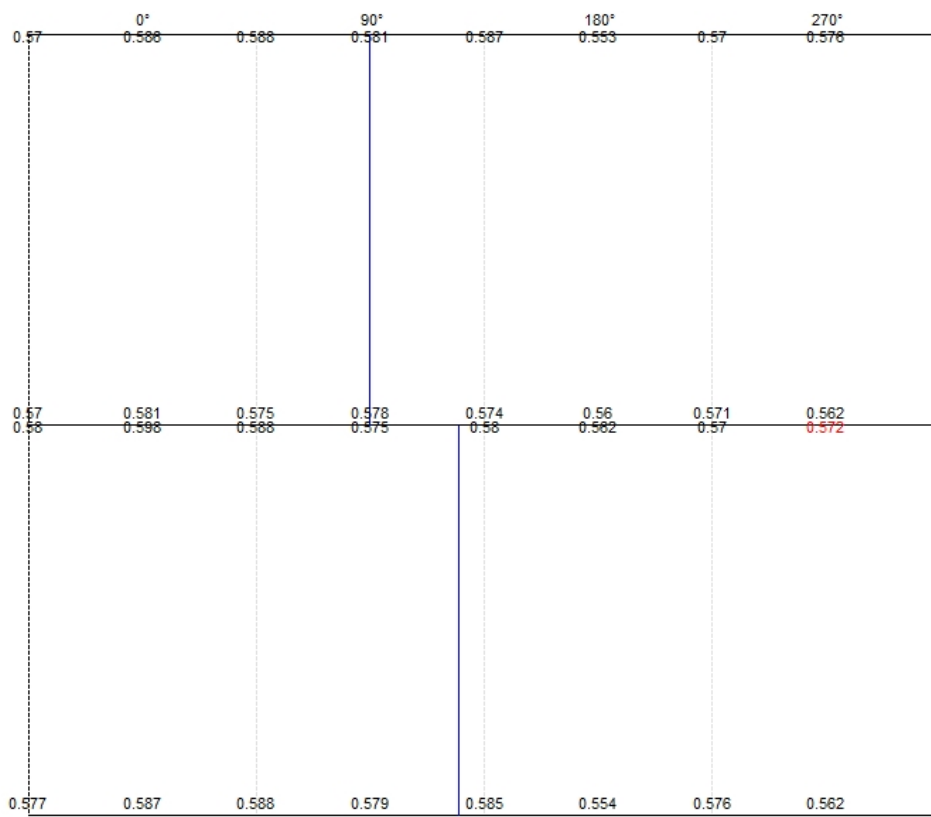
Summary of Thickness Measurements								
Component	Previous Average Thickness (in)	Average Measured Thickness (in)	Governing CML Thickness (in)	Minimum Required Thickness (in)	Short Term Corrosion Rate (in / year)	Long Term Corrosion Rate (in / year)	Remaining Life (years)	Governing Component
C-01	0.328	0.3265	0.29	0.2794	0.000849	0.000849	12.49	No
V-01	0.573	0.5648	0.538	0.5739	0.000782	0.000782	-45.927	No
V-02	0.573	0.5781	0.572	0.5739	0.000022	0.000022	-85.073	No
C-02	0.328	0.3207	0.3028	0.2794	0.000563	0.000563	41.577	No

The Previous Average Thickness is average measured thickness from the previous thickness inspection of each component.

Inspection on 10-04-2019			
Inspection Date:	10-04-2019	Report Date:	10-04-2019
Inspection Name:	VALORIZACIÓN	Inspector Name:	Oliver Añez
Inspection Company:	Inspectra SRL	Service:	Gas service
Inspections Performed			
Visual Inspection(VT): External	YES	Visual Inspection(VT): Internal	NO
Thickness Inspection:	YES		

Shell Courses						
Course	ID	Course Length	Allowable Stress	Joint Efficiency (circ, long)	Actual Thickness	Required Thickness
1	V-01	113.1496" - 0"	18,300 psi	1, 1	0.538"	0.5739"
2	V-02	226.2992" - 113.1496"	18,300 psi	1, 1	0.572"	0.5739"

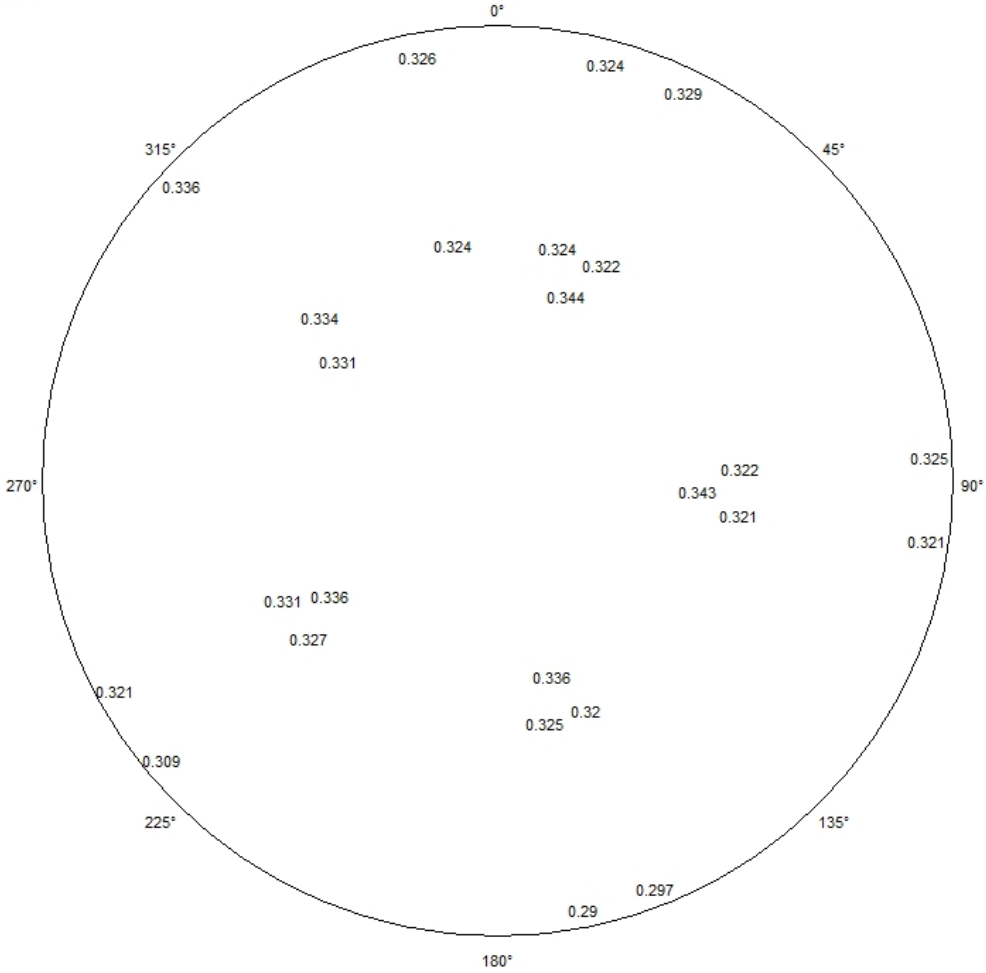
Shell Measured Thickness								
	0 deg	45 deg	90 deg	135 deg	180 deg	225 deg	270 deg	315 deg
1.9685"	0.5855"	0.5876"	0.5808"	0.5874"	0.5529"	0.5699"	0.5756"	0.5697"
111.1811"	0.5809"	0.5749"	0.5778"	0.5743"	0.5603"	0.5713"	0.5621"	0.5702"
115.1181"	0.5982"	0.588"	0.5746"	0.5796"	0.5624"	0.5699"	0.572"	0.5802"
224.3307"	0.5873"	0.5883"	0.5789"	0.5846"	0.554"	0.5757"	0.5615"	0.5769"

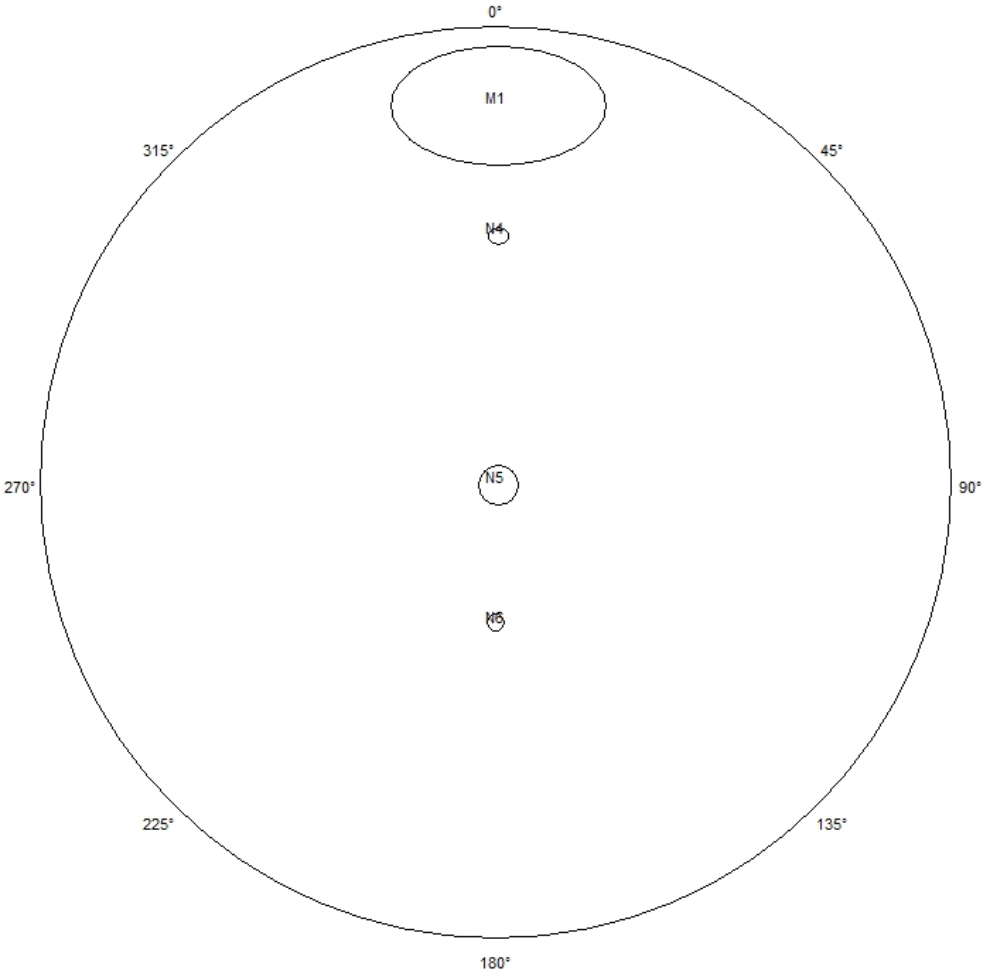


0°	90°	180°	270°
N8 8		N1 1 N2 2 N3 3	
L8 8			

C-01 Measured Thickness															
	14.5 deg	20 deg	25.5 deg	86.5 deg	92 deg	97.5 deg	158.5 deg	164 deg	168.5 deg	230.5 deg	236 deg	241.5 deg	308 deg	313.5 deg	349.5 deg
40.0394"	0.3241"		0.3289"	0.3246"		0.3213"	0.2965"		0.29"	0.3091"		0.321"		0.3359"	0.3257"
22.4409"	0.3239"		0.3217"	0.322"		0.3207"	0.32"		0.3248"	0.3272"		0.3312"		0.3344"	0.3243"
18.5039"		0.3442"			0.3434"			0.3358"			0.3358"		0.3308"		

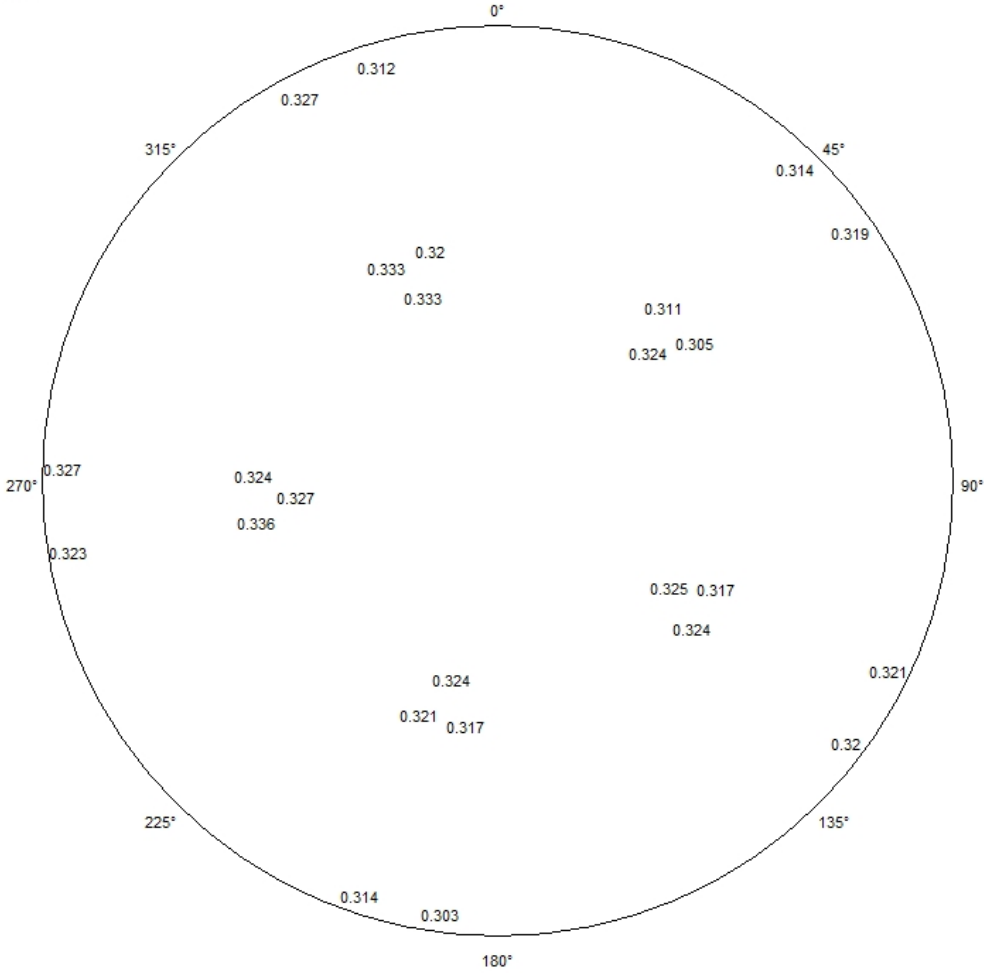
C-01





C-02 Measured Thickness															
	43.5 deg	49 deg	54.5 deg	115.5 deg	121 deg	126.5 deg	187.5 deg	193 deg	198.5 deg	261 deg	266.5 deg	272 deg	333 deg	338.5 deg	344 deg
40.0394"	0.3136"		0.3192"	0.3209"		0.3198"	0.3028"		0.3135"	0.323"		0.3272"	0.3269"		0.3115"
22.4409"	0.3114"		0.3045"	0.3169"		0.3235"	0.3171"		0.3213"	0.3355"		0.3239"	0.3327"		0.3202"
18.5039"		0.3241"			0.3254"			0.3241"			0.3269"			0.3327"	

C-02



Nozzle Local Shell Readings						
	Parent	Dist from Nozzle OD	0 deg	90 deg	180 deg	270 deg
M1	C-01	1.9685"	0.3224"	0.3229"	0.3205"	0.3202"
N4	C-01	1.9685"	0.317"	0.3192"	0.3198"	0.3213"
N5	C-01	1.9685"	0.3406"	0.3394"	0.338"	0.3361"
N6	C-01	1"	0.3378"	0.34"	0.3333"	0.3394"
N3	V-01	1.9685"	0.5528"	0.5483"	0.5429"	0.5426"
N8	V-01	1.9685"	0.5875"	0.5741"	0.5781"	0.5734"
N1	V-01	1.9685"	0.5428"	0.566"	0.5423"	0.5431"
N2	V-01	1.9685"	0.538"	0.5518"	0.538"	0.5691"
N7	V-02	1.9685"	0.5819"	0.5745"	0.5855"	0.5871"

Shell Details							
Component	Measured Thickness	Min. Required Thickness	Length	Rem Corr.	Governs	Corr. Allow	Material
V-01	0.538"	0.5739"	113.1496"	-0.0359"	No	0"	SA-455
V-02	0.572"	0.5739"	113.1496"	-0.0019"	No	0"	SA-455

Head Details						
Component	Measured Thickness	Min. Required Thickness	Rem Corr.	Governs	Corr. Allow	Material
C-01	0.29"	0.2794"	0.0106"	No	0"	SA-455
C-02	0.3028"	0.2794"	0.0234"	No	0"	SA-455

The Remaining Life Calculations failed.

*Insufficient MAWP on Salida (N2).

Salida (N2) has no thickness measurements, so it was evaluated at its nominal thickness.

Engineering Notes

1. Dado que la entrada de hombre no es de tamaño estandar, se ha modelado con un cuello de las mismas dimensiones de la instalada y una tapa soldada con aceros SA105. El software no acepta tapas tipo studbolt no estandar.
2. No es posible con el software espaciar los refuerzos de las cunas de forma que no sea regular.
3. No es posible modelar placas de soporte que no sean rectangulares con el software
4. La deficiencia que se presenta sobre la la entrada de inspección M1 donde obliga realizar PWHT, no es válida dado que se ha colocado esta entrada de inspección hecha de tubo, manulamente, porque las dimensiones no son estándar, y este tipo de accesorios forjados se fabrican sin costura.

Nozzle Schedule

Specifications									
Nozzle mark	Identifier	Size	Materials		Impact Tested	Normalized	Fine Grain	Flange	Blind
M1	Entrada de Inspección	19.685 OD x 2.3425	Nozzle	SA-105	No	No	No	N/A	No
	Welded Cover #1	ID = 15" x Thk = 1.4516"	Welded Cover	SA-105	No	No	No	N/A	N/A
N1	Entrada PVT	NPS 3 Class 6000 - Threaded Full Coupling	Nozzle	SA-105	No	No	No	N/A	No
N2	Salida	NPS 2 Class 3000 - Threaded Full Coupling	Nozzle	SA-105	No	No	No	N/A	No
N3	Compensación	NPS 2 Class 3000 - Threaded Full Coupling	Nozzle	SA-105	No	No	No	N/A	No
N4	Indicador de Presión	NPS 0.75 Class 6000 - Threaded Full Coupling	Nozzle	SA-105	No	No	No	N/A	No
N5	Indicador de Nivel	NPS 2.5 Class 3000 - Threaded Full Coupling	Nozzle	SA-105	No	No	No	N/A	No
N6	Indicador de Temperatura	NPS 0.75 Class 3000 - Threaded Full Coupling	Nozzle	SA-105	No	No	No	N/A	No
N7	Alivio de presión	NPS 2 Class 3000 - Threaded Full Coupling	Nozzle	SA-105	No	No	No	N/A	No
N8	Alivio de presión	NPS 2 Class 3000 - Threaded Full Coupling	Nozzle	SA-105	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 _d /A _r (%)
						Nom t (in)	Design t (in)	User t (in)	Width (in)	t _{pad} (in)		
M1	19.685	2.3425	0.2709	Yes	Yes	0.29*	0.2709	0.3202	N/A	N/A	0	100.0
N1	5	0.75	0.0625	Yes	Yes	0.538	0.5423	0.5423	N/A	N/A	0	100.1
N2	3	0.31	0.0625	Yes	Yes	0.538	0.3668	0.538	N/A	N/A	0	100.0
N3	3	0.31	0.0625	Yes	Yes	0.538	0.3725	0.5426	N/A	N/A	0	100.0
N4	1.75	0.345	0.0625	Yes	Yes	0.29*	N/A	0.317	N/A	N/A	0	Exempt
N5	3.62	0.37	0.0625	Yes	Yes	0.29*	N/A	0.3361	N/A	N/A	0	Exempt
N6	1.38	0.16	0.0625	Yes	Yes	0.29*	N/A	0.3333	N/A	N/A	0	Exempt
N7	3	0.31	0.0625	Yes	Yes	0.572	0.3967	0.5745	N/A	N/A	0	100.0
N8	3	0.31	0.0625	Yes	Yes	0.538	0.3842	0.5734	N/A	N/A	0	100.0
*Head minimum thickness after forming												

Definitions	
tn	Nozzle thickness
Req tn	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)	MDMT (°F)	MDMT Exemption	Impact Tested
C-01	250	125	220.48	N/A	N/A	No
V-01	250	125	234.2	N/A	N/A	No
V-02	250	125	249.17	N/A	N/A	No
C-02	250	125	230.32	N/A	N/A	No
PT (Cuna 1 v 2)	250	125	158.97	N/A	N/A	N/A
Entrada de Inspección (M1)	250	125	243.52	N/A	N/A	No
Welded Cover #1	250	125	496.62	N/A	N/A	No
Entrada PVT (N1)	250	125	236.08	N/A	N/A	No
Salida (N2)	250	125	158.97	N/A	N/A	No
Compensación (N3)	250	125	161.45	N/A	N/A	No
Indicador de Presión (N4)	250	125	285.15	N/A	N/A	No
Indicador de Nivel (N5)	250	125	301.86	N/A	N/A	No
Indicador de Temperatura (N6)	250	125	299.09	N/A	N/A	No
Alivio de presión (N7)	250	125	173.48	N/A	N/A	No
Alivio de presión (N8)	250	125	167.98	N/A	N/A	No

Chamber Summary	
MAWP hot & corroded	158.97 psi @ 125 °F
(1) This pressure chamber is not designed for external pressure.	

Settings Summary

INSPECT 2019 Build 7900	
ASME Section VIII Division 1, 1995 Edition	
Vessel calculations are based on the projected corroded state of the vessel at the date of the inspection on 10-04-2019	
Units	U.S. Customary
Datum Line Location	0.00" from left seam
Vessel Design Mode	Rating Mode (Analysis)
Minimum thickness	0.0625" per UG-16(b)
Design for cold shut down only	No
Design for lethal service (full radiography required)	No
User has limited MAWP to	250 psi
Design nozzles for	Design P only
Corrosion weight loss	100% of theoretical loss
UG-23 Stress Increase	1.20
Skirt/legs stress increase	1.0
Minimum nozzle projection	0.25"
Juncture calculations for $\alpha > 30$ only	Yes
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	Yes
Nozzles made from pipe are entered as minimum thickness	Yes
ASME B16.9 fittings are entered as minimum thickness	Yes
Butt welds	Tapered per Figure UCS-66.3(a)
Disallow Appendix 1-5, 1-8 calculations under 15 psi	No
Hydro/Pneumatic Test	
Maximum stress during test	90% of yield
Required Marking - UG-116	
UG-116(e) Radiography	RT4
UG-116(f) Postweld heat treatment	None
Code Cases/Interpretations	
Use Code Case 2901	No
Apply interpretation VIII-1-83-66	No
Apply interpretation VIII-1-86-175	No
Apply interpretation VIII-1-83-115	No
Use Code Case 2236 if opening fails 1-7(b)	No
Apply interpretation VIII-1-01-37	No
Apply interpretation VIII-1-04-08	No
Apply interpretation VIII-1-01-150	No
Apply interpretation VIII-1-16-85	No
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)	No
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	No
Note: UG-22(b),(c) and (f) loads only considered when supports are present.	

License Information	
Company Name	Inspectra S.r.l.
License	Enterprise
License Key ID	38243
Support Expires	octubre 15, 2019

Radiography Summary

UG-116 Radiography							
Component	Longitudinal Seam		Left Circumferential Seam		Right Circumferential Seam		Mark
	Category (Fig UW-3)	Radiography / Joint Type	Category (Fig UW-3)	Radiography / Joint Type	Category (Fig UW-3)	Radiography / Joint Type	
C-01	A	Spot UW-11(b) / Type 1	N/A	N/A	A	Full UW-11(a) / Type 1	RT4
Welded Cover #1	N/A	Seamless No RT	N/A	N/A	N/A	N/A	N/A
V-01	A	Full UW-11(a) / Type 1	A	Full UW-11(a) / Type 1	B	Full UW-11(a) / Type 1	RT1
V-02	A	Full UW-11(a) / Type 1	B	Full UW-11(a) / Type 1	A	Full UW-11(a) / Type 1	RT1
C-02	A	Spot UW-11(b) / Type 1	A	Full UW-11(a) / Type 1	N/A	N/A	RT4
Nozzle	Longitudinal Seam		Nozzle to Vessel Circumferential Seam		Nozzle free end Circumferential Seam		
Entrada de Inspección (M1)	N/A	Seamless No RT	D	N/A / Type 7	B	N/A	N/A
Indicador de Presión (N4)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
Indicador de Nivel (N5)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
Indicador de Temperatura (N6)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
Compensación (N3)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
Alivio de presión (N8)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
Entrada PVT (N1)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
Salida (N2)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
Alivio de presión (N7)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
UG-116(e) Required Marking: RT4							

Thickness Summary

Component Data								
Component Identifier	Material	Diameter (in)	Length (in)	Nominal t (in)	Design t (in)	Total Corrosion (in)	Joint E	Load
C-01	SA-455 <= 3/8	84.0157 OD	42.0079	0.29*	0.3284	0	0.85	Internal
V-01	SA-455 (3/8 < t <= 5/8)	84.0157 OD	113.1496	0.538	0.5739	0	1.00	Internal
V-02	SA-455 (3/8 < t <= 5/8)	84.0157 OD	113.1496	0.572	0.5739	0	1.00	Internal
C-02	SA-455 <= 3/8	84.0157 OD	42.0079	0.3028*	0.3284	0	0.85	Internal
Welded Cover #1	SA-105	15 ID	1.4516	1.4516	1.0299	0	1.00	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 ft²
							New	Corroded	New	Corroded	
C-01	877.6	877.6	0	0	0	0	2,782.6	2,782.6	5,495.4	5,495.4	75
V-01	4,511.7	4,511.7	0	0	0	0	10,825.1	10,825.1	22,069.5	22,069.5	207
V-02	4,800.4	4,800.4	0	0	0	0	10,809.2	10,809.2	22,031.1	22,031.1	207
C-02	943.3	943.3	0	0	0	0	2,779.7	2,779.7	5,484	5,484	77
PT (Cuna 1 v 2)	886	886	0	0	0	0	0	0	0	0	77
TOTAL:	12,019	12,019	0	0	0	0	27,196.6	27,196.6	55,080	55,080	644

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

*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	Trays	Tray Supports	Rings & Clips	Vertical Loads	Surface Area ft²
	New	Corroded	New	Corroded						
C-01	0	0	219.7	219.7	0	0	0	0	0	4
V-01	0	0	19.4	19.4	0	0	0	0	0	1
V-02	0	0	2.5	2.5	0	0	0	0	0	0
C-02	0	0	0	0	0	0	0	0	0	0
TOTAL:	0	0	241.6	241.6	0	0	0	0	0	5

Vessel Totals		
	New	Corroded
Operating Weight (lb)	39,457	39,457
Empty Weight (lb)	12,261	12,261
Test Weight (lb)	67,341	67,341
Surface Area (ft²)	648	-
Capacity** (US gal)	6,604	6,604
**The vessel capacity does not include volume of nozzle, piping or other attachments.		

Vessel Lift Condition	
Vessel Lift Weight, New (lb)	12,261
Center of Gravity from Datum (in)	112.5687

Test Report

The shop test condition has not been investigated.

The field test condition has not been investigated.

ASME Section VIII Division 1, 1995 Edition				
Component		Hemispherical Head		
Material		SA-455 <= 3/8 (II-D p. 22, ln. 21)		
Attached To		V-01		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Maximize MDMT/ No MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		250	125	6
Static Liquid Head				
Condition		P _s (psi)	H _s (in)	SG
Operating		1.38	71.4686	0.5368
Dimensions				
Outer Diameter		84.0157"		
Minimum Thickness		0.29"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		Capacity (US gal)
New		877.56		658.28
Corroded		877.56		658.28
Radiography				
Category A joints - Long Seam		Spot UW-11(b) Type 1		
Category A joints - Circ Seam		Full UW-11(a) Type 1		

Results Summary	
Governing condition	Internal pressure
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	0.3284"
Maximum allowable working pressure (MAWP)	220.48 psi

Design thickness, (at 125 °F) Appendix 1-1

$$\begin{aligned}
 t &= P \cdot R_o / (2 \cdot S \cdot E + 0.80 \cdot P) + \text{Corrosion} \\
 &= 251.38 \cdot 42.0079 / (2 \cdot 18,800 \cdot 0.85 + 0.80 \cdot 251.38) + 0 \\
 &= \underline{0.3284"}
 \end{aligned}$$

Maximum allowable working pressure, (at 125 °F) Appendix 1-1

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (R_o - 0.80 \cdot t) - P_s \\
 &= 2 \cdot 18,800 \cdot 0.85 \cdot 0.29 / (42.0079 - 0.80 \cdot 0.29) - 1.38 \\
 &= \underline{220.48 \text{ psi}}
 \end{aligned}$$

% Extreme fiber elongation - UCS-79(d)

$$\begin{aligned}
 \text{EFE} &= (75 \cdot t / R_o) \cdot (1 - R_i / R_o) \\
 &= (75 \cdot 0.29 / 41.8629) \cdot (1 - 41.8629 / \text{infinity}) \\
 &= 0.5196\%
 \end{aligned}$$

The extreme fiber elongation does not exceed 5%.

Allowable Compressive Stress, Hot and Corroded- S_{cHC} , (table CS-2)

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.29) \\ &= 0.000863 \\ B &= 11,656 \text{ psi} \\ S &= 18,800 / 1.00 = 18,800 \text{ psi} \\ S_{cHC} &= \min(B, S) = 11,656 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Hot and New- S_{cHN}

$$\begin{aligned} S_{cHN} &= S_{cHC} \\ &= 11,656 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Cold and New- S_{cCN} , (table CS-2)

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.29) \\ &= 0.000863 \\ B &= 11,656 \text{ psi} \\ S &= 18,800 / 1.00 = 18,800 \text{ psi} \\ S_{cCN} &= \min(B, S) = 11,656 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Cold and Corroded- S_{cCC}

$$\begin{aligned} S_{cCC} &= S_{cCN} \\ &= 11,656 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Vacuum and Corroded- S_{cVC} , (table CS-2)

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.29) \\ &= 0.000863 \\ B &= 11,656 \text{ psi} \\ S &= 18,800 / 1.00 = 18,800 \text{ psi} \\ S_{cVC} &= \min(B, S) = 11,656 \text{ psi} \end{aligned}$$

ASME Section VIII Division 1, 1995 Edition				
Component		Hemispherical Head		
Material		SA-455 <= 3/8 (II-D p. 22, ln. 21)		
Attached To		V-02		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Maximize MDMT/ No MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		250	125	6
Static Liquid Head				
Condition		P _s (psi)	H _s (in)	SG
Operating		1.38	71.4558	0.5368
Dimensions				
Outer Diameter		84.0157"		
Minimum Thickness		0.3028"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		Capacity (US gal)
New		943.3		657.68
Corroded		943.3		657.68
Radiography				
Category A joints - Long Seam		Spot UW-11(b) Type 1		
Category A joints - Circ Seam		Full UW-11(a) Type 1		

Results Summary	
Governing condition	Internal pressure
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	<u>0.3284"</u>
Maximum allowable working pressure (MAWP)	<u>230.32 psi</u>

Design thickness, (at 125 °F) Appendix 1-1

$$\begin{aligned}
 t &= P \cdot R_o / (2 \cdot S \cdot E + 0.80 \cdot P) + \text{Corrosion} \\
 &= 251.38 \cdot 42.0079 / (2 \cdot 18,800 \cdot 0.85 + 0.80 \cdot 251.38) + 0 \\
 &= \underline{0.3284"}
 \end{aligned}$$

Maximum allowable working pressure, (at 125 °F) Appendix 1-1

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (R_o - 0.80 \cdot t) - P_s \\
 &= 2 \cdot 18,800 \cdot 0.85 \cdot 0.3028 / (42.0079 - 0.80 \cdot 0.3028) - 1.38 \\
 &= \underline{230.32 \text{ psi}}
 \end{aligned}$$

% Extreme fiber elongation - UCS-79(d)

$$\begin{aligned}
 EFE &= (75 \cdot t / R_o) \cdot (1 - R_t / R_o) \\
 &= (75 \cdot 0.3028 / 41.8565) \cdot (1 - 41.8565 / \text{infinity}) \\
 &= 0.5426\%
 \end{aligned}$$

The extreme fiber elongation does not exceed 5%.

Allowable Compressive Stress, Hot and Corroded- S_{cHC} , (table CS-2)

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.3028) \\ &= 0.000901 \\ B &= 11,805 \text{ psi} \\ S &= 18,800 / 1.00 = 18,800 \text{ psi} \\ S_{cHC} &= \min(B, S) = 11,805 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Hot and New- S_{cHN}

$$\begin{aligned} S_{cHN} &= S_{cHC} \\ &= 11,805 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Cold and New- S_{cCN} , (table CS-2)

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.3028) \\ &= 0.000901 \\ B &= 11,805 \text{ psi} \\ S &= 18,800 / 1.00 = 18,800 \text{ psi} \\ S_{cCN} &= \min(B, S) = 11,805 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Cold and Corroded- S_{cCC}

$$\begin{aligned} S_{cCC} &= S_{cCN} \\ &= 11,805 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Vacuum and Corroded- S_{cVC} , (table CS-2)

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.3028) \\ &= 0.000901 \\ B &= 11,805 \text{ psi} \\ S &= 18,800 / 1.00 = 18,800 \text{ psi} \\ S_{cVC} &= \min(B, S) = 11,805 \text{ psi} \end{aligned}$$

ASME Section VIII Division 1, 1995 Edition				
Component		Cylinder		
Material		SA-455 (3/8 < t <= 5/8) (II-D p. 22, ln. 16)		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Maximize MDMT/ No MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		250	125	6
Static Liquid Head				
Condition		P _s (psi)	H _s (in)	SG
Operating		1.38	71.2206	0.5368
Dimensions				
Outer Diameter		84.0157"		
Length		113.1496"		
Nominal Thickness		0.538"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		Capacity (US gal)
New		4,511.74		2,646.41
Corroded		4,511.74		2,646.41
Radiography				
Longitudinal seam		Full UW-11(a) Type 1		
Left Circumferential seam		Full UW-11(a) Type 1		
Right Circumferential seam		Full UW-11(a) Type 1		

Results Summary	
Governing condition	Internal pressure
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	0.5739"
Maximum allowable working pressure (MAWP)	234.2 psi

Design thickness, (at 125 °F) Appendix 1-1

$$\begin{aligned}
 t &= P \cdot R_o / (S \cdot E + 0.40 \cdot P) + \text{Corrosion} \\
 &= 251.38 \cdot 42.0079 / (18,300 \cdot 1.00 + 0.40 \cdot 251.38) + 0 \\
 &= \text{0.5739"}
 \end{aligned}$$

Maximum allowable working pressure, (at 125 °F) Appendix 1-1

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R_o - 0.40 \cdot t) - P_s \\
 &= 18,300 \cdot 1.00 \cdot 0.538 / (42.0079 - 0.40 \cdot 0.538) - 1.38 \\
 &= \text{234.2 psi}
 \end{aligned}$$

% Extreme fiber elongation - UCS-79(d)

$$\begin{aligned}
 \text{EFE} &= (50 \cdot t / R_p) \cdot (1 - R_f / R_o) \\
 &= (50 \cdot 0.538 / 41.7389) \cdot (1 - 41.7389 / \text{infinity}) \\
 &= 0.6445\%
 \end{aligned}$$

The extreme fiber elongation does not exceed 5%.

Allowable Compressive Stress, Hot and Corroded- S_{cHC} , (table CS-2)

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.538) \\ &= 0.001601 \\ B &= 14,074 \text{ psi} \\ S &= 18,300 / 1.00 = 18,300 \text{ psi} \\ S_{cHC} &= \min(B, S) = 14,074 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Hot and New- S_{cHN}

$$\begin{aligned} S_{cHN} &= S_{cHC} \\ &= 14,074 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Cold and New- S_{cCN} , (table CS-2)

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.538) \\ &= 0.001601 \\ B &= 14,074 \text{ psi} \\ S &= 18,300 / 1.00 = 18,300 \text{ psi} \\ S_{cCN} &= \min(B, S) = 14,074 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Cold and Corroded- S_{cCC}

$$\begin{aligned} S_{cCC} &= S_{cCN} \\ &= 14,074 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Vacuum and Corroded- S_{cVC} , (table CS-2)

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.538) \\ &= 0.001601 \\ B &= 14,074 \text{ psi} \\ S &= 18,300 / 1.00 = 18,300 \text{ psi} \\ S_{cVC} &= \min(B, S) = 14,074 \text{ psi} \end{aligned}$$

ASME Section VIII Division 1, 1995 Edition				
Component		Cylinder		
Material		SA-455 (3/8 < t <= 5/8) (II-D p. 22, ln. 16)		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Maximize MDMT/ No MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		250	125	6
Static Liquid Head				
Condition		P _s (psi)	H _s (in)	SG
Operating		1.38	71.1866	0.5368
Dimensions				
Outer Diameter		84.0157"		
Length		113.1496"		
Nominal Thickness		0.572"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		Capacity (US gal)
New		4,800.38		2,642.07
Corroded		4,800.38		2,642.07
Radiography				
Longitudinal seam		Full UW-11(a) Type 1		
Left Circumferential seam		Full UW-11(a) Type 1		
Right Circumferential seam		Full UW-11(a) Type 1		

Results Summary	
Governing condition	Internal pressure
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	0.5739"
Maximum allowable working pressure (MAWP)	249.17 psi

Design thickness, (at 125 °F) Appendix 1-1

$$\begin{aligned}
 t &= P \cdot R_o / (S \cdot E + 0.40 \cdot P) + \text{Corrosion} \\
 &= 251.38 \cdot 42.0079 / (18,300 \cdot 1.00 + 0.40 \cdot 251.38) + 0 \\
 &= \text{0.5739"}
 \end{aligned}$$

Maximum allowable working pressure, (at 125 °F) Appendix 1-1

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R_o - 0.40 \cdot t) - P_s \\
 &= 18,300 \cdot 1.00 \cdot 0.572 / (42.0079 - 0.40 \cdot 0.572) - 1.38 \\
 &= \text{249.17 psi}
 \end{aligned}$$

% Extreme fiber elongation - UCS-79(d)

$$\begin{aligned}
 \text{EFE} &= (50 \cdot t / R_p) \cdot (1 - R_f / R_o) \\
 &= (50 \cdot 0.572 / 41.7219) \cdot (1 - 41.7219 / \text{infinity}) \\
 &= 0.6855\%
 \end{aligned}$$

The extreme fiber elongation does not exceed 5%.

Allowable Compressive Stress, Hot and Corroded- S_{cHC} , (table CS-2)

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.572) \\ &= 0.001702 \\ B &= 14,323 \text{ psi} \\ S &= 18,300 / 1.00 = 18,300 \text{ psi} \\ S_{cHC} &= \min(B, S) = 14,323 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Hot and New- S_{cHN}

$$\begin{aligned} S_{cHN} &= S_{cHC} \\ &= 14,323 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Cold and New- S_{cCN} , (table CS-2)

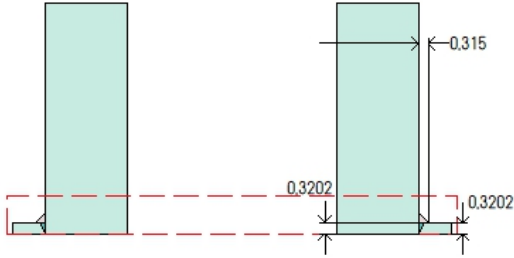
$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.572) \\ &= 0.001702 \\ B &= 14,323 \text{ psi} \\ S &= 18,300 / 1.00 = 18,300 \text{ psi} \\ S_{cCN} &= \min(B, S) = 14,323 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Cold and Corroded- S_{cCC}

$$\begin{aligned} S_{cCC} &= S_{cCN} \\ &= 14,323 \text{ psi} \end{aligned}$$

Allowable Compressive Stress, Vacuum and Corroded- S_{cVC} , (table CS-2)

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.572) \\ &= 0.001702 \\ B &= 14,323 \text{ psi} \\ S &= 18,300 / 1.00 = 18,300 \text{ psi} \\ S_{cVC} &= \min(B, S) = 14,323 \text{ psi} \end{aligned}$$

ASME Section VIII Division 1, 1995 Edition	
	
Note: round inside edges per UG-76(c)	
Location and Orientation	
Located on	C-01
Orientation	0°
End of nozzle to datum line	-23.583"
Calculated as hillside	No
Distance to head center, R	35.1575"
Passes through a Category A joint	No
Nozzle	
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 6)
Inside diameter, new	15"
Nominal wall thickness	2.3425"
Corrosion allowance	0"
Projection available outside vessel, Lpr	2.1468"
User input vessel thickness	0.3202"
Liquid static head included	0 psi
Longitudinal joint efficiency	1
Welds	
Inner fillet, Leg ₄₁	0.315"
Nozzle to vessel groove weld	0.3202"

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 250 psi @ 125 °F The opening is NOT 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}
4.2605	4.0413	0.6189	3.3301	--	--	0.0923	0.278	2.3425

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)	0.2241	0.2205	weld size is NOT adequate

Calculations for internal pressure 250 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(15, 7.5 + (2.3425 - 0) + (0.3202 - 0)) \\
 &= 15 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.3202 - 0), 2.5*(2.3425 - 0) + 0) \\
 &= 0.8005 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P*R_n / (S_n*E - 0.6*P) \\
 &= 250*7.5 / (17,500*1 - 0.6*250) \\
 &= 0.1081 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 250*42.0381 / (2*18,800*1 + 0.8*250) \\
 &= 0.278 \text{ in}
 \end{aligned}$$

Required thickness t_r per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 250*42.0381 / (2*18,800*0.85 + 0.8*250) \\
 &= 0.3268 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses: S_n = 17,500, S_v = 18,800 psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9309$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9309$$

$$\begin{aligned}
 A &= d*t_r*F + 2*t_n*t_r*F*(1 - f_{r1}) \\
 &= 15*0.278*1 + 2*2.3425*0.278*1*(1 - 0.9309) \\
 &= [4.2605](#) \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

A₁ = larger of the following= [0.6189](#) in²

$$\begin{aligned}
 &= d*(E_1*t_r - F*t_r) - 2*t_n*(E_1*t_r - F*t_r)*(1 - f_{r1}) \\
 &= 15*(1*0.3202 - 1*0.278) - 2*2.3425*(1*0.3202 - 1*0.278)*(1 - 0.9309)
 \end{aligned}$$

$$\begin{aligned}
&= 0.6189 \text{ in}^2 \\
&= 2*(t + t_n)*(E_1*t - F*t_p) - 2*t_n*(E_1*t - F*t_p)*(1 - f_{r1}) \\
&= 2*(0.3202 + 2.3425)*(1*0.3202 - 1*0.278) - 2*2.3425*(1*0.3202 - 1*0.278)*(1 - 0.9309) \\
&= 0.2109 \text{ in}^2
\end{aligned}$$

A_2 = smaller of the following= 3.3301 in²

$$\begin{aligned}
&= 5*(t_n - t_m)*f_{r2}*t \\
&= 5*(2.3425 - 0.1081)*0.9309*0.3202 \\
&= 3.3301 \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
&= 2*(t_n - t_m)*f_{r2}*L_{pr} \\
&= 2*(2.3425 - 0.1081)*0.9309*2.1468 \\
&= 8.9307 \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
A_{41} &= Leg^2*f_{r2} \\
&= 0.315^2*0.9309 \\
&= 0.0923 \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
Area &= A_1 + A_2 + A_{41} \\
&= 0.6189 + 3.3301 + 0.0923 \\
&= 4.0413 \text{ in}^2
\end{aligned}$$

**** As Area < A the reinforcement is NOT adequate. ****

UW-16(c) Weld Check

Fillet weld: t_{min} = lesser of 0.75 or t_n or $t = 0.3202$ in
 $t_{c(min)}$ = lesser of 0.25 or $0.7*t_{min} = 0.2241$ in
 $t_{c(actual)} = 0.7*Leg = 0.7*0.315 = 0.2205$ in

**** The fillet weld size IS NOT satisfactory. ****

UG-45 Nozzle Neck Thickness Check

Wall thickness per UG-45(a): $t_{r1} = 0.1081$ in ($E = 1$)
 Wall thickness per UG-45(b)(1): $t_{r2} = 0.278$ in
 Wall thickness per UG-16(b): $t_{r3} = 0.0625$ in
 Standard wall pipe per UG-45(b)(4): $t_{r4} = 0.3281$ in
 The greater of t_{r2} or t_{r3} : $t_{r5} = 0.278$ in
 The lesser of t_{r4} or t_{r5} : $t_{r6} = 0.278$ in

Required per UG-45 is the larger of t_{r1} or $t_{r6} = 0.278$ in

Available nozzle wall thickness new, $t_n = 2.3425$ in

The nozzle neck thickness 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 = 243.52 psi @ 125 °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}
4.1506	4.1508	0.7241	3.3344	--	--	0.0923	0.2709	2.3425

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)	0.2241	0.2205	weld size is NOT adequate

Calculations for internal pressure 243.52 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(15, 7.5 + (2.3425 - 0) + (0.3202 - 0)) \\
 &= 15 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_v) \\
 &= \text{MIN}(2.5*(0.3202 - 0), 2.5*(2.3425 - 0) + 0) \\
 &= 0.8005 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P*R_n / (S_n*E - 0.6*P) \\
 &= 243.5226*7.5 / (17,500*1 - 0.6*243.5226) \\
 &= 0.1052 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 243.5226*42.0381 / (2*18,800*1 + 0.8*243.5226) \\
 &= 0.2709 \text{ in}
 \end{aligned}$$

Required thickness t_r per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 243.5226*42.0381 / (2*18,800*0.85 + 0.8*243.5226) \\
 &= 0.3184 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses: S_n = 17,500, S_v = 18,800 psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9309$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9309$$

$$\begin{aligned}
 A &= d*t_r*F + 2*t_n*t_r*F*(1 - f_{r1}) \\
 &= 15*0.2709*1 + 2*2.3425*0.2709*1*(1 - 0.9309) \\
 &= [4.1506](#) \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = [0.7241](#) \text{ in}^2$$

$$\begin{aligned}
&= d^2(E_1 * t - F * t_r) - 2 * t_n^2 * (E_1 * t - F * t_r) * (1 - f_{r1}) \\
&= 15^2(1 * 0.3202 - 1 * 0.2709) - 2 * 2.3425^2(1 * 0.3202 - 1 * 0.2709) * (1 - 0.9309) \\
&= 0.7241 \text{ in}^2 \\
&= 2 * (t + t_n) * (E_1 * t - F * t_r) - 2 * t_n^2 * (E_1 * t - F * t_r) * (1 - f_{r1}) \\
&= 2 * (0.3202 + 2.3425) * (1 * 0.3202 - 1 * 0.2709) - 2 * 2.3425^2(1 * 0.3202 - 1 * 0.2709) * (1 - 0.9309) \\
&= 0.2468 \text{ in}^2
\end{aligned}$$

A_2 = smaller of the following = [3.3344](#) in²

$$\begin{aligned}
&= 5 * (t_n - t_m) * f_{r2} * t \\
&= 5 * (2.3425 - 0.1052) * 0.9309 * 0.3202 \\
&= 3.3344 \text{ in}^2 \\
&= 2 * (t_n - t_m) * f_{r2} * L_{pr} \\
&= 2 * (2.3425 - 0.1052) * 0.9309 * 2.1468 \\
&= 8.9423 \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
A_{41} &= Leg^2 * f_{r2} \\
&= 0.315^2 * 0.9309 \\
&= [0.0923](#) \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
\text{Area} &= A_1 + A_2 + A_{41} \\
&= 0.7241 + 3.3344 + 0.0923 \\
&= [4.1508](#) \text{ in}^2
\end{aligned}$$

As Area >= A the reinforcement is adequate.

UW-16(c) Weld Check

Fillet weld: t_{min} = lesser of 0.75 or t_n or $t = 0.3202$ in
 $t_{c(min)}$ = lesser of 0.25 or $0.7 * t_{min} = [0.2241](#)$ in
 $t_{c(actual)} = 0.7 * Leg = 0.7 * 0.315 = 0.2205$ in

**** The fillet weld size IS NOT satisfactory. ****

UG-45 Nozzle Neck Thickness Check

Wall thickness per UG-45(a): $t_{r1} = 0.1052$ in ($E = 1$)
 Wall thickness per UG-45(b)(1): $t_{r2} = 0.2709$ in
 Wall thickness per UG-16(b): $t_{r3} = 0.0625$ in
 Standard wall pipe per UG-45(b)(4): $t_{r4} = 0.3281$ in
 The greater of t_{r2} or t_{r3} : $t_{r5} = 0.2709$ in
 The lesser of t_{r4} or t_{r5} : $t_{r6} = 0.2709$ in

Required per UG-45 is the larger of t_{r1} or $t_{r6} = [0.2709](#)$ in

Available nozzle wall thickness new, $t_n = 2.3425$ in

The nozzle neck thickness is adequate.

Welded Cover #1

ASME Section VIII Division 1, 1995 Edition				
Component		Welded Cover		
Configuration		Figure UG-34 Sketch (h)		
Weld Detail		Figure UW-13.2 Sketch (c)		
Material		SA-105 (II-D p. 18, ln. 6)		
Attached To		Entrada de Inspección (M1)		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Maximize MDMT/ No MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		250	125	6
Dimensions				
Inner Diameter		15"		
Nominal Thickness		1.4516"		
Weld Bevel Depth (a)		2.3425"		
Weld Bevel Depth (b)		1.2016"		
Outer Surface to Edge of Weld (t _p)		0.25"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		Capacity (US gal)
New		125.02		0
Corroded		125.02		0
Radiography				
Category A joints		Seamless No RT		

Results Summary	
Governing condition	internal pressure
Minimum thickness per UG-16	$0.0625" + 0" = 0.0625"$
Design thickness due to internal pressure (t)	<u>1.0299"</u>
Maximum allowable working pressure (MAWP)	<u>496.62</u> psi
Rated MDMT	0°F

Figure UW-13.2 Weld Sizing					
$a + b \geq 2t_s + C_{i,shell} + C_{o,shell} + C_i$					
$t_p \geq \min[t_s, 0.25] + C_o$					
Results					
$a + b =$	3.5441"	<	$2 \times 2.3425 + 0 + 0 =$	4.685"	Not OK
$t_p =$	0.25"	\geq	$\min[2.3425, 0.25] + 0 =$	0.25"	OK

UG-34(d) Dimensional Checks

$$t_s (2.3425") \geq 1.25 \times t_r (1.25 \times 0.1081 = 0.1351") \quad \text{OK}$$

Factor C from Figure UG-34 Sketch (h)

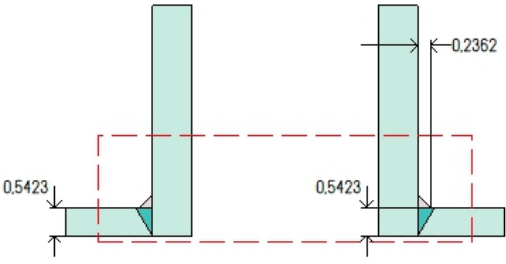
Factor C = 0.33

Design thickness, (at 125 °F) UG-34(c)(2)

$$\begin{aligned}
 t &= d \cdot \sqrt{C \cdot P / (S \cdot E)} + \text{Corrosion} \\
 &= 15 \cdot \sqrt{0.33 \cdot 250 / (17,500 \cdot 1)} + 0 \\
 &= \underline{1.0299"}
 \end{aligned}$$

Maximum allowable working pressure, (at 125 °F)

$$\begin{aligned}
 \text{MAWP} &= (S \cdot E / C) \cdot (t / d)^2 - P_s \\
 &= (17,500 \cdot 1 / 0.33) \cdot (1.4516 / 15)^2 - 0 \\
 &= \underline{496.62} \text{ psi}
 \end{aligned}$$

ASME Section VIII Division 1, 1995 Edition	
	
Note: round inside edges per UG-76(c)	
Location and Orientation	
Located on	V-01
Orientation	180°
Nozzle center line offset to datum line	11.8504"
End of nozzle to shell center	45.6094"
Passes through a Category A joint	No
Nozzle	
Description	NPS 3 Class 6000 - Threaded Full Coupling
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 6)
Inside diameter, new	3.5"
Nominal wall thickness	0.75"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	3.6015"
User input vessel thickness	0.5423"
Liquid static head included	1.39 psi
Longitudinal joint efficiency	1
Welds	
Inner fillet, Leg ₄₁	0.2362"
Nozzle to vessel groove weld	0.5423"

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 251.39 psi @ 125 °F The opening is NOT adequately reinforced							The nozzle passes UG-44	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
2.0463	1.9323	--	1.8789	--	--	0.0534	0.0625	0.75

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 (Leg41)	0.25	0.1654	weld size is NOT adequate

Calculations for internal pressure 251.39 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(3.5, 1.75 + (0.75 - 0) + (0.5423 - 0)) \\
 &= 3.5 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.5423 - 0), 2.5*(0.75 - 0) + 0) \\
 &= 1.3558 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P*R_n / (S_n*E - 0.6*P) \\
 &= 251.3905*1.75 / (17,500*1 - 0.6*251.3905) \\
 &= 0.0254 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (S*E + 0.4*P) \\
 &= 251.3905*42.0079 / (18,300*1 + 0.4*251.3905) \\
 &= 0.5739 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses: S_n = 17,500, S_v = 18,300 psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$\begin{aligned}
 A &= d*t_r*F + 2*t_n*t_r*F*(1 - f_{r1}) \\
 &= 3.5*0.5739*1 + 2*0.75*0.5739*1*(1 - 0.9563) \\
 &= 2.0463 \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

A₁ = larger of the following = 0 in²

$$\begin{aligned}
 &= d*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
 &= 3.5*(1*0.5423 - 1*0.5739) - 2*0.75*(1*0.5423 - 1*0.5739)*(1 - 0.9563) \\
 &= -0.1086 \text{ in}^2 \\
 &= 2*(t + t_n)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
 &= 2*(0.5423 + 0.75)*(1*0.5423 - 1*0.5739) - 2*0.75*(1*0.5423 - 1*0.5739)*(1 - 0.9563)
 \end{aligned}$$

$$= -0.0797 \text{ in}^2$$

A_2 = smaller of the following= 1.8789 in²

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.75 - 0.0254) \cdot 0.9563 \cdot 0.5423 \\ &= 1.8789 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.75 - 0.0254) \cdot 0.9563 \cdot 0.75 \\ &= 2.5985 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.2362^2 \cdot 0.9563 \\ &= \underline{0.0534} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0 + 1.8789 + 0.0534 \\ &= \underline{1.9323} \text{ in}^2 \end{aligned}$$

**** As Area < A the reinforcement is NOT adequate. ****

UW-16(c) Weld Check

Fillet weld: t_{\min} = lesser of 0.75 or t_n or $t = 0.5423$ in

$t_{c(\min)}$ = lesser of 0.25 or $0.7 \cdot t_{\min} = \underline{0.25}$ in

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.2362 = 0.1654$ in

**** The fillet weld size IS NOT satisfactory. ****

UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned} t_{a \text{ App 1-1}} &= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 251.4602 \cdot 2.5 / (17,500 \cdot 1 + 0.4 \cdot 251.4602) + 0 \\ &= 0.0357 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\ &= \max[0.0357 , 0.0625] \\ &= \underline{0.0625} \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.75$ in

The nozzle neck thickness is adequate.

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 237.47 psi @ 125 °F The opening is adequately reinforced							The nozzle passes UG-44	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
<u>1.9336</u>	<u>1.9362</u>	--	<u>1.8828</u>	--	--	<u>0.0534</u>	<u>0.0625</u>	0.75

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)	<u>0.25</u>	0.1654	weld size is NOT adequate

Calculations for internal pressure 237.47 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(3.5, 1.75 + (0.75 - 0) + (0.5423 - 0)) \\
 &= 3.5 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.5423 - 0), 2.5*(0.75 - 0) + 0) \\
 &= 1.3558 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P * R_n / (S_n * E - 0.6 * P) \\
 &= 237.4669 * 1.75 / (17,500 * 1 - 0.6 * 237.4669) \\
 &= 0.0239 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P * R_o / (S * E + 0.4 * P) \\
 &= 237.4669 * 42.0079 / (18,300 * 1 + 0.4 * 237.4669) \\
 &= 0.5423 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses: S_n = 17,500, S_v = 18,300 psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$\begin{aligned}
 A &= d * t_r * F + 2 * t_n * t_r * F * (1 - f_{r1}) \\
 &= 3.5 * 0.5423 * 1 + 2 * 0.75 * 0.5423 * 1 * (1 - 0.9563) \\
 &= \underline{1.9336} \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

A₁ = larger of the following = 0 in²

$$\begin{aligned}
 &= d * (E_1 * t - F * t_r) - 2 * t_n * (E_1 * t - F * t_r) * (1 - f_{r1}) \\
 &= 3.5 * (1 * 0.5423 - 1 * 0.5423) - 2 * 0.75 * (1 * 0.5423 - 1 * 0.5423) * (1 - 0.9563) \\
 &= 0 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
&= 2*(t + t_n)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
&= 2*(0.5423 + 0.75)*(1*0.5423 - 1*0.5423) - 2*0.75*(1*0.5423 - 1*0.5423)*(1 - 0.9563) \\
&= 0 \text{ in}^2
\end{aligned}$$

A_2 = smaller of the following= 1.8828 in²

$$\begin{aligned}
&= 5*(t_n - t_m)*f_{r2}*t \\
&= 5*(0.75 - 0.0239)*0.9563*0.5423 \\
&= 1.8828 \text{ in}^2 \\
&= 5*(t_n - t_m)*f_{r2}*t_n \\
&= 5*(0.75 - 0.0239)*0.9563*0.75 \\
&= 2.6039 \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
A_{41} &= \text{Leg}^2*f_{r2} \\
&= 0.2362^2*0.9563 \\
&= \underline{0.0534} \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
\text{Area} &= A_1 + A_2 + A_{41} \\
&= 0 + 1.8828 + 0.0534 \\
&= \underline{1.9362} \text{ in}^2
\end{aligned}$$

As Area >= A the reinforcement is adequate.

UW-16(c) Weld Check

Fillet weld: t_{\min} = lesser of 0.75 or t_n or $t = 0.5423$ in

$t_{c(\min)}$ = lesser of 0.25 or $0.7*t_{\min} = \underline{0.25}$ in

$t_{c(\text{actual})} = 0.7*\text{Leg} = 0.7*0.2362 = 0.1654$ in

**** The fillet weld size IS NOT satisfactory. ****

UG-44 Thickness Check - ASME B16.11 Coupling

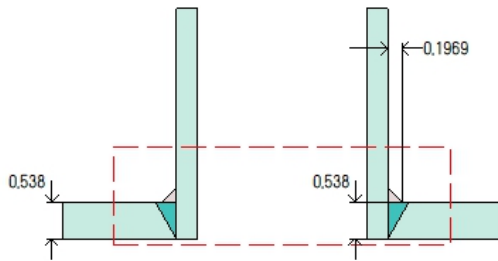
$$\begin{aligned}
t_{a \text{ App 1-1}} &= P*R_o / (S_n*E + 0.4*P) + \text{Corrosion} \\
&= 237.5366*2.5 / (17,500*1 + 0.4*237.5366) + 0 \\
&= 0.0338 \text{ in}
\end{aligned}$$

$$\begin{aligned}
t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\
&= \max[0.0338 , 0.0625] \\
&= \underline{0.0625} \text{ in}
\end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.75$ in

The nozzle neck thickness is adequate.

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

Location and Orientation

Located on	V-01
Orientation	180°
Nozzle center line offset to datum line	23.8583"
End of nozzle to shell center	44.7877"
Passes through a Category A joint	No

Nozzle

Description	NPS 2 Class 3000 - Threaded Full Coupling
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 6)
Inside diameter, new	2.38"
Nominal wall thickness	0.31"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	2.7798"
User input vessel thickness	0.538"
Liquid static head included	1.39 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.1969"
Nozzle to vessel groove weld	0.538"

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 251.39 psi @ 125 °F The opening is NOT adequately reinforced							The nozzle passes UG-44	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.3815	0.4711	--	0.434	--	--	0.0371	0.0625	0.31

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 (Leg41)	0.217	0.1378	weld size is NOT adequate

Calculations for internal pressure 251.39 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.538 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.538 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 251.3905 \cdot 1.19 / (17,500 \cdot 1 - 0.6 \cdot 251.3905) \\
 &= 0.0172 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 251.3905 \cdot 42.0079 / (18,300 \cdot 1 + 0.4 \cdot 251.3905) \\
 &= 0.5739 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses: $S_n = 17,500$, $S_v = 18,300$ psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$\begin{aligned}
 A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\
 &= 2.38 \cdot 0.5739 \cdot 1 + 2 \cdot 0.31 \cdot 0.5739 \cdot 1 \cdot (1 - 0.9563) \\
 &= 1.3815 \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

$A_1 = \text{larger of the following} = 0 \text{ in}^2$

$$\begin{aligned}
 &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 2.38 \cdot (1 \cdot 0.538 - 1 \cdot 0.5739) - 2 \cdot 0.31 \cdot (1 \cdot 0.538 - 1 \cdot 0.5739) \cdot (1 - 0.9563) \\
 &= -0.0845 \text{ in}^2 \\
 &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 2 \cdot (0.538 + 0.31) \cdot (1 \cdot 0.538 - 1 \cdot 0.5739) - 2 \cdot 0.31 \cdot (1 \cdot 0.538 - 1 \cdot 0.5739) \cdot (1 - 0.9563)
 \end{aligned}$$

$$= -0.0599 \text{ in}^2$$

A_2 = smaller of the following = 0.434 in²

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.31 - 0.0172) \cdot 0.9563 \cdot 0.538 \\ &= 0.7532 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.31 - 0.0172) \cdot 0.9563 \cdot 0.31 \\ &= 0.434 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.1969^2 \cdot 0.9563 \\ &= \underline{0.0371} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0 + 0.434 + 0.0371 \\ &= \underline{0.4711} \text{ in}^2 \end{aligned}$$

**** As Area < A the reinforcement is NOT adequate. ****

UW-16(c) Weld Check

Fillet weld: t_{\min} = lesser of 0.75 or t_n or $t = 0.31$ in

$t_{c(\min)}$ = lesser of 0.25 or $0.7 \cdot t_{\min} = \underline{0.217}$ in

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.1969 = 0.1378$ in

**** The fillet weld size IS NOT satisfactory. ****

UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned} t_{a \text{ App 1-1}} &= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 251.4443 \cdot 1.5 / (17,500 \cdot 1 + 0.4 \cdot 251.4443) + 0 \\ &= 0.0214 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\ &= \max[0.0214 , 0.0625] \\ &= \underline{0.0625} \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.31$ in

The nozzle neck thickness 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-44 Summary (in)	
For P = 160.36 psi @ 125 °F The opening is adequately reinforced							The nozzle passes UG-44	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.883	0.883	0.4027	0.4432	--	--	0.0371	0.0625	0.31

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 (Leg41)	0.217	0.1378	weld size is NOT adequate

Calculations for internal pressure 160.36 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.538 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.538 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 160.3642 \cdot 1.19 / (17,500 \cdot 1 - 0.6 \cdot 160.3642) \\
 &= 0.011 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 160.3642 \cdot 42.0079 / (18,300 \cdot 1 + 0.4 \cdot 160.3642) \\
 &= 0.3668 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses: $S_n = 17,500$, $S_v = 18,300$ psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$\begin{aligned}
 A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\
 &= 2.38 \cdot 0.3668 \cdot 1 + 2 \cdot 0.31 \cdot 0.3668 \cdot 1 \cdot (1 - 0.9563) \\
 &= 0.883 \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = 0.4027 \text{ in}^2$$

$$\begin{aligned}
 &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 2.38 \cdot (1 \cdot 0.538 - 1 \cdot 0.3668) - 2 \cdot 0.31 \cdot (1 \cdot 0.538 - 1 \cdot 0.3668) \cdot (1 - 0.9563) \\
 &= 0.4027 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
&= 2*(t + t_n)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
&= 2*(0.538 + 0.31)*(1*0.538 - 1*0.3668) - 2*0.31*(1*0.538 - 1*0.3668)*(1 - 0.9563) \\
&= 0.2857 \text{ in}^2
\end{aligned}$$

A_2 = smaller of the following = 0.4432 in²

$$\begin{aligned}
&= 5*(t_n - t_m)*f_{r2}*t \\
&= 5*(0.31 - 0.011)*0.9563*0.538 \\
&= 0.7692 \text{ in}^2 \\
&= 5*(t_n - t_m)*f_{r2}*t_n \\
&= 5*(0.31 - 0.011)*0.9563*0.31 \\
&= 0.4432 \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
A_{41} &= \text{Leg}^2*f_{r2} \\
&= 0.1969^2*0.9563 \\
&= \underline{0.0371} \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
\text{Area} &= A_1 + A_2 + A_{41} \\
&= 0.4027 + 0.4432 + 0.0371 \\
&= \underline{0.883} \text{ in}^2
\end{aligned}$$

As Area >= A the reinforcement is adequate.

UW-16(c) Weld Check

Fillet weld: t_{\min} = lesser of 0.75 or t_n or $t = 0.31$ in

$t_{c(\min)}$ = lesser of 0.25 or $0.7*t_{\min} = \underline{0.217}$ in

$t_{c(\text{actual})} = 0.7*\text{Leg} = 0.7*0.1969 = 0.1378$ in

**** The fillet weld size IS NOT satisfactory. ****

UG-44 Thickness Check - ASME B16.11 Coupling

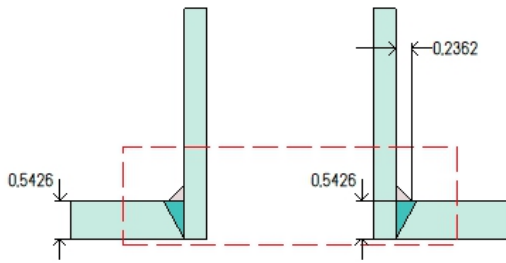
$$\begin{aligned}
t_{a \text{ App 1-1}} &= P*R_o / (S_n*E + 0.4*P) + \text{Corrosion} \\
&= 160.418*1.5 / (17,500*1 + 0.4*160.418) + 0 \\
&= 0.0137 \text{ in}
\end{aligned}$$

$$\begin{aligned}
t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\
&= \max[0.0137 , 0.0625] \\
&= \underline{0.0625} \text{ in}
\end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.31$ in

The nozzle neck thickness is adequate.

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

Location and Orientation

Located on	V-01
Orientation	180°
Nozzle center line offset to datum line	35.8661"
End of nozzle to shell center	44.7877"
Passes through a Category A joint	No

Nozzle

Description	NPS 2 Class 3000 - Threaded Full Coupling
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 6)
Inside diameter, new	2.38"
Nominal wall thickness	0.31"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	2.7798"
User input vessel thickness	0.5426"
Liquid static head included	1.39 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.2362"
Nozzle to vessel groove weld	0.5426"

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 251.39 psi @ 125 °F The opening is NOT adequately reinforced							The nozzle passes UG-44	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.3815	0.4874	--	0.434	--	--	0.0534	0.0625	0.31

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 (Leg41)	0.217	0.1654	weld size is NOT adequate

Calculations for internal pressure 251.39 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.5426 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.5426 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 251.3905 \cdot 1.19 / (17,500 \cdot 1 - 0.6 \cdot 251.3905) \\
 &= 0.0172 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 251.3905 \cdot 42.0079 / (18,300 \cdot 1 + 0.4 \cdot 251.3905) \\
 &= 0.5739 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses: S_n = 17,500, S_v = 18,300 psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$\begin{aligned}
 A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\
 &= 2.38 \cdot 0.5739 \cdot 1 + 2 \cdot 0.31 \cdot 0.5739 \cdot 1 \cdot (1 - 0.9563) \\
 &= 1.3815 \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

A₁ = larger of the following = 0 in²

$$\begin{aligned}
 &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 2.38 \cdot (1 \cdot 0.5426 - 1 \cdot 0.5739) - 2 \cdot 0.31 \cdot (1 \cdot 0.5426 - 1 \cdot 0.5739) \cdot (1 - 0.9563) \\
 &= -0.0737 \text{ in}^2 \\
 &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 2 \cdot (0.5426 + 0.31) \cdot (1 \cdot 0.5426 - 1 \cdot 0.5739) - 2 \cdot 0.31 \cdot (1 \cdot 0.5426 - 1 \cdot 0.5739) \cdot (1 - 0.9563)
 \end{aligned}$$

$$= -0.0526 \text{ in}^2$$

A_2 = smaller of the following = 0.434 in²

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.31 - 0.0172) \cdot 0.9563 \cdot 0.5426 \\ &= 0.7597 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.31 - 0.0172) \cdot 0.9563 \cdot 0.31 \\ &= 0.434 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.2362^2 \cdot 0.9563 \\ &= \underline{0.0534} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0 + 0.434 + 0.0534 \\ &= \underline{0.4874} \text{ in}^2 \end{aligned}$$

**** As Area < A the reinforcement is NOT adequate. ****

UW-16(c) Weld Check

Fillet weld: t_{\min} = lesser of 0.75 or t_n or $t = 0.31$ in

$t_{c(\min)}$ = lesser of 0.25 or $0.7 \cdot t_{\min} = \underline{0.217}$ in

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.2362 = 0.1654$ in

**** The fillet weld size IS NOT satisfactory. ****

UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned} t_{a \text{ App 1-1}} &= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 251.4443 \cdot 1.5 / (17,500 \cdot 1 + 0.4 \cdot 251.4443) + 0 \\ &= 0.0214 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\ &= \max[0.0214 , 0.0625] \\ &= \underline{0.0625} \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.31$ in

The nozzle neck thickness 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-44 Summary (in)	
For P = 162.84 psi @ 125 °F The opening is adequately reinforced							The nozzle passes UG-44	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.8966	0.8967	0.4003	0.443	--	--	0.0534	0.0625	0.31

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 (Leg41)	0.217	0.1654	weld size is NOT adequate

Calculations for internal pressure 162.84 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.5426 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.5426 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P * R_n / (S_n * E - 0.6 * P) \\
 &= 162.8437 * 1.19 / (17,500 * 1 - 0.6 * 162.8437) \\
 &= 0.0111 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P * R_o / (S * E + 0.4 * P) \\
 &= 162.8437 * 42.0079 / (18,300 * 1 + 0.4 * 162.8437) \\
 &= 0.3725 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses: $S_n = 17,500$, $S_v = 18,300$ psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$\begin{aligned}
 A &= d * t_r * F + 2 * t_n * t_r * F * (1 - f_{r1}) \\
 &= 2.38 * 0.3725 * 1 + 2 * 0.31 * 0.3725 * 1 * (1 - 0.9563) \\
 &= [0.8966](#) \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

A_1 = larger of the following = [0.4003](#) in²

$$\begin{aligned}
 &= d * (E_1 * t - F * t_r) - 2 * t_n * (E_1 * t - F * t_r) * (1 - f_{r1}) \\
 &= 2.38 * (1 * 0.5426 - 1 * 0.3725) - 2 * 0.31 * (1 * 0.5426 - 1 * 0.3725) * (1 - 0.9563) \\
 &= 0.4003 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
&= 2*(t + t_n)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
&= 2*(0.5426 + 0.31)*(1*0.5426 - 1*0.3725) - 2*0.31*(1*0.5426 - 1*0.3725)*(1 - 0.9563) \\
&= 0.2855 \text{ in}^2
\end{aligned}$$

A_2 = smaller of the following = 0.443 in²

$$\begin{aligned}
&= 5*(t_n - t_m)*f_{r2}*t \\
&= 5*(0.31 - 0.0111)*0.9563*0.5426 \\
&= 0.7755 \text{ in}^2 \\
&= 5*(t_n - t_m)*f_{r2}*t_n \\
&= 5*(0.31 - 0.0111)*0.9563*0.31 \\
&= 0.443 \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
A_{41} &= \text{Leg}^2*f_{r2} \\
&= 0.2362^2*0.9563 \\
&= \underline{0.0534} \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
\text{Area} &= A_1 + A_2 + A_{41} \\
&= 0.4003 + 0.443 + 0.0534 \\
&= \underline{0.8967} \text{ in}^2
\end{aligned}$$

As Area >= A the reinforcement is adequate.

UW-16(c) Weld Check

Fillet weld: t_{\min} = lesser of 0.75 or t_n or $t = 0.31$ in

$t_{c(\min)}$ = lesser of 0.25 or $0.7*t_{\min} = \underline{0.217}$ in

$t_{c(\text{actual})} = 0.7*\text{Leg} = 0.7*0.2362 = 0.1654$ in

**** The fillet weld size IS NOT satisfactory. ****

UG-44 Thickness Check - ASME B16.11 Coupling

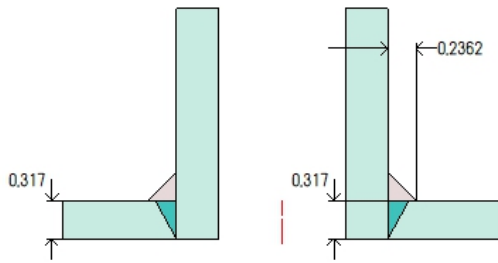
$$\begin{aligned}
t_{a \text{ App 1-1}} &= P*R_o / (S_n*E + 0.4*P) + \text{Corrosion} \\
&= 162.8975*1.5 / (17,500*1 + 0.4*162.8975) + 0 \\
&= 0.0139 \text{ in}
\end{aligned}$$

$$\begin{aligned}
t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\
&= \max[0.0139 , 0.0625] \\
&= \underline{0.0625} \text{ in}
\end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.31$ in

The nozzle neck thickness is adequate.

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

Location and Orientation

Located on	C-01
Orientation	0°
End of nozzle to datum line	-36.7753"
Calculated as hillside	No
Distance to head center, R	23.2283"
Passes through a Category A joint	No

Nozzle

Description	NPS 0.75 Class 6000 - Threaded Full Coupling
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 6)
Inside diameter, new	1.06"
Nominal wall thickness	0.345"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	2.1255"
User input vessel thickness	0.317"
Liquid static head included	0.13 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.2362"
Nozzle to vessel groove weld	0.317"

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 250.13 psi @ 125 °F							The nozzle passes UG-44	
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)							<u>0.0625</u>	0.345

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)	<u>0.2219</u>	0.1654	weld size is <i>NOT</i> adequate

Calculations for internal pressure 250.13 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.06, 0.53 + (0.345 - 0) + (0.317 - 0)) \\
 &= 1.192 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.317 - 0), 2.5*(0.345 - 0) + 0) \\
 &= 0.7925 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 250.1264 \cdot 0.53 / (17,500 \cdot 1 - 0.6 \cdot 250.1264) \\
 &= 0.0076 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\
 &= 250.1264 \cdot 42.0349 / (2 \cdot 18,800 \cdot 1 + 0.8 \cdot 250.1264) \\
 &= 0.2782 \text{ in}
 \end{aligned}$$

Required thickness t_r per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P \cdot R_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\
 &= 250.1264 \cdot 42.0349 / (2 \cdot 18,800 \cdot 0.85 + 0.8 \cdot 250.1264) \\
 &= 0.3269 \text{ in}
 \end{aligned}$$

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

UW-16(c) Weld Check

Fillet weld: t_{min} = lesser of 0.75 or t_n or t = 0.317 in

t_{c(min)} = lesser of 0.25 or 0.7 * t_{min} = 0.2219 in

t_{c(actual)} = 0.7 * Leg = 0.7 * 0.2362 = 0.1654 in

**** The fillet weld size IS NOT satisfactory. ****

UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned}
 t_{a \text{ App 1-1}} &= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) + \text{Corrosion} \\
 &= 250.1264 \cdot 0.875 / (17,500 \cdot 1 + 0.4 \cdot 250.1264) + 0 \\
 &= 0.0124 \text{ in}
 \end{aligned}$$

$$t_{a \text{ UG-44}} = \max[t_{a \text{ App 1-1}}, t_{b \text{ UG16}}]$$

$$= \max[0.0124, 0.0625]$$
$$= \underline{0.0625} \text{ in}$$

Available nozzle wall thickness new, $t_n = 0.345$ in

The nozzle neck thickness is adequate.

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 285.27 psi @ 125 °F							The nozzle passes UG-44	
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)							<u>0.0625</u>	0.345

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)	<u>0.2219</u>	0.1654	weld size is NOT adequate

Calculations for internal pressure 285.27 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.06, 0.53 + (0.345 - 0) + (0.317 - 0)) \\
 &= 1.192 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.317 - 0), 2.5*(0.345 - 0) + 0) \\
 &= 0.7925 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P*R_n / (S_n*E - 0.6*P) \\
 &= 285.2741*0.53 / (17,500*1 - 0.6*285.2741) \\
 &= 0.0087 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 285.2741*42.0349 / (2*18,800*1 + 0.8*285.2741) \\
 &= 0.317 \text{ in}
 \end{aligned}$$

Required thickness t_r per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 285.2741*42.0349 / (2*18,800*0.85 + 0.8*285.2741) \\
 &= 0.3725 \text{ in}
 \end{aligned}$$

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

UW-16(c) Weld Check

Fillet weld: t_{min} = lesser of 0.75 or t_n or t = 0.317 in
t_{c(min)} = lesser of 0.25 or 0.7*t_{min} = 0.2219 in
t_{c(actual)} = 0.7*Leg = 0.7*0.2362 = 0.1654 in

**** The fillet weld size IS NOT satisfactory. ****

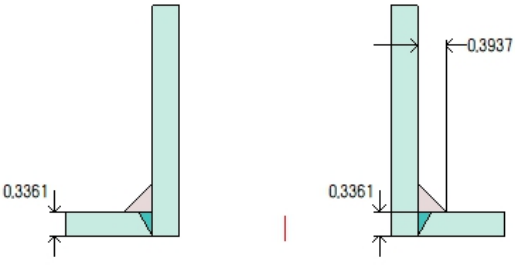
UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned}
 t_{a \text{ App 1-1}} &= P*R_o / (S_n*E + 0.4*P) + \text{Corrosion} \\
 &= 285.2741*0.875 / (17,500*1 + 0.4*285.2741) + 0 \\
 &= 0.0142 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}}, t_{b \text{ UG16}}] \\
 &= \max[0.0142, 0.0625] \\
 &= \underline{0.0625} \text{ in}
 \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.345$ in

The nozzle neck thickness is adequate.

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Note: round inside edges per UG-76(c)	
Location and Orientation	
Located on	C-01
Orientation	0°
End of nozzle to datum line	-45.5813"
Calculated as hillside	No
Distance to head center, R	0"
Passes through a Category A joint	No
Nozzle	
Description	NPS 2.5 Class 3000 - Threaded Full Coupling
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 6)
Inside diameter, new	2.88"
Nominal wall thickness	0.37"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	3.6124"
User input vessel thickness	0.3361"
Liquid static head included	0.58 psi
Longitudinal joint efficiency	1
Welds	
Inner fillet, Leg ₄₁	0.3937"
Nozzle to vessel groove weld	0.3361"

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 250.58 psi @ 125 °F							The nozzle passes UG-44	
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)							0.0625	0.37

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)	0.2353	0.2756	weld size is adequate

Calculations for internal pressure 250.58 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.88, 1.44 + (0.37 - 0) + (0.3361 - 0)) \\
 &= 2.88 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.3361 - 0), 2.5*(0.37 - 0) + 0) \\
 &= 0.8403 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 250.5765 \cdot 1.44 / (17,500 \cdot 1 - 0.6 \cdot 250.5765) \\
 &= 0.0208 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\
 &= 250.5765 \cdot 42.054 / (2 \cdot 18,800 \cdot 1 + 0.8 \cdot 250.5765) \\
 &= 0.2788 \text{ in}
 \end{aligned}$$

Required thickness t_r per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P \cdot R_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\
 &= 250.5765 \cdot 42.054 / (2 \cdot 18,800 \cdot 0.85 + 0.8 \cdot 250.5765) \\
 &= 0.3277 \text{ in}
 \end{aligned}$$

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

UW-16(c) Weld Check

Fillet weld: t_{min} = lesser of 0.75 or t_n or t = 0.3361 in
t_{c(min)} = lesser of 0.25 or 0.7*t_{min} = 0.2353 in
t_{c(actual)} = 0.7*Leg = 0.7*0.3937 = 0.2756 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned}
 t_{a \text{ App 1-1}} &= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) + \text{Corrosion} \\
 &= 250.5765 \cdot 1.81 / (17,500 \cdot 1 + 0.4 \cdot 250.5765) + 0 \\
 &= 0.0258 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\
 &= \max[0.0258 , 0.0625] \\
 &= \underline{0.0625} \text{ in}
 \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.37$ in

The nozzle neck thickness is adequate.

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 302.43 psi @ 125 °F							The nozzle passes UG-44	
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)							0.0625	0.37

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)	0.2353	0.2756	weld size is adequate

Calculations for internal pressure 302.43 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.88, 1.44 + (0.37 - 0) + (0.3361 - 0)) \\
 &= 2.88 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.3361 - 0), 2.5*(0.37 - 0) + 0) \\
 &= 0.8403 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P*R_n / (S_n*E - 0.6*P) \\
 &= 302.4333*1.44 / (17,500*1 - 0.6*302.4333) \\
 &= 0.0251 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 302.4333*42.054 / (2*18,800*1 + 0.8*302.4333) \\
 &= 0.3361 \text{ in}
 \end{aligned}$$

Required thickness t_r per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 302.4333*42.054 / (2*18,800*0.85 + 0.8*302.4333) \\
 &= 0.395 \text{ in}
 \end{aligned}$$

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

UW-16(c) Weld Check

Fillet weld: t_{min} = lesser of 0.75 or t_n or t = 0.3361 in
t_{c(min)} = lesser of 0.25 or 0.7*t_{min} = 0.2353 in
t_{c(actual)} = 0.7*Leg = 0.7*0.3937 = 0.2756 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

UG-44 Thickness Check - ASME B16.11 Coupling

$$t_{a \text{ App 1-1}} = P*R_o / (S_n*E + 0.4*P) + \text{Corrosion}$$

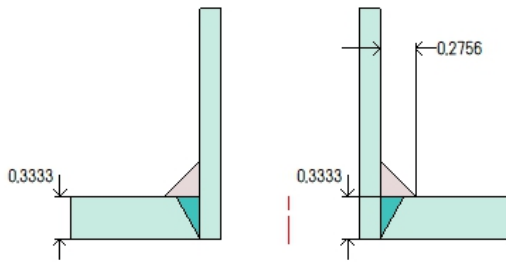
$$\begin{aligned}
&= 302.4333 \cdot 1.81 / (17,500 \cdot 1 + 0.4 \cdot 302.4333) + 0 \\
&= 0.0311 \text{ in}
\end{aligned}$$

$$\begin{aligned}
t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}}, t_{b \text{ UG16}}] \\
&= \max[0.0311, 0.0625] \\
&= \underline{0.0625} \text{ in}
\end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.37$ in

The nozzle neck thickness is adequate.

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

Location and Orientation

Located on	C-01
Orientation	180°
End of nozzle to datum line	-41.7365"
Calculated as hillside	No
Distance to head center, R	13.3858"
Passes through a Category A joint	No

Nozzle

Description	NPS 0.75 Class 3000 - Threaded Full Coupling
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 6)
Inside diameter, new	1.06"
Nominal wall thickness	0.16"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	2.0245"
User input vessel thickness	0.3333"
Liquid static head included	0.84 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.2756"
Nozzle to vessel groove weld	0.3333"

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 250.84 psi @ 125 °F							The nozzle passes UG-44	
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)							0.0625	0.16

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)	0.112	0.1929	weld size is adequate

Calculations for internal pressure 250.84 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.06, 0.53 + (0.16 - 0) + (0.3333 - 0)) \\
 &= 1.06 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.3333 - 0), 2.5*(0.16 - 0) + 0) \\
 &= 0.4 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 250.8359 \cdot 0.53 / (17,500 \cdot 1 - 0.6 \cdot 250.8359) \\
 &= 0.0077 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\
 &= 250.8359 \cdot 42.0512 / (2 \cdot 18,800 \cdot 1 + 0.8 \cdot 250.8359) \\
 &= 0.279 \text{ in}
 \end{aligned}$$

Required thickness t_r per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P \cdot R_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\
 &= 250.8359 \cdot 42.0512 / (2 \cdot 18,800 \cdot 0.85 + 0.8 \cdot 250.8359) \\
 &= 0.328 \text{ in}
 \end{aligned}$$

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

UW-16(c) Weld Check

Fillet weld: t_{min} = lesser of 0.75 or t_n or t = 0.16 in
t_{c(min)} = lesser of 0.25 or 0.7*t_{min} = 0.112 in
t_{c(actual)} = 0.7*Leg = 0.7*0.2756 = 0.1929 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned}
 t_{a \text{ App 1-1}} &= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) + \text{Corrosion} \\
 &= 250.848 \cdot 0.69 / (17,500 \cdot 1 + 0.4 \cdot 250.848) + 0 \\
 &= 0.0098 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\
 &= \max[0.0098 , 0.0625] \\
 &= \underline{0.0625} \text{ in}
 \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.16$ in

The nozzle neck thickness is adequate.

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 299.92 psi @ 125 °F							The nozzle passes UG-44	
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)							0.0625	0.16

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)	0.112	0.1929	weld size is adequate

Calculations for internal pressure 299.92 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.06, 0.53 + (0.16 - 0) + (0.3333 - 0)) \\
 &= 1.06 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.3333 - 0), 2.5*(0.16 - 0) + 0) \\
 &= 0.4 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P*R_n / (S_n*E - 0.6*P) \\
 &= 299.9218*0.53 / (17,500*1 - 0.6*299.9218) \\
 &= 0.0092 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 299.9218*42.0512 / (2*18,800*1 + 0.8*299.9218) \\
 &= 0.3333 \text{ in}
 \end{aligned}$$

Required thickness t_r per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 299.9218*42.0512 / (2*18,800*0.85 + 0.8*299.9218) \\
 &= 0.3917 \text{ in}
 \end{aligned}$$

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

UW-16(c) Weld Check

Fillet weld: t_{min} = lesser of 0.75 or t_n or t = 0.16 in

t_{c(min)} = lesser of 0.25 or 0.7*t_{min} = 0.112 in

t_{c(actual)} = 0.7*Leg = 0.7*0.2756 = 0.1929 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

UG-44 Thickness Check - ASME B16.11 Coupling

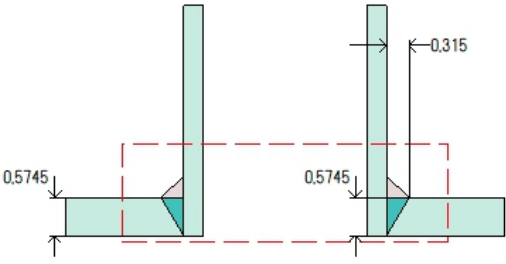
$$t_{a \text{ App 1-1}} = P*R_o / (S_n*E + 0.4*P) + \text{Corrosion}$$

$$\begin{aligned}
&= 299.9339 \cdot 0.69 / (17,500 \cdot 1 + 0.4 \cdot 299.9339) + 0 \\
&= 0.0117 \text{ in}
\end{aligned}$$

$$\begin{aligned}
t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}}, t_{b \text{ UG16}}] \\
&= \max[0.0117, 0.0625] \\
&= \underline{0.0625} \text{ in}
\end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.16 \text{ in}$

The nozzle neck thickness is adequate.

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Note: round inside edges per UG-76(c)	
Location and Orientation	
Located on	V-02
Orientation	0°
Nozzle center line offset to datum line	214.6063"
End of nozzle to shell center	44.7877"
Passes through a Category A joint	No
Nozzle	
Description	NPS 2 Class 3000 - Threaded Full Coupling
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 6)
Inside diameter, new	2.38"
Nominal wall thickness	0.31"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	2.7798"
User input vessel thickness	0.5745"
Liquid static head included	0 psi
Longitudinal joint efficiency	1
Welds	
Inner fillet, Leg ₄₁	0.315"
Nozzle to vessel groove weld	0.5745"

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 250 psi @ 125 °F The opening is NOT adequately reinforced							The nozzle passes UG-44	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.3739	0.5379	0.0088	0.4342	--	--	0.0949	0.0625	0.31

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 (Leg41)	0.217	0.2205	weld size is adequate

Calculations for internal pressure 250 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.5745 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.5745 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 250 \cdot 1.19 / (17,500 \cdot 1 - 0.6 \cdot 250) \\
 &= 0.0171 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 250 \cdot 42.0079 / (18,300 \cdot 1 + 0.4 \cdot 250) \\
 &= 0.5708 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses: $S_n = 17,500$, $S_v = 18,300$ psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$\begin{aligned}
 A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\
 &= 2.38 \cdot 0.5708 \cdot 1 + 2 \cdot 0.31 \cdot 0.5708 \cdot 1 \cdot (1 - 0.9563) \\
 &= [1.3739](#) \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

A_1 = larger of the following = [0.0088](#) in²

$$\begin{aligned}
 &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 2.38 \cdot (1 \cdot 0.5745 - 1 \cdot 0.5708) - 2 \cdot 0.31 \cdot (1 \cdot 0.5745 - 1 \cdot 0.5708) \cdot (1 - 0.9563) \\
 &= 0.0088 \text{ in}^2 \\
 &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 2 \cdot (0.5745 + 0.31) \cdot (1 \cdot 0.5745 - 1 \cdot 0.5708) - 2 \cdot 0.31 \cdot (1 \cdot 0.5745 - 1 \cdot 0.5708) \cdot (1 - 0.9563)
 \end{aligned}$$

$$= 0.0065 \text{ in}^2$$

A_2 = smaller of the following= 0.4342 in²

$$\begin{aligned} &= 5(t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5(0.31 - 0.0171) \cdot 0.9563 \cdot 0.5745 \\ &= 0.8046 \text{ in}^2 \\ &= 5(t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5(0.31 - 0.0171) \cdot 0.9563 \cdot 0.31 \\ &= 0.4342 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.315^2 \cdot 0.9563 \\ &= \underline{0.0949} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0.0088 + 0.4342 + 0.0949 \\ &= \underline{0.5379} \text{ in}^2 \end{aligned}$$

**** As Area < A the reinforcement is NOT adequate. ****

UW-16(c) Weld Check

Fillet weld: t_{\min} = lesser of 0.75 or t_n or $t = 0.31$ in

$t_{c(\min)}$ = lesser of 0.25 or $0.7 \cdot t_{\min} = \underline{0.217}$ in

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.315 = 0.2205$ in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned} t_{a \text{ App 1-1}} &= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 250 \cdot 1.5 / (17,500 \cdot 1 + 0.4 \cdot 250) + 0 \\ &= 0.0213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}}, t_{b \text{ UG16}}] \\ &= \max[0.0213, 0.0625] \\ &= \underline{0.0625} \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.31$ in

The nozzle neck thickness 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-44 Summary (in)	
For P = 173.48 psi @ 125 °F The opening is adequately reinforced							The nozzle passes UG-44	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.955	0.9551	0.4183	0.4419	--	--	0.0949	0.0625	0.31

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 (Leg41)	0.217	0.2205	weld size is adequate

Calculations for internal pressure 173.48 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.5745 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.5745 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P*R_n / (S_n*E - 0.6*P) \\
 &= 173.4848*1.19 / (17,500*1 - 0.6*173.4848) \\
 &= 0.0119 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (S*E + 0.4*P) \\
 &= 173.4848*42.0079 / (18,300*1 + 0.4*173.4848) \\
 &= 0.3967 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses: S_n = 17,500, S_v = 18,300 psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$\begin{aligned}
 A &= d*t_r*F + 2*t_n*t_r*F*(1 - f_{r1}) \\
 &= 2.38*0.3967*1 + 2*0.31*0.3967*1*(1 - 0.9563) \\
 &= [0.955](#) \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = [0.4183](#) \text{ in}^2$$

$$\begin{aligned}
 &= d*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
 &= 2.38*(1*0.5745 - 1*0.3967) - 2*0.31*(1*0.5745 - 1*0.3967)*(1 - 0.9563) \\
 &= 0.4183 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
&= 2*(t + t_n)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
&= 2*(0.5745 + 0.31)*(1*0.5745 - 1*0.3967) - 2*0.31*(1*0.5745 - 1*0.3967)*(1 - 0.9563) \\
&= 0.3097 \text{ in}^2
\end{aligned}$$

A_2 = smaller of the following = 0.4419 in²

$$\begin{aligned}
&= 5*(t_n - t_m)*f_{r2}*t \\
&= 5*(0.31 - 0.0119)*0.9563*0.5745 \\
&= 0.8189 \text{ in}^2 \\
&= 5*(t_n - t_m)*f_{r2}*t_n \\
&= 5*(0.31 - 0.0119)*0.9563*0.31 \\
&= 0.4419 \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
A_{41} &= \text{Leg}^2*f_{r2} \\
&= 0.315^2*0.9563 \\
&= \underline{0.0949} \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
\text{Area} &= A_1 + A_2 + A_{41} \\
&= 0.4183 + 0.4419 + 0.0949 \\
&= \underline{0.9551} \text{ in}^2
\end{aligned}$$

As Area >= A the reinforcement is adequate.

UW-16(c) Weld Check

Fillet weld: t_{\min} = lesser of 0.75 or t_n or $t = 0.31$ in

$t_{c(\min)}$ = lesser of 0.25 or $0.7*t_{\min} = \underline{0.217}$ in

$t_{c(\text{actual})} = 0.7*\text{Leg} = 0.7*0.315 = 0.2205$ in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

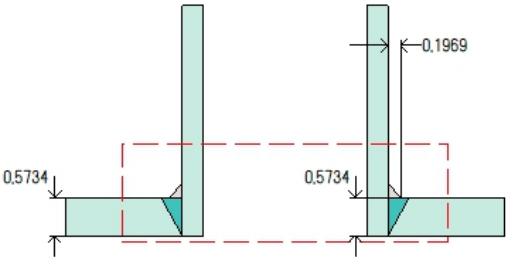
UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned}
t_{a \text{ App 1-1}} &= P*R_o / (S_n*E + 0.4*P) + \text{Corrosion} \\
&= 173.4848*1.5 / (17,500*1 + 0.4*173.4848) + 0 \\
&= 0.0148 \text{ in}
\end{aligned}$$

$$\begin{aligned}
t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\
&= \max[0.0148 , 0.0625] \\
&= \underline{0.0625} \text{ in}
\end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.31$ in

The nozzle neck thickness is adequate.

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Note: round inside edges per UG-76(c)	
Location and Orientation	
Located on	V-01
Orientation	0°
Nozzle center line offset to datum line	47.9528"
End of nozzle to shell center	44.7877"
Passes through a Category A joint	No
Nozzle	
Description	NPS 2 Class 3000 - Threaded Full Coupling
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 6)
Inside diameter, new	2.38"
Nominal wall thickness	0.31"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	2.7798"
User input vessel thickness	0.5734"
Liquid static head included	0 psi
Longitudinal joint efficiency	1
Welds	
Inner fillet, Leg ₄₁	0.1969"
Nozzle to vessel groove weld	0.5734"

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 250 psi @ 125 °F The opening is NOT adequately reinforced							The nozzle passes UG-44	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.3739	0.4775	0.0062	0.4342	--	--	0.0371	0.0625	0.31

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 (Leg41)	0.217	0.1378	weld size is NOT adequate

Calculations for internal pressure 250 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.5734 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.5734 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 250 \cdot 1.19 / (17,500 \cdot 1 - 0.6 \cdot 250) \\
 &= 0.0171 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 250 \cdot 42.0079 / (18,300 \cdot 1 + 0.4 \cdot 250) \\
 &= 0.5708 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses: $S_n = 17,500$, $S_v = 18,300$ psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$\begin{aligned}
 A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\
 &= 2.38 \cdot 0.5708 \cdot 1 + 2 \cdot 0.31 \cdot 0.5708 \cdot 1 \cdot (1 - 0.9563) \\
 &= [1.3739](#) \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

A_1 = larger of the following = [0.0062](#) in²

$$\begin{aligned}
 &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 2.38 \cdot (1 \cdot 0.5734 - 1 \cdot 0.5708) - 2 \cdot 0.31 \cdot (1 \cdot 0.5734 - 1 \cdot 0.5708) \cdot (1 - 0.9563) \\
 &= 0.0062 \text{ in}^2 \\
 &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 2 \cdot (0.5734 + 0.31) \cdot (1 \cdot 0.5734 - 1 \cdot 0.5708) - 2 \cdot 0.31 \cdot (1 \cdot 0.5734 - 1 \cdot 0.5708) \cdot (1 - 0.9563)
 \end{aligned}$$

$$= 0.0046 \text{ in}^2$$

A_2 = smaller of the following= [0.4342](#) in²

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.31 - 0.0171) \cdot 0.9563 \cdot 0.5734 \\ &= 0.803 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.31 - 0.0171) \cdot 0.9563 \cdot 0.31 \\ &= 0.4342 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.1969^2 \cdot 0.9563 \\ &= \text{0.0371} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0.0062 + 0.4342 + 0.0371 \\ &= \text{0.4775} \text{ in}^2 \end{aligned}$$

**** As Area < A the reinforcement is NOT adequate. ****

UW-16(c) Weld Check

Fillet weld: t_{\min} = lesser of 0.75 or t_n or $t = 0.31$ in

$t_{c(\min)}$ = lesser of 0.25 or $0.7 \cdot t_{\min} = \text{0.217}$ in

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.1969 = 0.1378$ in

**** The fillet weld size IS NOT satisfactory. ****

UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned} t_{a \text{ App 1-1}} &= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 250 \cdot 1.5 / (17,500 \cdot 1 + 0.4 \cdot 250) + 0 \\ &= 0.0213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\ &= \max[0.0213 , 0.0625] \\ &= \text{0.0625} \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.31$ in

The nozzle neck thickness 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-44 Summary (in)	
For P = 167.98 psi @ 125 °F The opening is adequately reinforced							The nozzle passes UG-44	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.9248	0.9248	0.4452	0.4425	--	--	0.0371	0.0625	0.31

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 (Leg41)	0.217	0.1378	weld size is NOT adequate

Calculations for internal pressure 167.98 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.5734 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.5734 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P * R_n / (S_n * E - 0.6 * P) \\
 &= 167.9764 * 1.19 / (17,500 * 1 - 0.6 * 167.9764) \\
 &= 0.0115 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P * R_o / (S * E + 0.4 * P) \\
 &= 167.9764 * 42.0079 / (18,300 * 1 + 0.4 * 167.9764) \\
 &= 0.3842 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses: S_n = 17,500, S_v = 18,300 psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 0.9563$$

$$\begin{aligned}
 A &= d * t_r * F + 2 * t_n * t_r * F * (1 - f_{r1}) \\
 &= 2.38 * 0.3842 * 1 + 2 * 0.31 * 0.3842 * 1 * (1 - 0.9563) \\
 &= [0.9248](#) \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = [0.4452](#) \text{ in}^2$$

$$\begin{aligned}
 &= d * (E_1 * t - F * t_r) - 2 * t_n * (E_1 * t - F * t_r) * (1 - f_{r1}) \\
 &= 2.38 * (1 * 0.5734 - 1 * 0.3842) - 2 * 0.31 * (1 * 0.5734 - 1 * 0.3842) * (1 - 0.9563) \\
 &= 0.4452 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
&= 2*(t + t_n)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
&= 2*(0.5734 + 0.31)*(1*0.5734 - 1*0.3842) - 2*0.31*(1*0.5734 - 1*0.3842)*(1 - 0.9563) \\
&= 0.3292 \text{ in}^2
\end{aligned}$$

A_2 = smaller of the following = 0.4425 in²

$$\begin{aligned}
&= 5*(t_n - t_m)*f_{r2}*t \\
&= 5*(0.31 - 0.0115)*0.9563*0.5734 \\
&= 0.8184 \text{ in}^2 \\
&= 5*(t_n - t_m)*f_{r2}*t_n \\
&= 5*(0.31 - 0.0115)*0.9563*0.31 \\
&= 0.4425 \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
A_{41} &= \text{Leg}^2*f_{r2} \\
&= 0.1969^2*0.9563 \\
&= \underline{0.0371} \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
\text{Area} &= A_1 + A_2 + A_{41} \\
&= 0.4452 + 0.4425 + 0.0371 \\
&= \underline{0.9248} \text{ in}^2
\end{aligned}$$

As Area >= A the reinforcement is adequate.

UW-16(c) Weld Check

Fillet weld: t_{\min} = lesser of 0.75 or t_n or $t = 0.31$ in

$t_{c(\min)}$ = lesser of 0.25 or $0.7*t_{\min} = \underline{0.217}$ in

$t_{c(\text{actual})} = 0.7*\text{Leg} = 0.7*0.1969 = 0.1378$ in

**** The fillet weld size IS NOT satisfactory. ****

UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned}
t_{a \text{ App 1-1}} &= P*R_o / (S_n*E + 0.4*P) + \text{Corrosion} \\
&= 167.9764*1.5 / (17,500*1 + 0.4*167.9764) + 0 \\
&= 0.0143 \text{ in}
\end{aligned}$$

$$\begin{aligned}
t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\
&= \max[0.0143 , 0.0625] \\
&= \underline{0.0625} \text{ in}
\end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.31$ in

The nozzle neck thickness is adequate.

ASME Section VIII Division 1, 1995 Edition		
Saddle Material	A283 GR C	
Saddle Construction	Web at edge of rib	
Welded to Vessel	Yes	
Saddle Allowable Stress, S_s	20,624 psi	
Saddle Yield Stress, S_y	36,000 psi	
Foundation Allowable Stress	1,658 psi	
Design Pressure	Left Saddle	Right Saddle
Operating	160.35 psi	160.35 psi
Test	240.53 psi	240.53 psi
Dimensions		
Right saddle distance to datum	160.0394"	
Tangent To Tangent Length, L	226.2992"	
Saddle separation, L_s	95.6299"	
Vessel Radius, R	42.0079"	
Tangent Distance Left, A_l	64.4094"	
Tangent Distance Right, A_r	66.2598"	
Saddle Height, H_s	47.5591"	
Saddle Contact Angle, θ	120°	
Web Plate Thickness, t_s	0.4724"	
Base Plate Length, E	74.4488"	
Base Plate Width, F	12.0079"	
Base Plate Thickness, t_b	0.4724"	
Number of Stiffening Ribs, n	4	
Largest Stiffening Rib Spacing, d_i	26.9414"	
Stiffening Rib Thickness, t_w	0.4724"	
Saddle Width, b	12.0079"	
Reinforcing Plate		
Thickness, t_p	0.2756"	
Width, W_p	14.2126"	
Contact Angle, θ_w	132°	
Bolting		
Material	SA-193 B8	
Bolt Allowable Shear	18,800 psi	
Description	0.625" coarse threaded	
Corrosion on root	0"	
Anchor Bolts per Saddle	2	
Base coefficient of friction, μ	0.45	
Weight		
	Operating, Corroded	Hydrotest
Weight on Left Saddle	18,990 lb	32,689 lb
Weight on Right Saddle	19,581 lb	33,766 lb
Weight of Saddle Pair	886 lb	

Notes
(1) Saddle calculations are based on the method presented in "Stresses in Large Cylindrical Pressure Vessels on Two Saddle Supports" by L.P. Zick.

Stress Summary										
Load	Condition	Saddle	Bending + pressure between saddles (psi)				Bending + pressure at the saddle (psi)			
			S ₁ (+)	allow (+)	S ₁ (-)	allow (-)	S ₂ (+)	allow (+)	S ₂ (-)	allow (-)
Weight	Operating	Right Saddle	6.057	18,300	-123	14,074	7.468	18,300	1.660	14,323
		Left Saddle					7.868	18,300	1.688	14,074
	Test	Right Saddle	9.059	33,300	-212	14,074	11.571	33,300	2.859	14,323
		Left Saddle					12.178	33,300	2.908	14,074

Stress Summary										
Load	Condition	Saddle	Tangential shear (psi)		Circumferential stress (psi)		Stress over saddle (psi)		Splitting (psi)	
			S ₃	allow	S ₄ (hoops)	allow (+/-)	S ₅	allow	S ₆	allow
Weight	Operating	Right Saddle	329	14,640	-7.440	27,450	1.796	18,000	644	13,749
		Left Saddle	332	14,640	-8.136	27,450	1.850	18,000	625	13,749
	Test	Right Saddle	568	26,640	-12.829	33,300	3.097	32,400	1.111	32,400
		Left Saddle	570	26,640	-14.005	33,300	3.185	32,400	1.075	32,400

Load Case 1: Weight, Operating

Longitudinal stress between saddles (Weight, Operating, left saddle loading and geometry govern)

$$S_1 = \pm 3K_1 Q^* (L / 12) / (\pi R^2 t)$$

$$= 3 * -0.3369 * 18,990 * (226.2992 / 12) / (\pi * 41.7389^2 * 0.538)$$

$$= -123 \text{ psi}$$

$$S_p = P^* R / (2t)$$

$$= 160.35 * 41.4699 / (2 * 0.538)$$

$$= 6,180 \text{ psi}$$

Maximum tensile stress $S_{1t} = S_1 + S_p = \text{6.057}$ psi
Maximum compressive stress (shut down) $S_{1c} = S_1 = \text{-123}$ psi

Tensile stress is acceptable ($\leq S^* E = 18,300$ psi)
Compressive stress is acceptable ($\leq S_c = 14,074$ psi)

Longitudinal stress at the right saddle (Weight, Operating)

$$L_c = 2 * (\text{Left head depth}) / 3 + L + 2 * (\text{Right head depth}) / 3$$

$$= 2 * 42.0079 / 3 + 226.2992 + 2 * 42.0079 / 3$$

$$= 282.3097 \text{ in}$$

$$w = W_l / L_c = 38,571 / 282.3097 = 136.63 \text{ lb/in}$$

Bending moment at the right saddle:

$$M_q = w * (2 * H^* A_r / 3 + A_r^2 / 2 - (R^2 - H^2) / 4)$$

$$= 136.63 * (2 * 42.0079 * 66.2598 / 3 + 66.2598^2 / 2 - (42.0079^2 - 42.0079^2) / 4)$$

$$= 553,447.6 \text{ lb-in}$$

$$S_2 = \pm M_q^* K_1' / (\pi R^2 t)$$

$$= 553,447.6 * 9.3799 / (\pi * 41.7219^2 * 0.572)$$

$$= 1,660 \text{ psi}$$

$$S_p = P^* R / (2t)$$

$$= 160.35 * 41.4359 / (2 * 0.572)$$

$$= 5,808 \text{ psi}$$

Maximum tensile stress $S_{2t} = S_2 + S_p = \text{7.468}$ psi
Maximum compressive stress (shut down) $S_{2c} = S_2 = \text{1.660}$ psi

Tensile stress is acceptable ($\leq S = 18,300$ psi)
Compressive stress is acceptable ($\leq S_c = 14,323$ psi)

Tangential shear stress in the shell (right saddle, Weight, Operating)

$$Q_{\text{shear}} = Q - w * (a + 2 * H / 3)$$

$$= 19,581 - 136.63 * (66.2598 + 2 * 42.0079 / 3)$$

$$= 6,701.89 \text{ lb}_f$$

$$\begin{aligned}
 S_3 &= K_{2.2} * Q_{\text{shear}} / (R * t) \\
 &= 1.1707 * 6,701.89 / (41.7219 * 0.572) \\
 &= \underline{329} \text{ psi}
 \end{aligned}$$

Tangential shear stress is acceptable ($\leq 0.8 * S = 14,640$ psi)

Circumferential stress at the right saddle horns (Weight, Operating)

$$\begin{aligned}
 S_4 &= -Q / (4 * t * (b + 1.56 * \text{Sqr}(R_o * t))) - 12 * K_3 * Q * R / (L * t^2) \\
 &= -19,581 / (4 * 0.572 * (12.0079 + 1.56 * \text{Sqr}(42.0079 * 0.572))) - 12 * 0.0529 * 19,581 * 41.7219 / (226.2992 * 0.572^2) \\
 &= \underline{-7,440} \text{ psi}
 \end{aligned}$$

Circumferential stress at saddle horns is acceptable ($\leq 1.5 * S_a = 27,450$ psi)

The wear plate was not considered in the calculation of S_4 because the wear plate width is not at least $\{b + 1.56 * (R_o * t)^{0.5}\} = 19.6548$ in

Ring compression in shell over right saddle (Weight, Operating)

$$\begin{aligned}
 S_5 &= K_5 * Q / ((t + t_p) * (t_s + 1.56 * \text{Sqr}(R_o * t_s))) \\
 &= 0.7603 * 19,581 / ((0.572 + 0.2756) * (0.4724 + 1.56 * \text{Sqr}(42.0079 * 0.8476))) \\
 &= \underline{1,796} \text{ psi}
 \end{aligned}$$

Ring compression in shell is acceptable ($\leq 0.5 * S_y = 18,000$ psi)

Saddle splitting load (right, Weight, Operating)

Area resisting splitting force = Web area + wear plate area

$$\begin{aligned}
 A_e &= H_{\text{eff}} * t_s + t_p * W_p \\
 &= 4.8031 * 0.4724 + 0.2756 * 14.2126 \\
 &= 6.1861 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 S_6 &= K_8 * Q / A_e \\
 &= 0.2035 * 19,581 / 6.1861 \\
 &= \underline{644} \text{ psi}
 \end{aligned}$$

Stress in saddle is acceptable ($\leq (2 / 3) * S_s = 13,749$ psi)

Longitudinal stress at the left saddle (Weight, Operating)

$$\begin{aligned}
 L_e &= 2 * (\text{Left head depth}) / 3 + L + 2 * (\text{Right head depth}) / 3 \\
 &= 2 * 42.0079 / 3 + 226.2992 + 2 * 42.0079 / 3 \\
 &= 282.3097 \text{ in}
 \end{aligned}$$

$$w = W_t / L_e = 38,571 / 282.3097 = 136.63 \text{ lb/in}$$

Bending moment at the left saddle:

$$\begin{aligned}
 M_q &= w * (2 * H * A_1 / 3 + A_1^2 / 2 - (R^2 - H^2) / 4) \\
 &= 136.63 * (2 * 42.0079 * 64.4094 / 3 + 64.4094^2 / 2 - (42.0079^2 - 42.0079^2) / 4) \\
 &= 529,850 \text{ lb-in}
 \end{aligned}$$

$$\begin{aligned}
 S_2 &= \pm M_q * K_1' / (\pi * R^2 * t) \\
 &= 529,850 * 9.3799 / (\pi * 41.7389^2 * 0.538) \\
 &= 1,688 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 S_p &= P * R / (2 * t) \\
 &= 160.35 * 41.4699 / (2 * 0.538) \\
 &= 6,180 \text{ psi}
 \end{aligned}$$

Maximum tensile stress $S_{2t} = S_2 + S_p = \underline{7,868}$ psi

Maximum compressive stress (shut down) $S_{2c} = S_2 = \underline{1,688}$ psi

Tensile stress is acceptable ($\leq S = 18,300$ psi)

Compressive stress is acceptable ($\leq S_c = 14,074$ psi)

Tangential shear stress in the shell (left saddle, Weight, Operating)

$$\begin{aligned}
 Q_{\text{shear}} &= Q - w * (a + 2 * H / 3) \\
 &= 18,990 - 136.63 * (64.4094 + 2 * 42.0079 / 3) \\
 &= 6,363.7 \text{ lb}_f
 \end{aligned}$$

$$\begin{aligned}
 S_3 &= K_{2.2} * Q_{\text{shear}} / (R * t) \\
 &= 1.1707 * 6,363.7 / (41.7389 * 0.538) \\
 &= \underline{332} \text{ psi}
 \end{aligned}$$

Tangential shear stress is acceptable ($\leq 0.8 * S = 14,640$ psi)

Circumferential stress at the left saddle horns (Weight, Operating)

$$\begin{aligned}
 S_4 &= -Q / (4 * t * (b + 1.56 * \text{Sqr}(R_o * t))) - 12 * K_3 * Q * R / (L * t^2) \\
 &= -18,990 / (4 * 0.538 * (12.0079 + 1.56 * \text{Sqr}(42.0079 * 0.538))) - 12 * 0.0529 * 18,990 * 41.7389 / (226.2992 * 0.538^2) \\
 &= \underline{-8,136} \text{ psi}
 \end{aligned}$$

Circumferential stress at saddle horns is acceptable ($\leq 1.5 \cdot S_a = 27,450$ psi)

The wear plate was not considered in the calculation of S_a because the wear plate width is not at least $\{b + 1.56 \cdot (R_o \cdot t)^{0.5}\} = 19.4241$ in

Ring compression in shell over left saddle (Weight, Operating)

$$\begin{aligned} S_5 &= K_5 \cdot Q / ((t + t_p) \cdot (t_s + 1.56 \cdot \text{Sqr}(R_o \cdot t_c))) \\ &= 0.7603 \cdot 18,990 / ((0.538 + 0.2756) \cdot (0.4724 + 1.56 \cdot \text{Sqr}(42.0079 \cdot 0.8136))) \\ &= \underline{1,850} \text{ psi} \end{aligned}$$

Ring compression in shell is acceptable ($\leq 0.5 \cdot S_y = 18,000$ psi)

Saddle splitting load (left, Weight, Operating)

Area resisting splitting force = Web area + wear plate area

$$\begin{aligned} A_c &= H_{\text{eff}} \cdot t_s + t_p \cdot W_p \\ &= 4.8031 \cdot 0.4724 + 0.2756 \cdot 14.2126 \\ &= 6.1861 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} S_6 &= K_8 \cdot Q / A_c \\ &= 0.2035 \cdot 18,990 / 6.1861 \\ &= \underline{625} \text{ psi} \end{aligned}$$

Stress in saddle is acceptable ($\leq (2/3) \cdot S_s = 13,749$ psi)

Load Case 2: Weight, Test

Longitudinal stress between saddles (Weight, Test, left saddle loading and geometry govern)

$$\begin{aligned} S_1 &= \pm 3 \cdot K_1 \cdot Q \cdot (L / 12) / (\pi \cdot R^2 \cdot t) \\ &= 3 \cdot -0.3369 \cdot 32,689 \cdot (226.2992 / 12) / (\pi \cdot 41.7389^2 \cdot 0.538) \\ &= -212 \text{ psi} \end{aligned}$$

$$\begin{aligned} S_p &= P \cdot R / (2 \cdot t) \\ &= 240.53 \cdot 41.4699 / (2 \cdot 0.538) \\ &= 9,270 \text{ psi} \end{aligned}$$

Maximum tensile stress $S_{1t} = S_1 + S_p = \underline{9,059}$ psi

Maximum compressive stress (shut down) $S_{1c} = S_1 = \underline{-212}$ psi

Tensile stress is acceptable ($\leq 0.9 \cdot S_y \cdot E = 33,300$ psi)

Compressive stress is acceptable ($\leq S_c = 14,074$ psi)

Longitudinal stress at the right saddle (Weight, Test)

$$\begin{aligned} L_c &= 2 \cdot (\text{Left head depth}) / 3 + L + 2 \cdot (\text{Right head depth}) / 3 \\ &= 2 \cdot 42.0079 / 3 + 226.2992 + 2 \cdot 42.0079 / 3 \\ &= 282.3097 \text{ in} \end{aligned}$$

$$w = W_t / L_c = 66,455 / 282.3097 = 235.4 \text{ lb/in}$$

Bending moment at the right saddle:

$$\begin{aligned} M_q &= w \cdot (2 \cdot H \cdot A_c / 3 + A_c^2 / 2 - (R^2 - H^2) / 4) \\ &= 235.4 \cdot (2 \cdot 42.0079 \cdot 66.2598 / 3 + 66.2598^2 / 2 - (42.0079^2 - 42.0079^2) / 4) \\ &= 953,549.5 \text{ lb}_f\text{-in} \end{aligned}$$

$$\begin{aligned} S_2 &= \pm M_q \cdot K_1' / (\pi \cdot R^2 \cdot t) \\ &= 953,549.5 \cdot 9.3799 / (\pi \cdot 41.7219^2 \cdot 0.572) \\ &= 2,859 \text{ psi} \end{aligned}$$

$$\begin{aligned} S_p &= P \cdot R / (2 \cdot t) \\ &= 240.53 \cdot 41.4359 / (2 \cdot 0.572) \\ &= 8,712 \text{ psi} \end{aligned}$$

Maximum tensile stress $S_{2t} = S_2 + S_p = \underline{11,571}$ psi

Maximum compressive stress (shut down) $S_{2c} = S_2 = \underline{2,859}$ psi

Tensile stress is acceptable ($\leq 0.9 \cdot S_y = 33,300$ psi)

Compressive stress is acceptable ($\leq S_c = 14,323$ psi)

Tangential shear stress in the shell (right saddle, Weight, Test)

$$\begin{aligned} Q_{\text{shear}} &= Q - w \cdot (a + 2 \cdot H / 3) \\ &= 33,766 - 235.4 \cdot (66.2598 + 2 \cdot 42.0079 / 3) \\ &= 11,576.23 \text{ lb}_f \end{aligned}$$

$$\begin{aligned} S_3 &= K_{2.2} \cdot Q_{\text{shear}} / (R \cdot t) \\ &= 1.1707 \cdot 11,576.23 / (41.7219 \cdot 0.572) \\ &= \underline{568} \text{ psi} \end{aligned}$$

Tangential shear stress is acceptable ($\leq 0.8 \cdot (0.9 \cdot S_y) = 26,640$ psi)

Circumferential stress at the right saddle horns (Weight, Test)

$$\begin{aligned} S_4 &= -Q / (4 * t * (b + 1.56 * \text{Sqr}(R_o * t))) - 12 * K_3 * Q * R / (L * t^2) \\ &= -33,766 / (4 * 0.572 * (12.0079 + 1.56 * \text{Sqr}(42.0079 * 0.572))) - 12 * 0.0529 * 33,766 * 41.7219 / (226.2992 * 0.572^2) \\ &= \underline{-12.829} \text{ psi} \end{aligned}$$

Circumferential stress at saddle horns is acceptable ($\leq 0.9 * S_y = 33,300$ psi)

The wear plate was not considered in the calculation of S_4 because the wear plate width is not at least $\{b + 1.56 * (R_o * t)^{0.5}\} = 19.6548$ in

Ring compression in shell over right saddle (Weight, Test)

$$\begin{aligned} S_5 &= K_5 * Q / ((t + t_p) * (t_s + 1.56 * \text{Sqr}(R_o * t_c))) \\ &= 0.7603 * 33,766 / ((0.572 + 0.2756) * (0.4724 + 1.56 * \text{Sqr}(42.0079 * 0.8476))) \\ &= \underline{3.097} \text{ psi} \end{aligned}$$

Ring compression in shell is acceptable ($\leq 0.9 * S_y = 32,400$ psi)

Saddle splitting load (right, Weight, Test)

Area resisting splitting force = Web area + wear plate area

$$\begin{aligned} A_e &= H_{eff} * t_s + t_p * W_p \\ &= 4.8031 * 0.4724 + 0.2756 * 14.2126 \\ &= 6.1861 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} S_6 &= K_8 * Q / A_e \\ &= 0.2035 * 33,766 / 6.1861 \\ &= \underline{1.111} \text{ psi} \end{aligned}$$

Stress in saddle is acceptable ($\leq 0.9 * S_y = 32,400$ psi)

Longitudinal stress at the left saddle (Weight, Test)

$$\begin{aligned} L_e &= 2 * (\text{Left head depth}) / 3 + L + 2 * (\text{Right head depth}) / 3 \\ &= 2 * 42.0079 / 3 + 226.2992 + 2 * 42.0079 / 3 \\ &= 282.3097 \text{ in} \end{aligned}$$

$$w = W_l / L_e = 66,455 / 282.3097 = 235.4 \text{ lb/in}$$

Bending moment at the left saddle:

$$\begin{aligned} M_q &= w * (2 * H * A_l / 3 + A_l^2 / 2 - (R^2 - H^2) / 4) \\ &= 235.4 * (2 * 42.0079 * 64.4094 / 3 + 64.4094^2 / 2 - (42.0079^2 - 42.0079^2) / 4) \\ &= 912,892.7 \text{ lb}_f\text{-in} \end{aligned}$$

$$\begin{aligned} S_2 &= \pm M_q * K_1' / (\pi * R^2 * t) \\ &= 912,892.7 * 9.3799 / (\pi * 41.7389^2 * 0.538) \\ &= 2,908 \text{ psi} \end{aligned}$$

$$\begin{aligned} S_p &= P * R / (2 * t) \\ &= 240.53 * 41.4699 / (2 * 0.538) \\ &= 9,270 \text{ psi} \end{aligned}$$

Maximum tensile stress $S_{2t} = S_2 + S_p = \underline{12.178}$ psi

Maximum compressive stress (shut down) $S_{2c} = S_2 = \underline{2.908}$ psi

Tensile stress is acceptable ($\leq 0.9 * S_y = 33,300$ psi)

Compressive stress is acceptable ($\leq S_c = 14,074$ psi)

Tangential shear stress in the shell (left saddle, Weight, Test)

$$\begin{aligned} Q_{\text{shear}} &= Q - w * (a + 2 * H / 3) \\ &= 32,689 - 235.4 * (64.4094 + 2 * 42.0079 / 3) \\ &= 10,934.81 \text{ lb}_f \end{aligned}$$

$$\begin{aligned} S_3 &= K_{2.2} * Q_{\text{shear}} / (R * t) \\ &= 1.1707 * 10,934.81 / (41.7389 * 0.538) \\ &= \underline{570} \text{ psi} \end{aligned}$$

Tangential shear stress is acceptable ($\leq 0.8 * (0.9 * S_y) = 26,640$ psi)

Circumferential stress at the left saddle horns (Weight, Test)

$$\begin{aligned} S_4 &= -Q / (4 * t * (b + 1.56 * \text{Sqr}(R_o * t))) - 12 * K_3 * Q * R / (L * t^2) \\ &= -32,689 / (4 * 0.538 * (12.0079 + 1.56 * \text{Sqr}(42.0079 * 0.538))) - 12 * 0.0529 * 32,689 * 41.7389 / (226.2992 * 0.538^2) \\ &= \underline{-14.005} \text{ psi} \end{aligned}$$

Circumferential stress at saddle horns is acceptable ($\leq 0.9 * S_y = 33,300$ psi)

The wear plate was not considered in the calculation of S_4 because the wear plate width is not at least $\{b + 1.56 * (R_o * t)^{0.5}\} = 19.4241$ in

Ring compression in shell over left saddle (Weight, Test)

$$S_5 = K_5 * Q / ((t + t_p) * (t_s + 1.56 * \text{Sqr}(R_o * t_c)))$$

$$= 0.7603 * 32,689 / ((0.538 + 0.2756) * (0.4724 + 1.56 * \text{Sqr}(42.0079 * 0.8136)))$$

$$= \underline{3.185} \text{ psi}$$

Ring compression in shell is acceptable ($\leq 0.9 * S_y = 32,400 \text{ psi}$)

Saddle splitting load (left, Weight, Test)

Area resisting splitting force = Web area + wear plate area

$$A_c = H_{ef} * t_s + t_p * W_p$$

$$= 4.8031 * 0.4724 + 0.2756 * 14.2126$$

$$= 6.1861 \text{ in}^2$$

$$S_6 = K_8 * Q / A_c$$

$$= 0.2035 * 32,689 / 6.1861$$

$$= \underline{1.075} \text{ psi}$$

Stress in saddle is acceptable ($\leq 0.9 * S_y = 32,400 \text{ psi}$)

Shear stress in anchor bolting, one end slotted

Maximum seismic or wind base shear = 0 lb_f

Thermal expansion base shear = $W * \mu = 20,024 * 0.45 = 9,010.8 \text{ lb}_f$
Corroded root area for a 0.625" coarse threaded bolt = 0.202 in² (2 per saddle)

Bolt shear stress = $9,010.8 / (0.202 * 1 * 2) = 22,304 \text{ psi}$

**** Anchor bolt stress is excessive (> 18,800 psi)****

Shear stress in anchor bolting, transverse

Maximum seismic or wind base shear = 0 lb_f
Corroded root area for a 0.625" coarse threaded bolt = 0.202 in² (2 per saddle)

Bolt shear stress = $0 / (0.202 * 2 * 2) = 0 \text{ psi}$

Anchor bolt stress is acceptable ($\leq 18,800 \text{ psi}$)

Web plate buckling check (Esgoe pg 251)

Allowable compressive stress S_c is the lesser of 20,624 or 10,317 psi: (10,317)

$$S_c = K_1 * \pi^2 * E / (12 * (1 - 0.3^2) * (d_i / t_s)^2)$$

$$= 1.28 * \pi^2 * 29E+06 / (12 * (1 - 0.3^2) * (26.9414 / 0.4724)^2)$$

$$= 10,317 \text{ psi}$$

Allowable compressive load on the saddle

$$b_c = d_i * t_s / (d_i * t_s + 2 * t_w * (b - 1))$$

$$= 26.9414 * 0.4724 / (26.9414 * 0.4724 + 2 * 0.4724 * (12.0079 - 1))$$

$$= 0.5503$$

$$F_b = n * (A_s + 2 * b_c * t_s) * S_c$$

$$= 4 * (5.4498 + 2 * 0.5503 * 0.4724) * 10,317$$

$$= 246,352.69 \text{ lb}_f$$

Saddle loading of 34,209 lb_f is $\leq F_b$; satisfactory.

Primary bending + axial stress in the saddle due to end loads (assumes one saddle slotted)

$$\sigma_b = V * (H_s - x_o) * y / I + Q / A$$

$$= 0 * (47.5591 - 34.7402) * 7.6325 / 485.97 + 19,581 / 56.1739$$

$$= 349 \text{ psi}$$

The primary bending + axial stress in the saddle $\leq S_s = 20,624 \text{ psi}$; satisfactory.

Secondary bending + axial stress in the saddle due to end loads (includes thermal expansion, assumes one saddle slotted)

$$\sigma_b = V * (H_s - x_o) * y / I + Q / A$$

$$= 9,010.8 * (47.5591 - 34.7402) * 7.6325 / 485.97 + 19,581 / 56.1739$$

$$= 2,163 \text{ psi}$$

The secondary bending + axial stress in the saddle $\leq 2 * S_y = 72,000 \text{ psi}$; satisfactory.

Saddle base plate thickness check (Roark sixth edition, Table 26, case 7a)

where $a = 26.9414$, $b = 11.5354 \text{ in}$

$$t_b = (\beta_1 * q * b^2 / (1.5 * S_u))^{0.5}$$

$$= (2.0208 * 38 * 11.5354^2 / (1.5 * 20,624))^{0.5}$$

$$= 0.5767 \text{ in}$$

**** WARNING The base plate thickness is not adequate ****

Foundation bearing check

$$\begin{aligned} S_f &= Q_{\max} / (F * E) \\ &= 34,209 / (12.0079 * 74.4488) \\ &= 38 \text{ psi} \end{aligned}$$

Concrete bearing stress $\leq 1,658$ psi ; satisfactory.