

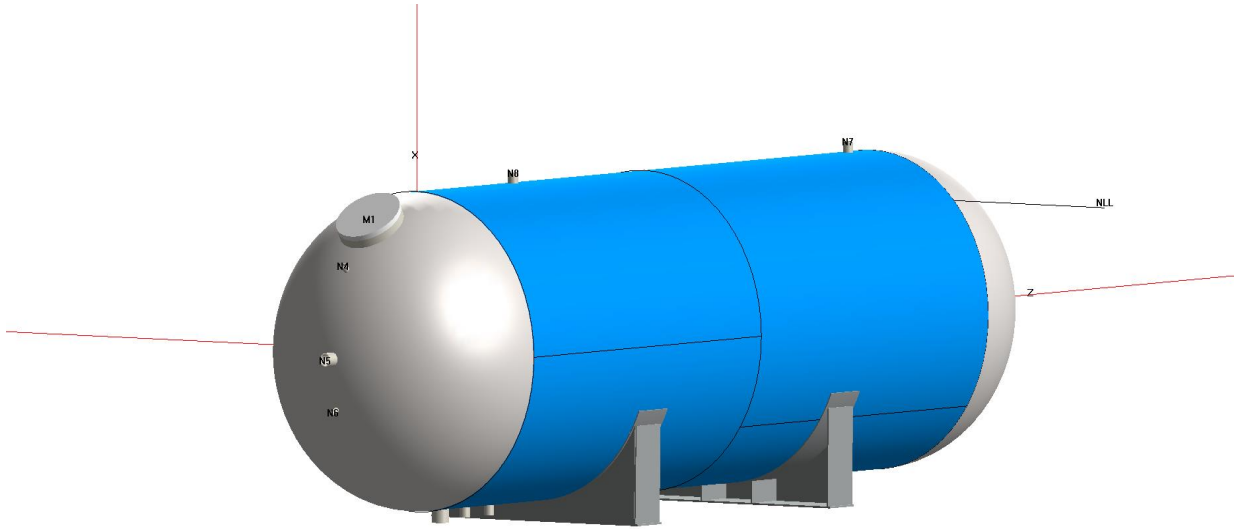
INSPECTRA S.R.L.

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Santa Cruz de la Sierra

Bolivia



N. Trabajo 116-18-T-C

Vessel N° GLP-V-09

Número Documento MC-V-09/01

Revisión: 0

Cliente: YPFB TRANSPORTE S.A.

Diseñado por: Ingeniería Inspectra S.R.L.

Fecha: jueves, abril 04, 2019

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Deficiencies Summary

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

Nozzle MAWP (173.17 psi) is less than the design pressure (250 psi).

UG-37: Not adequately reinforced (Internal Pressure)

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

Nozzle MAWP (167.88 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 (0.328") is less than the design thickness (0.3284").

Deficiencies for [C-02](#)

The nominal thickness (0.328") is less than the design thickness (0.3284").

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

Nozzle MAWP (167.98 psi) is less than the design pressure (250 psi).

Required thickness t_r for the input nozzle pressure exceeds the component 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 (249.49 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 0.328 in.

SA-105: PWHT is mandatory for thicknesses over 1.25 in. (nozzle circumferential seam).

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

Nozzle MAWP (249.33 psi) is less than the design pressure (250 psi).

Required thickness t_r for the input nozzle pressure exceeds the component 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 0.328 in.

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

The base plate thickness is not adequate.

Anchor bolting is not adequate.

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

Nozzle MAWP (166.5 psi) is less than the design pressure (250 psi).

Required thickness t_r for the input nozzle pressure exceeds the component 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 (0.573") is less than the design thickness (0.5739").

Deficiencies for [V-02](#)

The nominal thickness (0.573") 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").

SA-105: PWHT is mandatory for thicknesses over 1.25 in.

Engineering Notes

1. Dado que la entrada de hombre no es de tamaño estándar, se ha modelado con un cuello de las mismas dimensiones de la instalada y una tapa soldada con acero SA-105. El software no acepta tapas tipo studbolt no estándar.
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 para efectos del modelado se ha colocado esta entrada de inspección hecha de tubo, manulamente, ya que las dimensiones no son estándar, y este tipo de accesorios forjados se fabrican sin costura.
5. La deficiencia que se presenta sobre el Welded Cover #1 no es válida, ya que la unión con la entrada de hombre es bridada, y dado que la entrada de inspección no tiene medidas estándares no se puede modelar la unión con bridada.

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 _a /A _r (%)
						Nom t (in)	Design t (in)	User t (in)	Width (in)	t _{pad} (in)		
M1	19.685	2.3425	0.2773	Yes	Yes	0.328*	0.2773		N/A	N/A	0	100.0
N1	5	0.75	0.0625	Yes	Yes	0.573	0.5724		N/A	N/A	0	100.0
N2	3	0.31	0.0625	Yes	Yes	0.573	0.384		N/A	N/A	0	100.0
N3	3	0.31	0.0625	Yes	Yes	0.573	0.3874		N/A	N/A	0	100.0
N4	1.75	0.345	0.0625	Yes	Yes	0.328*	N/A		N/A	N/A	0	Exempt
N5	3.62	0.37	0.0625	Yes	Yes	0.328*	N/A		N/A	N/A	0	Exempt
N6	1.38	0.16	0.0625	Yes	Yes	0.328*	N/A		N/A	N/A	0	Exempt
N7	3	0.31	0.0625	Yes	Yes	0.573	0.396		N/A	N/A	0	100.0
N8	3	0.31	0.0625	Yes	Yes	0.573	0.384		N/A	N/A	0	100.0
*Head minimum thickness after forming												

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

Pressure Summary

Component Summary						
Identifier	P Design (psi)	T Design (° F)	MAWP (psi)	MDMT (° F)	MDMT Exemption	Impact Tested
C-01	250	125	249.73	-27	Note 1	No
V-01	250	125	249.61	5.01	Note 2	No
V-02	250	125	249.61	5.01	Note 2	No
C-02	250	125	249.73	-27	Note 1	No
PT (Cuna 1 y 2)	250	125	166.5	N/A	N/A	N/A
Entrada de Inspección (M1)	250	125	249.49	-150	Note 3	No
Welded Cover #1	250	125	496.62	-150	Note 4	No
Entrada PVT (N1)	250	125	249.33	-150	Note 5	No
Salida (N2)	250	125	166.5	-150	Note 6	No
Compensación (N3)	250	125	167.98	-150	Note 6	No
Indicador de Presión (N4)	250	125	295.3	-150	Note 7	No
Indicador de Nivel (N5)	250	125	294.86	-150	Note 8	No
Indicador de Temperatura (N6)	250	125	294.59	-150	Note 9	No
Alivio de presión (N7)	250	125	173.17	-150	Note 10	No
Alivio de presión (N8)	250	125	167.88	-150	Note 10	No

Chamber Summary	
Design MDMT	6 ° F
Rated MDMT	5.01 ° F @ 166.5 psi
MAWP hot & corroded	166.5 psi @ 125 ° F
(1) This pressure chamber is not designed for external pressure.	

Notes for Maximum Pressure Rating	
Note #	Details
1.	Option to calculate MAP was not selected. See the Calculation->General tab of the Set Mode dialog.

Notes for MDMT Rating		
Note #	Exemption	Details
1.	Material impact test exemption temperature from Fig UCS-66 Curve A = 18 °F Fig UCS-66.1 MDMT reduction = 45 °F, (coincident ratio = 0.5694)	UCS-66 governing thickness = 0.328 in
2.	Material impact test exemption temperature from Fig UCS-66 Curve A = 38.01 °F Fig UCS-66.1 MDMT reduction = 33 °F, (coincident ratio = 0.6701)	UCS-66 governing thickness = 0.573 in
3.	Nozzle is impact test exempt to -150 °F per UCS-66(b)(3) (coincident ratio = 0.0306).	
4.	Head is impact test exempt to -150 °F per UCS-66(b)(3) (coincident ratio = 0.3353)	
5.	Nozzle is impact test exempt to -150 °F per UCS-66(b)(3) (coincident ratio = 0.0225).	
6.	Nozzle is impact test exempt to -150 °F per UCS-66(b)(3) (coincident ratio = 0.037).	
7.	Nozzle is impact test exempt to -150 °F per UCS-66(b)(3) (coincident ratio = 0.0147).	
8.	Nozzle is impact test exempt to -150 °F per UCS-66(b)(3) (coincident ratio = 0.0374).	
9.	Nozzle is impact test exempt to -150 °F per UCS-66(b)(3) (coincident ratio = 0.0319).	
10.	Nozzle is impact test exempt to -150 °F per UCS-66(b)(3) (coincident ratio = 0.0367).	

Settings Summary

INSPECT 2019 Build 7900	
ASME Section VIII Division 1, 1995 Edition	
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 ≤ 1.50 " thick	No
UG-37(a) shell tr calculation considers longitudinal stress	No
Cylindrical shells made from pipe are entered as minimum thickness	No
Nozzles made from pipe are entered as minimum thickness	No
ASME B16.9 fittings are entered as minimum thickness	No
Butt welds	Tapered per Figure UCS-66.3(a)
Disallow Appendix 1-5, 1-8 calculations under 15 psi	No
Hydro/Pneumatic Test	
Shop Hydrotest Pressure	1.5 times vessel MAWP [UG-99(b)]
Test liquid specific gravity	1.00
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	October 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
Y-01	A	Full UW-11(a) / Type 1	A	Full UW-11(a) / Type 1	B	Full UW-11(a) / Type 1	RT1
Y-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 $\leq 3/8$	84.0157 OD	42.0079	0.328*	0.3284	0	0.85	Internal
V-01	SA-455 ($3/8 < t \leq 5/8$)	84.0157 OD	113.1496	0.573	0.5739	0	1.00	Internal
V-02	SA-455 ($3/8 < t \leq 5/8$)	84.0157 OD	113.1496	0.573	0.5739	0	1.00	Internal
C-02	SA-455 $\leq 3/8$	84.0157 OD	42.0079	0.328*	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 ft ²
							New	Corroded	New	Corroded	
C-01	991.6	991.6	0	0	0	0	2,775.7	2,775.7	5,481.9	5,481.9	75
V-01	4,803.2	4,803.2	0	0	0	0	10,810	10,810	22,032.2	22,032.2	207
V-02	4,808.7	4,808.7	0	0	0	0	10,808.8	10,808.8	22,030.1	22,030.1	207
C-02	1,021.2	1,021.2	0	0	0	0	2,775.2	2,775.2	5,474.1	5,474.1	77
PT (Cuna 1 y 2)	886	886	0	0	0	0	0	0	0	0	77
TOTAL:	12,510.8	12,510.8	0	0	0	0	27,169.6	27,169.6	55,018.3	55,018.3	644

*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 ft ²
	New	Corroded	New	Corroded						
C-01	0	0	223.8	223.8	0	0	0	0	0	4
V-01	0	0	19.6	19.6	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	245.9	245.9	0	0	0	0	0	5

Vessel Totals		
	New	Corroded
Operating Weight (lb)	39,926	39,926
Empty Weight (lb)	12,757	12,757
Test Weight (lb)	67,775	67,775
Surface Area (ft ²)	648	-
Capacity** (US gal)	6,597	6,597
**The vessel capacity does not include volume of nozzle, piping or other attachments.		

Vessel Lift Condition	
Vessel Lift Weight, New (lb)	12,757
Center of Gravity from Datum (in)	110.9125

Bill of Materials

Heads / Covers						
Item #	Type	Material	Thk [in]	Dia. [in]	Wt. [lb] (ea.)	Qty
H1	Hemi Head	SA-455 <= 3/8	0.328 (min.)	84.0157 OD	1,021.2	2
H2	Welded Cover	SA-105	1.4516	15 ID	125	1

Shells							
Item #	Type	Material	Thk [in]	Dia. [in]	Length [in]	Wt. [lb] (ea.)	Qty
S1	Cylinder	SA-455 (3/8 < t <= 5/8)	0.573	84.0157 OD	113.1	4,809.9	2

Nozzles							
Item #	Type	Material	NPS	Thk [in]	Dia. [in]	Length [in]	Wt. [lb]
Noz1	Nozzle	SA-105	-	2.3425	19.685 OD	2.6	93.1

Nozzles - Couplings						
Item #	Type		Material	Dia. [in]	Length [in]	Qty
C1	NPS 0.75 Class 6000 - Threaded Full Coupling		SA-105	1.75 OD	2.466	1
C2	NPS 2.5 Class 3000 - Threaded Full Coupling		SA-105	3.62 OD	3.9404	1
C3	NPS 0.75 Class 3000 - Threaded Full Coupling		SA-105	1.38 OD	2.3576	1
C4	NPS 2 Class 3000 - Threaded Full Coupling		SA-105	3 OD	3.38	4
C5	NPS 3 Class 6000 - Threaded Full Coupling		SA-105	5 OD	4.25	1

Fasteners				
Item #	Description	Material	Length [in]	Qty
SB1	5/8" coarse bolt	SA-193 B8	-	4

Plates				
Item #	Material	Thk [in]	Wt. [lb]	Qty [ft^2]
Plate1	A283 GR C	0.2756	214.6	19.17
Plate1 - Note: Applies to saddle wear plate				
Plate2	A283 GR C	0.4724	670.7	34.84
Plate2 - Note: Applies to saddle base plate, saddle web plate				

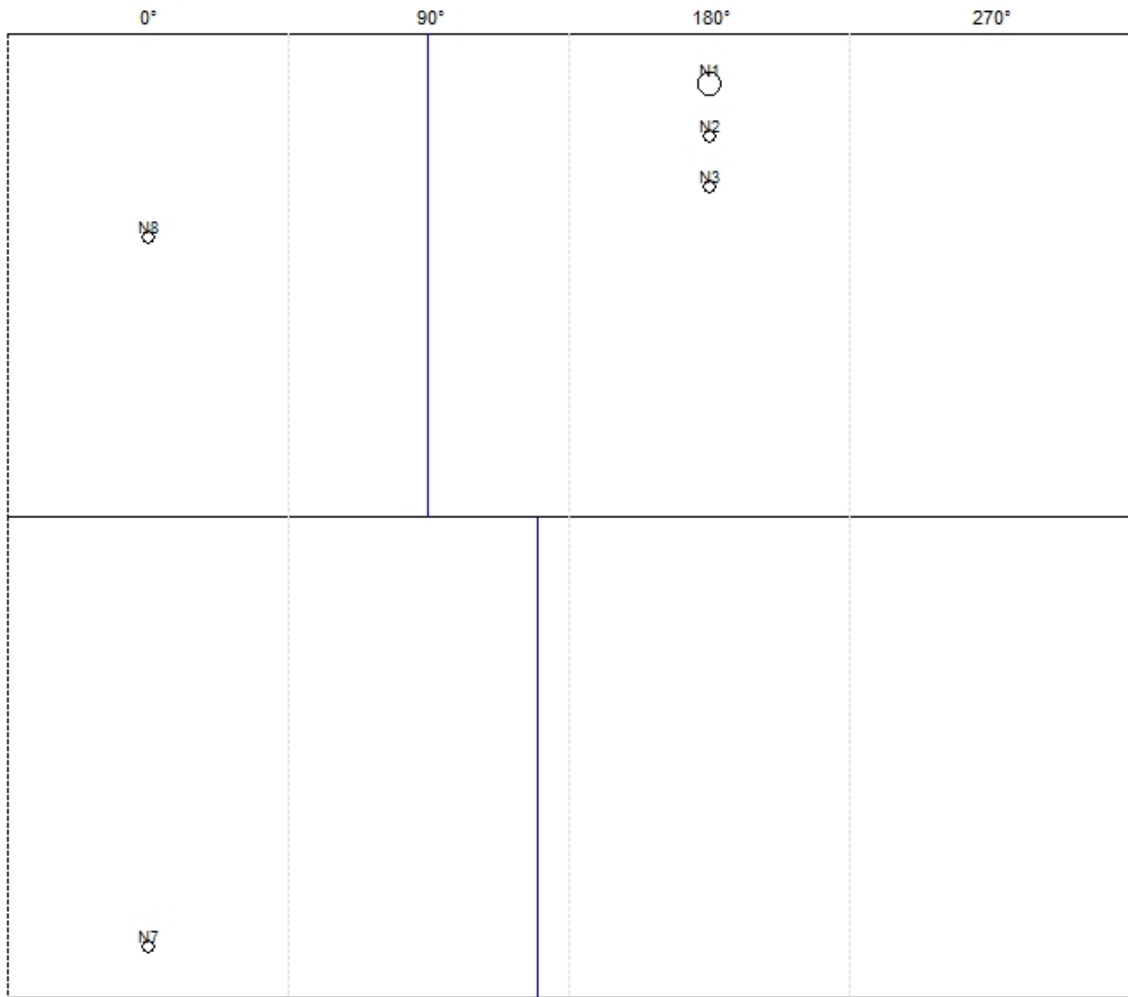
Long Seam Summary

Shell Long Seam Angles	
Component	Seam 1
V-01	90 deg
V-02	125 deg

Shell Plate Lengths		
Component	Starting Angle	Plate 1
V-01	90 deg	262.1431"
V-02	125 deg	262.1431"

Note

1) Plate Lengths use the circumference of the vessel based on the mid diameter of the components.



Shell Rollout

Hydrostatic Test

Horizontal shop hydrostatic test based on MAWP per UG-99(b)

$$\begin{aligned}
 \text{Gauge pressure at } 70^{\circ}\text{F} &= \\
 &= 1.5 \cdot \text{MAWP} \cdot \text{LSR} \\
 &= 1.5 \cdot 166.5 \cdot 1 \\
 &= 249.74 \text{ psi}
 \end{aligned}$$

Horizontal shop hydrostatic test				
Identifier	Local test pressure (psi)	Test liquid static head (psi)	UG-99(b) stress ratio	UG-99(b) pressure factor
C-01 (1)	252.866	3.121	1	1.50
V-01	252.857	3.112	1	1.50
V-02	252.857	3.112	1	1.50
C-02	252.866	3.121	1	1.50
Welded Cover #1	250.059	0.315	1	1.50
Alivio de presión (N7)	249.845	0.1	1	1.50
Alivio de presión (N8)	249.845	0.1	1	1.50
Compensación (N3)	252.978	3.233	1	1.50
Entrada PVT (N1)	253.008	3.263	1	1.50
Entrada de Inspección (M1)	250.092	0.348	1	1.50
Indicador de Nivel (N5)	251.413	1.669	1	1.50
Indicador de Presión (N4)	250.523	0.778	1	1.50
Indicador de Temperatura (N6)	251.868	2.123	1	1.50
Salida (N2)	252.978	3.233	1	1.50
(1) C-01 limits the UG-99(b) stress ratio. (2) The zero degree angular position is assumed to be up, and the test liquid height is assumed to the top-most flange.				

The field test condition has not been investigated.

The test temperature of 70 °F is warmer than the minimum recommended temperature of 35.01 °F so the brittle fracture provision of UG-99(h) has been met.

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	71.4306	0.5368
Test horizontal		3.12	86.4676	1
Dimensions				
Outer Diameter		84.0157"		
Minimum Thickness		0.328"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		Capacity (US gal)
New		991.62		656.49
Corroded		991.62		656.49
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)	249.73 psi
Rated MDMT	-27 °F

UCS-66 Material Toughness Requirements	
Governing thickness, $t_g =$	0.328"
Exemption temperature from Fig UCS-66 Curve A =	18 °F
$t_r = 167.88 \cdot 42.0079 / (2 \cdot 18,800 \cdot 0.85 + 0.8 \cdot 167.88) =$	0.2197"
Stress ratio $= t_r \cdot E^* / (t_n - c) = 0.2197 \cdot 0.85 / (0.328 - 0) =$	0.5694
Reduction in MDMT, T_R from Fig UCS-66.1 =	45 °F
MDMT = max[MDMT - T_R , -50] = max[18 - 45 , -50] =	-27 °F
Material is exempt from impact testing at the Design MDMT of 6 °F.	

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

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (R_o - 0.80 \cdot t) - P_s \\
 &= 2 \cdot 18,800 \cdot 0.85 \cdot 0.328 / (42.0079 - 0.80 \cdot 0.328) - 1.38 \\
 &= \underline{249.73} \text{ psi}
 \end{aligned}$$

% Extreme fiber elongation - UCS-79(d)

$$\begin{aligned}
 EFE &= (75 \cdot t / R_f) \cdot (1 - R_f / R_o) \\
 &= (75 \cdot 0.328 / 41.8439) \cdot (1 - 41.8439 / \text{infinity}) \\
 &= 0.5879\%
 \end{aligned}$$

The extreme fiber elongation does not exceed 5%.

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

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (42.0079 / 0.328) \\
 &= 0.000976 \\
 B &= 12,183 \text{ psi} \\
 S &= 18,800 / 1.00 = 18,800 \text{ psi} \\
 S_{cHC} &= \min(B, S) = 12,183 \text{ psi}
 \end{aligned}$$

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

$$\begin{aligned}
 S_{cHN} &= S_{cHC} \\
 &= 12,183 \text{ psi}
 \end{aligned}$$

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

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (42.0079 / 0.328) \\
 &= 0.000976 \\
 B &= 12,183 \text{ psi}
 \end{aligned}$$

$$S = 18,800 / 1.00 = 18,800 \text{ psi}$$

$$S_{cCN} = \min(B, S) = 12,183 \text{ psi}$$

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

$$\begin{aligned} S_{cCC} &= S_{cCN} \\ &= 12,183 \text{ psi} \end{aligned}$$

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

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.328) \\ &= 0.000976 \end{aligned}$$

$$B = 12,183 \text{ psi}$$

$$S = 18,800 / 1.00 = 18,800 \text{ psi}$$

$$S_{cVC} = \min(B, S) = 12,183 \text{ psi}$$

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	71.4306	0.5368
Test horizontal		3.12	86.4676	1
Dimensions				
Outer Diameter		84.0157"		
Minimum Thickness		0.328"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		Capacity (US gal)
New		1,021.19		656.49
Corroded		1,021.19		656.49
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)	249.73 psi
Rated MDMT	-27 °F

UCS-66 Material Toughness Requirements	
Governing thickness, $t_g =$	0.328"
Exemption temperature from Fig UCS-66 Curve A =	18 °F
$t_r = 167.88 \cdot 42.0079 / (2 \cdot 18,800 \cdot 0.85 + 0.8 \cdot 167.88) =$	0.2197"
Stress ratio $= t_r \cdot E^* / (t_n - c) = 0.2197 \cdot 0.85 / (0.328 - 0) =$	0.5694
Reduction in MDMT, T_R from Fig UCS-66.1 =	45 °F
MDMT $= \max[\text{MDMT} - T_R, -50] = \max[18 - 45, -50] =$	-27 °F
Material is exempt from impact testing at the Design MDMT of 6 °F.	

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

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (R_o - 0.80 \cdot t) - P_s \\
 &= 2 \cdot 18,800 \cdot 0.85 \cdot 0.328 / (42.0079 - 0.80 \cdot 0.328) - 1.38 \\
 &= \underline{249.73} \text{ psi}
 \end{aligned}$$

% Extreme fiber elongation - UCS-79(d)

$$\begin{aligned}
 EFE &= (75 \cdot t / R_f) \cdot (1 - R_f / R_o) \\
 &= (75 \cdot 0.328 / 41.8439) \cdot (1 - 41.8439 / \text{infinity}) \\
 &= 0.5879\%
 \end{aligned}$$

The extreme fiber elongation does not exceed 5%.

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

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (42.0079 / 0.328) \\
 &= 0.000976 \\
 B &= 12,183 \text{ psi} \\
 S &= 18,800 / 1.00 = 18,800 \text{ psi} \\
 S_{cHC} &= \min(B, S) = 12,183 \text{ psi}
 \end{aligned}$$

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

$$\begin{aligned}
 S_{cHN} &= S_{cHC} \\
 &= 12,183 \text{ psi}
 \end{aligned}$$

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

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (42.0079 / 0.328) \\
 &= 0.000976 \\
 B &= 12,183 \text{ psi}
 \end{aligned}$$

$$S = 18,800 / 1.00 = 18,800 \text{ psi}$$

$$S_{cCN} = \min(B, S) = 12,183 \text{ psi}$$

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

$$\begin{aligned} S_{cCC} &= S_{cCN} \\ &= 12,183 \text{ psi} \end{aligned}$$

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

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.328) \\ &= 0.000976 \end{aligned}$$

$$B = 12,183 \text{ psi}$$

$$S = 18,800 / 1.00 = 18,800 \text{ psi}$$

$$S_{cVC} = \min(B, S) = 12,183 \text{ psi}$$

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	71.1856	0.5368
Test horizontal		3.11	86.2226	1
Dimensions				
Outer Diameter		84.0157"		
Length		113.1496"		
Nominal Thickness		0.573"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		Capacity (US gal)
New		4,803.24		2,641.94
Corroded		4,803.24		2,641.94
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)	249.61 psi
Rated MDMT	5.01 °F

UCS-66 Material Toughness Requirements	
Governing thickness, $t_g =$	0.573"
Exemption temperature from Fig UCS-66 Curve A =	38.01 °F
$t_r = 167.88 \cdot 42.0079 / (18,300 \cdot 1 + 0.4 \cdot 167.88) =$	0.384"
Stress ratio $= t_r \cdot E' / (t_n - c) = 0.384 \cdot 1 / (0.573 - 0) =$	0.6701
Reduction in MDMT, T_R from Fig UCS-66.1 =	33 °F
MDMT $= \max[\text{MDMT} - T_R, -50] = \max[38.01 - 33, -50] =$	5.01 °F
Material is exempt from impact testing at the Design MDMT of 6 °F.	

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

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

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

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R_o - 0.40 \cdot t) - P_s \\
 &= 18,300 \cdot 1.00 \cdot 0.573 / (42.0079 - 0.40 \cdot 0.573) - 1.38 \\
 &= \a href="#">249.61 \text{ psi}
 \end{aligned}$$

% Extreme fiber elongation - UCS-79(d)

$$\begin{aligned}
 \text{EFE} &= (50 \cdot t / R_f) \cdot (1 - R_f / R_o) \\
 &= (50 \cdot 0.573 / 41.7214) \cdot (1 - 41.7214 / \text{infinity}) \\
 &= 0.6867\%
 \end{aligned}$$

The extreme fiber elongation does not exceed 5%.

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

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (42.0079 / 0.573) \\
 &= 0.001705 \\
 B &= 14,330 \text{ psi} \\
 S &= 18,300 / 1.00 = 18,300 \text{ psi} \\
 S_{cHC} &= \min(B, S) = 14,330 \text{ psi}
 \end{aligned}$$

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

$$\begin{aligned} S_{cHN} &= S_{cHC} \\ &= 14,330 \text{ psi} \end{aligned}$$

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

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.573) \\ &= 0.001705 \\ B &= 14,330 \text{ psi} \\ S &= 18,300 / 1.00 = 18,300 \text{ psi} \\ S_{cCN} &= \min(B, S) = 14,330 \text{ psi} \end{aligned}$$

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

$$\begin{aligned} S_{cCC} &= S_{cCN} \\ &= 14,330 \text{ psi} \end{aligned}$$

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

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.573) \\ &= 0.001705 \\ B &= 14,330 \text{ psi} \\ S &= 18,300 / 1.00 = 18,300 \text{ psi} \\ S_{cVC} &= \min(B, S) = 14,330 \text{ psi} \end{aligned}$$

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	71.1856	0.5368
Test horizontal		3.11	86.2226	1
Dimensions				
Outer Diameter		84.0157"		
Length		113.1496"		
Nominal Thickness		0.573"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		Capacity (US gal)
New		4,808.72		2,641.94
Corroded		4,808.72		2,641.94
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)	249.61 psi
Rated MDMT	5.01 °F

UCS-66 Material Toughness Requirements	
Governing thickness, $t_g =$	0.573"
Exemption temperature from Fig UCS-66 Curve A =	38.01 °F
$t_r = 167.88 \cdot 42.0079 / (18,300 \cdot 1 + 0.4 \cdot 167.88) =$	0.384"
Stress ratio $= t_r \cdot E' / (t_n - c) = 0.384 \cdot 1 / (0.573 - 0) =$	0.6701
Reduction in MDMT, T_R from Fig UCS-66.1 =	33 °F
MDMT $= \max[\text{MDMT} - T_R, -50] = \max[38.01 - 33, -50] =$	5.01 °F
Material is exempt from impact testing at the Design MDMT of 6 °F.	

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

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

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

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R_o - 0.40 \cdot t) - P_s \\
 &= 18,300 \cdot 1.00 \cdot 0.573 / (42.0079 - 0.40 \cdot 0.573) - 1.38 \\
 &= \a href="#">249.61 \text{ psi}
 \end{aligned}$$

% Extreme fiber elongation - UCS-79(d)

$$\begin{aligned}
 \text{EFE} &= (50 \cdot t / R_f) \cdot (1 - R_f / R_o) \\
 &= (50 \cdot 0.573 / 41.7214) \cdot (1 - 41.7214 / \text{infinity}) \\
 &= 0.6867\%
 \end{aligned}$$

The extreme fiber elongation does not exceed 5%.

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

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (42.0079 / 0.573) \\
 &= 0.001705 \\
 B &= 14,330 \text{ psi} \\
 S &= 18,300 / 1.00 = 18,300 \text{ psi} \\
 S_{cHC} &= \min(B, S) = 14,330 \text{ psi}
 \end{aligned}$$

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

$$\begin{aligned} S_{cHN} &= S_{cHC} \\ &= 14,330 \text{ psi} \end{aligned}$$

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

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.573) \\ &= 0.001705 \\ B &= 14,330 \text{ psi} \\ S &= 18,300 / 1.00 = 18,300 \text{ psi} \\ S_{cCN} &= \min(B, S) = 14,330 \text{ psi} \end{aligned}$$

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

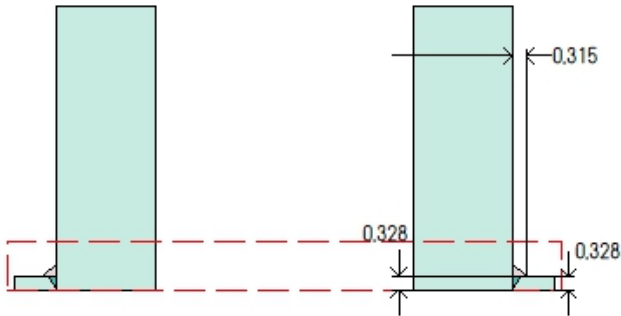
$$\begin{aligned} S_{cCC} &= S_{cCN} \\ &= 14,330 \text{ psi} \end{aligned}$$

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

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (42.0079 / 0.573) \\ &= 0.001705 \\ B &= 14,330 \text{ psi} \\ S &= 18,300 / 1.00 = 18,300 \text{ psi} \\ S_{cVC} &= \min(B, S) = 14,330 \text{ psi} \end{aligned}$$

Entrada de Inspección (M1)

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	Yes
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	2.25"
Local vessel minimum thickness	0.328"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.315"
Nozzle to vessel groove weld	0.328"

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 166.5 \times 7.5 / (17,500 \times 1 - 0.6 \times 166.5) =$	0.0718"
Stress ratio $= t_r \times E^* / (t_n - c) = 0.0718 \times 1 / (2.3425 - 0) =$	0.0306
Stress ratio ≤ 0.4 , MDMT per UCS-66(b)(3) =	-150°F
Material is exempt from impact testing at the Design MDMT of 6°F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 250 psi @ 125 °F <i>The opening is NOT adequately reinforced</i>							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
4.2574	4.2398	0.7363	3.4112	--	--	0.0923	0.2778	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)	0.2296	0.2205	weld size is NOT adequate

Calculations for internal pressure 250 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(15, 7.5 + (2.3425 - 0) + (0.328 - 0)) \\
 &= 15 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.328 - 0), 2.5*(2.3425 - 0) + 0) \\
 &= 0.82 \text{ in}
 \end{aligned}$$

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

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

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 250*42.0079 / (2*18,800*1 + 0.8*250) \\
 &= 0.2778 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 250*42.0079 / (2*18,800*0.85 + 0.8*250) \\
 &= 0.3266 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

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

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

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

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 15 \cdot 0.2778 \cdot 1 + 2 \cdot 2.3425 \cdot 0.2778 \cdot 1 \cdot (1 - 0.9309) \\ &= \underline{4.2574} \text{ in}^2 \end{aligned}$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0.7363} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 15 \cdot (1 \cdot 0.328 - 1 \cdot 0.2778) - 2 \cdot 2.3425 \cdot (1 \cdot 0.328 - 1 \cdot 0.2778) \cdot (1 - 0.9309) \\ &= 0.7363 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (0.328 + 2.3425) \cdot (1 \cdot 0.328 - 1 \cdot 0.2778) - 2 \cdot 2.3425 \cdot (1 \cdot 0.328 - 1 \cdot 0.2778) \cdot (1 - 0.9309) \\ &= 0.2517 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{3.4112} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (2.3425 - 0.1081) \cdot 0.9309 \cdot 0.328 \\ &= 3.4112 \text{ in}^2 \\ &= 2 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot L_{pr} \\ &= 2 \cdot (2.3425 - 0.1081) \cdot 0.9309 \cdot 2.25 \\ &= 9.3602 \text{ in}^2 \end{aligned}$$

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

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0.7363 + 3.4112 + 0.0923 \\ &= \underline{4.2398} \text{ in}^2 \end{aligned}$$

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

UW-16(c) Weld Check

Fillet weld: $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.328 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 * t_{\min} = 0.2296 \text{ in}$

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

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

UG-45 Nozzle Neck Thickness Check

Wall thickness per UG-45(a): $t_{r1} = 0.1081 \text{ in (E = 1)}$

Wall thickness per UG-45(b)(1): $t_{r2} = 0.2778 \text{ in}$

Wall thickness per UG-16(b): $t_{r3} = 0.0625 \text{ in}$

Standard wall pipe per UG-45(b)(4): $t_{r4} = 0.3281 \text{ in}$

The greater of t_{r2} or t_{r3} : $t_{r5} = 0.2778 \text{ in}$

The lesser of t_{r4} or t_{r5} : $t_{r6} = 0.2778 \text{ in}$

Required per UG-45 is the larger of t_{r1} or $t_{r6} = 0.2778 \text{ in}$

Available nozzle wall thickness new, $t_n = 2.3425 \text{ in}$

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 = 249.49 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}
4.2487	4.2487	0.7447	3.4117	--	--	0.0923	0.2773	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)	0.2296	0.2205	weld size is NOT adequate

Calculations for internal pressure 249.49 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(15, 7.5 + (2.3425 - 0) + (0.328 - 0)) \\
 &= 15 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.328 - 0), 2.5*(2.3425 - 0) + 0) \\
 &= 0.82 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
 t_{rn} &= P*R_n / (S_n*E - 0.6*P) \\
 &= 249.4891*7.5 / (17,500*1 - 0.6*249.4891) \\
 &= 0.1078 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 249.4891*42.0079 / (2*18,800*1 + 0.8*249.4891) \\
 &= 0.2773 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
t_r &= P \cdot R_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\
&= 249.4891 \cdot 42.0079 / (2 \cdot 18,800 \cdot 0.85 + 0.8 \cdot 249.4891) \\
&= 0.3259 \text{ in}
\end{aligned}$$

Area required per UG-37(c)

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

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

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

$$\begin{aligned}
A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\
&= 15 \cdot 0.2773 \cdot 1 + 2 \cdot 2.3425 \cdot 0.2773 \cdot 1 \cdot (1 - 0.9309) \\
&= \underline{4.2487} \text{ in}^2
\end{aligned}$$

Area available from FIG. UG-37.1

A_1 = larger of the following = 0.7447 in²

$$\begin{aligned}
&= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
&= 15 \cdot (1 \cdot 0.328 - 1 \cdot 0.2773) - 2 \cdot 2.3425 \cdot (1 \cdot 0.328 - 1 \cdot 0.2773) \cdot (1 - 0.9309) \\
&= 0.7447 \text{ in}^2 \\
&= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
&= 2 \cdot (0.328 + 2.3425) \cdot (1 \cdot 0.328 - 1 \cdot 0.2773) - 2 \cdot 2.3425 \cdot (1 \cdot 0.328 - 1 \cdot 0.2773) \cdot (1 - 0.9309) \\
&= 0.2546 \text{ in}^2
\end{aligned}$$

A_2 = smaller of the following = 3.4117 in²

$$\begin{aligned}
&= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\
&= 5 \cdot (2.3425 - 0.1078) \cdot 0.9309 \cdot 0.328 \\
&= 3.4117 \text{ in}^2 \\
&= 2 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot L_{pr} \\
&= 2 \cdot (2.3425 - 0.1078) \cdot 0.9309 \cdot 2.25 \\
&= 9.3615 \text{ in}^2
\end{aligned}$$

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

$$\begin{aligned}
\text{Area} &= A_1 + A_2 + A_{41} \\
&= 0.7447 + 3.4117 + 0.0923
\end{aligned}$$

$$= 4.2487 \text{ in}^2$$

As Area \geq A the reinforcement is adequate.

UW-16(c) Weld Check

Fillet weld: $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.328 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 * t_{\min} = 0.2296 \text{ in}$

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

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

UG-45 Nozzle Neck Thickness Check

Wall thickness per UG-45(a): $t_{r1} = 0.1078 \text{ in (E = 1)}$

Wall thickness per UG-45(b)(1): $t_{r2} = 0.2773 \text{ in}$

Wall thickness per UG-16(b): $t_{r3} = 0.0625 \text{ in}$

Standard wall pipe per UG-45(b)(4): $t_{r4} = 0.3281 \text{ in}$

The greater of t_{r2} or t_{r3} : $t_{r5} = 0.2773 \text{ in}$

The lesser of t_{r4} or t_{r5} : $t_{r6} = 0.2773 \text{ in}$

Required per UG-45 is the larger of t_{r1} or $t_{r6} = 0.2773 \text{ in}$

Available nozzle wall thickness new, $t_n = 2.3425 \text{ in}$

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, In. 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
Static Liquid Head				
Condition		P _s (psi)	H _s (in)	SG
Test horizontal		0.32	8.7258	1
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)	1.0299"
Maximum allowable working pressure (MAWP)	496.62 psi
Rated MDMT	-150 °F

UCS-66 Material Toughness Requirements	
Stress ratio per UCS-66(b)(1)(b) = $166.5 / 496.62 =$	0.3353
Stress ratio ≤ 0.4 , MDMT per UCS-66(b)(3) =	-150 °F
Material is exempt from impact testing at the Design MDMT of 6 °F.	

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

UG-34(d) Dimensional Checks

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

Factor C from Figure UG-34 Sketch (h)

$$\text{Factor C} = 0.33$$

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

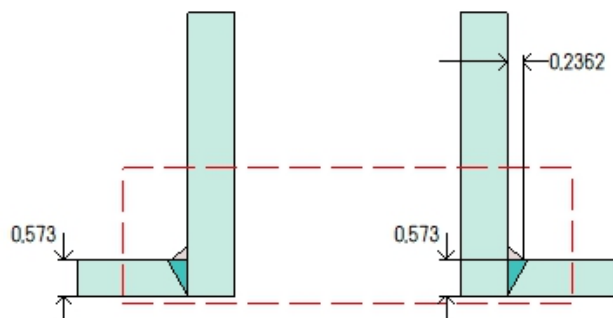
$$\begin{aligned}
 t &= d*\text{Sqr}(C*P / (S*E)) + \text{Corrosion} \\
 &= 15*\text{Sqr}(0.33*250 / (17,500*1)) + 0 \\
 &= \a href="#">1.0299"
 \end{aligned}$$

Maximum allowable working pressure, (at 125 °F)

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

Entrada PVT (N1)

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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	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"
Local vessel minimum thickness	0.573"
Liquid static head included	1.39 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.2362"
Nozzle to vessel groove weld	0.573"

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 167.89 \times 1.75 / (17,500 \times 1 - 0.6 \times 167.89) =$	0.0169"
Stress ratio $= t_r \times E^* / (t_n - c) = 0.0169 \times 1 / (0.75 - 0) =$	0.0225
Stress ratio ≤ 0.4 , MDMT per UCS-66(b)(3) =	-150° F
Material is exempt from impact testing at the Design MDMT of 6° F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 251.39 psi @ 125 °F <i>The opening is NOT adequately reinforced</i>							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	2.0387	--	1.9853	--	--	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 (Leg ₄₁)	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

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(3.5, 1.75 + (0.75 - 0) + (0.573 - 0)) \\
 &= 3.5 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.573 - 0), 2.5*(0.75 - 0) + 0) \\
 &= 1.4325 \text{ in}
 \end{aligned}$$

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

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

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

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

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

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

Area available from FIG. UG-37.1

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

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 3.5 \cdot (1 \cdot 0.573 - 1 \cdot 0.5739) - 2 \cdot 0.75 \cdot (1 \cdot 0.573 - 1 \cdot 0.5739) \cdot (1 - 0.9563) \\ &= -0.0032 \text{ in}^2 \\ \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (0.573 + 0.75) \cdot (1 \cdot 0.573 - 1 \cdot 0.5739) - 2 \cdot 0.75 \cdot (1 \cdot 0.573 - 1 \cdot 0.5739) \cdot (1 - 0.9563) \\ &= -0.0024 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{1.9853} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.75 - 0.0254) \cdot 0.9563 \cdot 0.573 \\ &= 1.9853 \text{ in}^2 \\ \\ &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.75 - 0.0254) \cdot 0.9563 \cdot 0.75 \\ &= 2.5985 \text{ in}^2 \end{aligned}$$

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

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0 + 1.9853 + 0.0534 \\ &= \underline{2.0387} \text{ in}^2 \end{aligned}$$

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

UW-16(c) Weld Check

Fillet weld: $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.573 \text{ in}$

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

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

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

UG-44 Thickness Check - ASME B16.11 Coupling

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

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

Available nozzle wall thickness new, $t_n = 0.75 \text{ in}$

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 = 250.72 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}
2.0409	2.041	0.0021	1.9855	--	--	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 (Leg ₄₁)	0.25	0.1654	weld size is NOT adequate

Calculations for internal pressure 250.72 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(3.5, 1.75 + (0.75 - 0) + (0.573 - 0)) \\
 &= 3.5 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.573 - 0), 2.5*(0.75 - 0) + 0) \\
 &= 1.4325 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
 t_{rn} &= P*R_n / (S_n*E - 0.6*P) \\
 &= 250.7191*1.75 / (17,500*1 - 0.6*250.7191) \\
 &= 0.0253 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (S*E + 0.4*P) \\
 &= 250.7191*42.0079 / (18,300*1 + 0.4*250.7191) \\
 &= 0.5724 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

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

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

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

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 3.5 \cdot 0.5724 \cdot 1 + 2 \cdot 0.75 \cdot 0.5724 \cdot 1 \cdot (1 - 0.9563) \\ &= \underline{2.0409} \text{ in}^2 \end{aligned}$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0.0021} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 3.5 \cdot (1 \cdot 0.573 - 1 \cdot 0.5724) - 2 \cdot 0.75 \cdot (1 \cdot 0.573 - 1 \cdot 0.5724) \cdot (1 - 0.9563) \\ &= 0.0021 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (0.573 + 0.75) \cdot (1 \cdot 0.573 - 1 \cdot 0.5724) - 2 \cdot 0.75 \cdot (1 \cdot 0.573 - 1 \cdot 0.5724) \cdot (1 - 0.9563) \\ &= 0.0016 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{1.9855} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.75 - 0.0253) \cdot 0.9563 \cdot 0.573 \\ &= 1.9855 \text{ in}^2 \\ &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.75 - 0.0253) \cdot 0.9563 \cdot 0.75 \\ &= 2.5989 \text{ in}^2 \end{aligned}$$

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

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0.0021 + 1.9855 + 0.0534 \\ &= \underline{2.041} \text{ in}^2 \end{aligned}$$

As $\text{Area} \geq A$ the reinforcement is adequate.

UW-16(c) Weld Check

Fillet weld: $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.573 \text{ in}$

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

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

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

UG-44 Thickness Check - ASME B16.11 Coupling

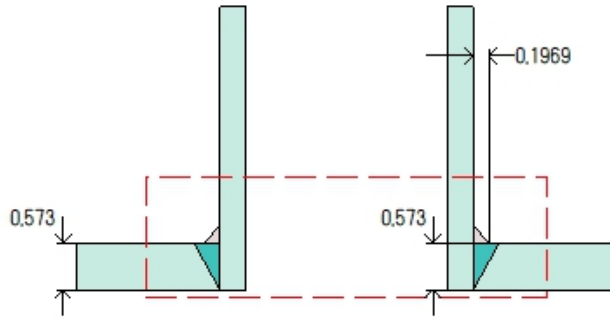
$$\begin{aligned} t_{a \text{ App 1-1}} &= P*R_o / (S_n*E + 0.4*P) + \text{Corrosion} \\ &= 250.7888*2.5 / (17,500*1 + 0.4*250.7888) + 0 \\ &= 0.0356 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\ &= \max[0.0356 , 0.0625] \\ &= 0.0625 \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.75 \text{ in}$

The nozzle neck thickness is adequate.

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

Location and Orientation

Located on	V-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"
Local vessel minimum thickness	0.573"
Liquid static head included	1.39 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.1969"
Nozzle to vessel groove weld	0.573"

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 167.89 \times 1.19 / (17,500 \times 1 - 0.6 \times 167.89) =$	0.0115"
Stress ratio $= t_r \times E^* / (t_n - c) = 0.0115 \times 1 / (0.31 - 0) =$	0.037
Stress ratio ≤ 0.4 , MDMT per UCS-66(b)(3) =	-150° F
Material is exempt from impact testing at the Design MDMT of 6° F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 251.39 psi @ 125 °F <i>The opening is NOT adequately reinforced</i>							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 (Leg ₄₁)	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

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.573 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.573 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

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

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

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

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

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

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

Area available from FIG. UG-37.1

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

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2.38 \cdot (1 \cdot 0.573 - 1 \cdot 0.5739) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.5739) \cdot (1 - 0.9563) \\ &= -0.0022 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (0.573 + 0.31) \cdot (1 \cdot 0.573 - 1 \cdot 0.5739) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.5739) \cdot (1 - 0.9563) \\ &= -0.0016 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{0.434} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.31 - 0.0172) \cdot 0.9563 \cdot 0.573 \\ &= 0.8022 \text{ in}^2 \\ &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.31 - 0.0172) \cdot 0.9563 \cdot 0.31 \\ &= 0.434 \text{ in}^2 \end{aligned}$$

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

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

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

UW-16(c) Weld Check

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

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

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

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

UG-44 Thickness Check - ASME B16.11 Coupling

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

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

Available nozzle wall thickness new, $t_n = 0.31 \text{ in}$

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 = 167.89 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}
0.9243	0.9243	0.4447	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 (Leg ₄₁)	0.217	0.1378	weld size is NOT adequate

Calculations for internal pressure 167.89 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.573 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.573 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
 t_{rn} &= P*R_n / (S_n*E - 0.6*P) \\
 &= 167.8868*1.19 / (17,500*1 - 0.6*167.8868) \\
 &= 0.0115 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (S*E + 0.4*P) \\
 &= 167.8868*42.0079 / (18,300*1 + 0.4*167.8868) \\
 &= 0.384 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

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

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

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

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 2.38 \cdot 0.384 \cdot 1 + 2 \cdot 0.31 \cdot 0.384 \cdot 1 \cdot (1 - 0.9563) \\ &= \underline{0.9243} \text{ in}^2 \end{aligned}$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0.4447} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2.38 \cdot (1 \cdot 0.573 - 1 \cdot 0.384) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.384) \cdot (1 - 0.9563) \\ &= 0.4447 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (0.573 + 0.31) \cdot (1 \cdot 0.573 - 1 \cdot 0.384) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.384) \cdot (1 - 0.9563) \\ &= 0.3287 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{0.4425} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.31 - 0.0115) \cdot 0.9563 \cdot 0.573 \\ &= 0.8178 \text{ in}^2 \\ &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.31 - 0.0115) \cdot 0.9563 \cdot 0.31 \\ &= 0.4425 \text{ in}^2 \end{aligned}$$

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

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0.4447 + 0.4425 + 0.0371 \\ &= \underline{0.9243} \text{ in}^2 \end{aligned}$$

As $\text{Area} \geq A$ the reinforcement is adequate.

UW-16(c) Weld Check

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

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

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

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

UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned} t_{a \text{ App 1-1}} &= P*R_o / (S_n*E + 0.4*P) + \text{Corrosion} \\ &= 167.9406*1.5 / (17,500*1 + 0.4*167.9406) + 0 \\ &= 0.0143 \text{ in} \end{aligned}$$

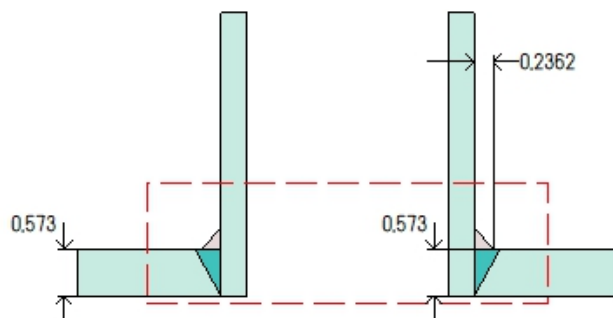
$$\begin{aligned} t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\ &= \max[0.0143 , 0.0625] \\ &= 0.0625 \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.31 \text{ in}$

The nozzle neck thickness is adequate.

Compensación (N3)

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	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"
Local vessel minimum thickness	0.573"
Liquid static head included	1.39 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.2362"
Nozzle to vessel groove weld	0.573"

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 167.89 \times 1.19 / (17,500 \times 1 - 0.6 \times 167.89) =$	0.0115"
Stress ratio $= t_r \times E^* / (t_n - c) = 0.0115 \times 1 / (0.31 - 0) =$	0.037
Stress ratio ≤ 0.4 , MDMT per UCS-66(b)(3) =	-150°F
Material is exempt from impact testing at the Design MDMT of 6°F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 251.39 psi @ 125 °F <i>The opening is NOT adequately reinforced</i>							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 (Leg ₄₁)	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

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.573 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.573 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

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

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

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

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

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

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

Area available from FIG. UG-37.1

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

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2.38 \cdot (1 \cdot 0.573 - 1 \cdot 0.5739) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.5739) \cdot (1 - 0.9563) \\ &= -0.0022 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (0.573 + 0.31) \cdot (1 \cdot 0.573 - 1 \cdot 0.5739) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.5739) \cdot (1 - 0.9563) \\ &= -0.0016 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{0.434} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.31 - 0.0172) \cdot 0.9563 \cdot 0.573 \\ &= 0.8022 \text{ in}^2 \\ &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.31 - 0.0172) \cdot 0.9563 \cdot 0.31 \\ &= 0.434 \text{ in}^2 \end{aligned}$$

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

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

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

UW-16(c) Weld Check

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

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

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

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

UG-44 Thickness Check - ASME B16.11 Coupling

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

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

Available nozzle wall thickness new, $t_n = 0.31 \text{ in}$

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 = 169.37 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}
0.9324	0.9325	0.4368	0.4423	--	--	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 (Leg ₄₁)	0.217	0.1654	weld size is NOT adequate

Calculations for internal pressure 169.37 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.573 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.573 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
 t_{rn} &= P*R_n / (S_n*E - 0.6*P) \\
 &= 169.3745*1.19 / (17,500*1 - 0.6*169.3745) \\
 &= 0.0116 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (S*E + 0.4*P) \\
 &= 169.3745*42.0079 / (18,300*1 + 0.4*169.3745) \\
 &= 0.3874 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

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

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

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

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 2.38 \cdot 0.3874 \cdot 1 + 2 \cdot 0.31 \cdot 0.3874 \cdot 1 \cdot (1 - 0.9563) \\ &= \underline{0.9324} \text{ in}^2 \end{aligned}$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0.4368} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2.38 \cdot (1 \cdot 0.573 - 1 \cdot 0.3874) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.3874) \cdot (1 - 0.9563) \\ &= 0.4368 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (0.573 + 0.31) \cdot (1 \cdot 0.573 - 1 \cdot 0.3874) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.3874) \cdot (1 - 0.9563) \\ &= 0.3228 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{0.4423} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.31 - 0.0116) \cdot 0.9563 \cdot 0.573 \\ &= 0.8176 \text{ in}^2 \\ &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.31 - 0.0116) \cdot 0.9563 \cdot 0.31 \\ &= 0.4423 \text{ in}^2 \end{aligned}$$

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

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0.4368 + 0.4423 + 0.0534 \\ &= \underline{0.9325} \text{ in}^2 \end{aligned}$$

As $\text{Area} \geq A$ the reinforcement is adequate.

UW-16(c) Weld Check

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

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

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

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

UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned} t_{a \text{ App 1-1}} &= P*R_o / (S_n*E + 0.4*P) + \text{Corrosion} \\ &= 169.4283*1.5 / (17,500*1 + 0.4*169.4283) + 0 \\ &= 0.0145 \text{ in} \end{aligned}$$

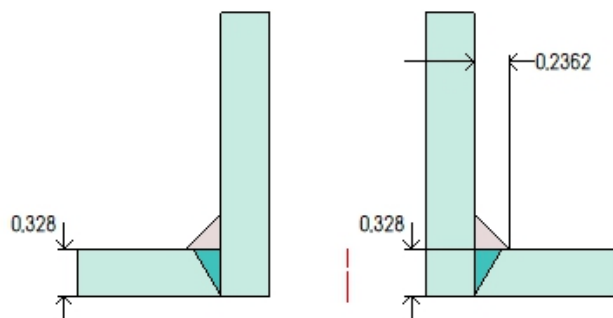
$$\begin{aligned} t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}} , t_{b \text{ UG16}}] \\ &= \max[0.0145 , 0.0625] \\ &= 0.0625 \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.31 \text{ in}$

The nozzle neck thickness is adequate.

Indicador de Presión (N4)

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	-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}	2.138"
Local vessel minimum thickness	0.328"
Liquid static head included	0.13 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.2362"
Nozzle to vessel groove weld	0.328"

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 166.62 \cdot 0.53 / (17,500 \cdot 1 - 0.6 \cdot 166.62) =$	0.0051"
Stress ratio $= t_r \cdot E^* / (t_n - c) = 0.0051 \cdot 1 / (0.345 - 0) =$	0.0147
Stress ratio ≤ 0.4 , MDMT per UCS-66(b)(3) =	-150° F
Material is exempt from impact testing at the Design MDMT of 6° F.	

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)							0.0625	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)	0.2296	0.1654	weld size is NOT adequate

Calculations for internal pressure 250.13 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.06, 0.53 + (0.345 - 0) + (0.328 - 0)) \\
 &= 1.203 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.328 - 0), 2.5*(0.345 - 0) + 0) \\
 &= 0.82 \text{ in}
 \end{aligned}$$

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

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

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 250.1264*42.0079 / (2*18,800*1 + 0.8*250.1264) \\
 &= 0.278 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 250.1264*42.0079 / (2*18,800*0.85 + 0.8*250.1264)
 \end{aligned}$$

$$= 0.3267 \text{ in}$$

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

UW-16(c) Weld Check

Fillet weld: $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.328 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 * t_{\min} = 0.2296 \text{ in}$

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

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

UG-44 Thickness Check - ASME B16.11 Coupling

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

$$\begin{aligned} t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}}, t_{b \text{ UG16}}] \\ &= \max[0.0124, 0.0625] \\ &= 0.0625 \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.345 \text{ in}$

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 = 295.43 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	0.345

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)	0.2296	0.1654	weld size is NOT adequate

Calculations for internal pressure 295.43 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.06, 0.53 + (0.345 - 0) + (0.328 - 0)) \\
 &= 1.203 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.328 - 0), 2.5*(0.345 - 0) + 0) \\
 &= 0.82 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
 t_{rn} &= P*R_n / (S_n*E - 0.6*P) \\
 &= 295.4278*0.53 / (17,500*1 - 0.6*295.4278) \\
 &= 0.009 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 295.4278*42.0079 / (2*18,800*1 + 0.8*295.4278) \\
 &= 0.328 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}t_r &= P \cdot R_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\&= 295.4278 \cdot 42.0079 / (2 \cdot 18,800 \cdot 0.85 + 0.8 \cdot 295.4278) \\&= 0.3855 \text{ in}\end{aligned}$$

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 $t = 0.328$ in

$t_{c(\min)}$ = lesser of 0.25 or $0.7 \cdot t_{\min} = 0.2296$ 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

$$\begin{aligned}t_{a \text{ App 1-1}} &= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) + \text{Corrosion} \\&= 295.4278 \cdot 0.875 / (17,500 \cdot 1 + 0.4 \cdot 295.4278) + 0 \\&= 0.0147 \text{ in}\end{aligned}$$

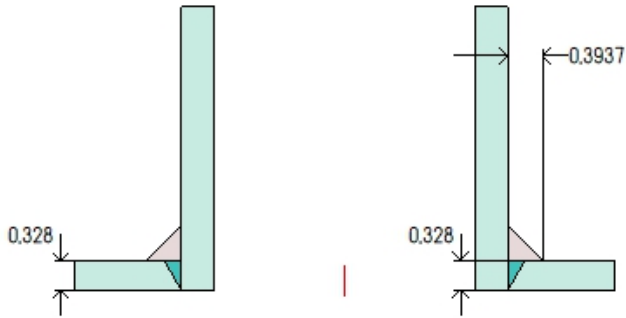
$$\begin{aligned}t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}}, t_{b \text{ UG16}}] \\&= \max[0.0147, 0.0625] \\&= 0.0625 \text{ in}\end{aligned}$$

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

The nozzle neck thickness is adequate.

Indicador de Nivel (N5)

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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"
Local vessel minimum thickness	0.328"
Liquid static head included	0.58 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.3937"
Nozzle to vessel groove weld	0.328"

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 167.07 \times 1.44 / (17,500 \times 1 - 0.6 \times 167.07) =$	0.0138"
Stress ratio $= t_r \times E^* / (t_n - c) = 0.0138 \times 1 / (0.37 - 0) =$	0.0374
Stress ratio ≤ 0.4 , MDMT per UCS-66(b)(3) =	-150°F
Material is exempt from impact testing at the Design MDMT of 6°F.	

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)	0.2296	0.2756	weld size is adequate

Calculations for internal pressure 250.58 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.88, 1.44 + (0.37 - 0) + (0.328 - 0)) \\
 &= 2.88 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.328 - 0), 2.5*(0.37 - 0) + 0) \\
 &= 0.82 \text{ in}
 \end{aligned}$$

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

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

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 250.5765*42.0079 / (2*18,800*1 + 0.8*250.5765) \\
 &= 0.2785 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
 t_r &= P \cdot R_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\
 &= 250.5765 \cdot 42.0079 / (2 \cdot 18,800 \cdot 0.85 + 0.8 \cdot 250.5765) \\
 &= 0.3273 \text{ in}
 \end{aligned}$$

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 $t = 0.328$ in

$t_{c(\min)}$ = lesser of 0.25 or $0.7 \cdot t_{\min} = 0.2296$ in

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.3937 = 0.2756$ 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

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

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

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 = 295.43 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)	0.2296	0.2756	weld size is adequate

Calculations for internal pressure 295.43 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.88, 1.44 + (0.37 - 0) + (0.328 - 0)) \\
 &= 2.88 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.328 - 0), 2.5*(0.37 - 0) + 0) \\
 &= 0.82 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 295.4316 \cdot 1.44 / (17,500 \cdot 1 - 0.6 \cdot 295.4316) \\
 &= 0.0246 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\
 &= 295.4316 \cdot 42.0079 / (2 \cdot 18,800 \cdot 1 + 0.8 \cdot 295.4316) \\
 &= 0.328 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
t_r &= P \cdot R_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\
&= 295.4316 \cdot 42.0079 / (2 \cdot 18,800 \cdot 0.85 + 0.8 \cdot 295.4316) \\
&= 0.3855 \text{ in}
\end{aligned}$$

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 $t = 0.328$ in

$t_{c(\min)}$ = lesser of 0.25 or $0.7 \cdot t_{\min} = 0.2296$ in

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.3937 = 0.2756$ 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

$$\begin{aligned}
t_{a \text{ App 1-1}} &= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) + \text{Corrosion} \\
&= 295.4316 \cdot 1.81 / (17,500 \cdot 1 + 0.4 \cdot 295.4316) + 0 \\
&= 0.0304 \text{ in}
\end{aligned}$$

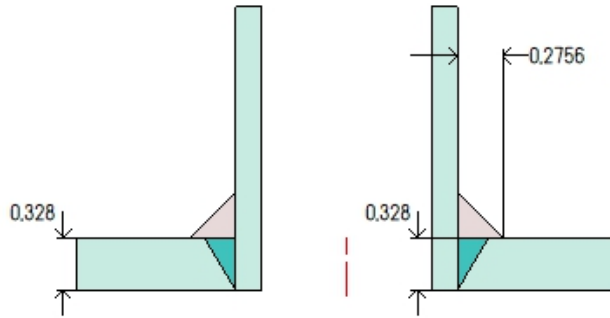
$$\begin{aligned}
t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}}, t_{b \text{ UG16}}] \\
&= \max[0.0304, 0.0625] \\
&= 0.0625 \text{ in}
\end{aligned}$$

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

The nozzle neck thickness is adequate.

Indicador de Temperatura (N6)

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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}	2.0296"
Local vessel minimum thickness	0.328"
Liquid static head included	0.84 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.2756"
Nozzle to vessel groove weld	0.328"

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 167.33 \cdot 0.53 / (17,500 \cdot 1 - 0.6 \cdot 167.33) =$	0.0051"
Stress ratio $= t_r \cdot E^* / (t_n - c) = 0.0051 \cdot 1 / (0.16 - 0) =$	0.0319
Stress ratio ≤ 0.4 , MDMT per UCS-66(b)(3) =	-150°F
Material is exempt from impact testing at the Design MDMT of 6°F.	

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

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.06, 0.53 + (0.16 - 0) + (0.328 - 0)) \\
 &= 1.06 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.328 - 0), 2.5*(0.16 - 0) + 0) \\
 &= 0.4 \text{ in}
 \end{aligned}$$

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

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

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 250.8359*42.0079 / (2*18,800*1 + 0.8*250.8359) \\
 &= 0.2788 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned} t_r &= P \cdot R_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\ &= 250.8359 \cdot 42.0079 / (2 \cdot 18,800 \cdot 0.85 + 0.8 \cdot 250.8359) \\ &= 0.3276 \text{ in} \end{aligned}$$

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

UW-16(c) Weld Check

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

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.112 \text{ in}$

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.2756 = 0.1929 \text{ in}$

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

$$\begin{aligned} t_{a \text{ App 1-1}} &= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 250.8484 \cdot 0.69 / (17,500 \cdot 1 + 0.4 \cdot 250.8484) + 0 \\ &= 0.0098 \text{ in} \end{aligned}$$

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

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

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 = 295.43 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	0.16

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 295.43 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.06, 0.53 + (0.16 - 0) + (0.328 - 0)) \\
 &= 1.06 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.328 - 0), 2.5*(0.16 - 0) + 0) \\
 &= 0.4 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
 t_{rn} &= P*R_n / (S_n*E - 0.6*P) \\
 &= 295.4307*0.53 / (17,500*1 - 0.6*295.4307) \\
 &= 0.009 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (2*S*E + 0.8*P) \\
 &= 295.4307*42.0079 / (2*18,800*1 + 0.8*295.4307) \\
 &= 0.328 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
 t_r &= P \cdot R_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\
 &= 295.4307 \cdot 42.0079 / (2 \cdot 18,800 \cdot 0.85 + 0.8 \cdot 295.4307) \\
 &= 0.3855 \text{ in}
 \end{aligned}$$

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 $0.7 \cdot t_{\min} = 0.112$ in

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.2756 = 0.1929$ 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

$$\begin{aligned}
 t_{a \text{ App 1-1}} &= P \cdot R_o / (S_n \cdot E + 0.4 \cdot P) + \text{Corrosion} \\
 &= 295.4432 \cdot 0.69 / (17,500 \cdot 1 + 0.4 \cdot 295.4432) + 0 \\
 &= 0.0116 \text{ in}
 \end{aligned}$$

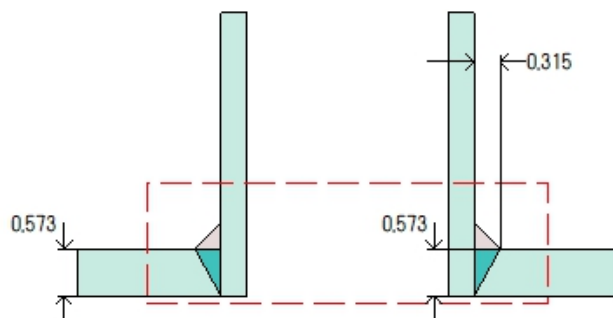
$$\begin{aligned}
 t_{a \text{ UG-44}} &= \max[t_{a \text{ App 1-1}}, t_{b \text{ UG16}}] \\
 &= \max[0.0116, 0.0625] \\
 &= 0.0625 \text{ in}
 \end{aligned}$$

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

The nozzle neck thickness is adequate.

Alivio de presión (N7)

ASME Section VIII Division 1, 1995 Edition



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, Lpr	2.7798"
Local vessel minimum thickness	0.573"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.315"
Nozzle to vessel groove weld	0.573"

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 166.5 \times 1.19 / (17,500 \times 1 - 0.6 \times 166.5) =$	0.0114"
Stress ratio $= t_r \times E^* / (t_n - c) = 0.0114 \times 1 / (0.31 - 0) =$	0.0367
Stress ratio ≤ 0.4 , MDMT per UCS-66(b)(3) =	-150°F
Material is exempt from impact testing at the Design MDMT of 6°F.	

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	0.5344	0.0053	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 (Leg ₄₁)	0.217	0.2205	weld size is adequate

Calculations for internal pressure 250 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.573 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.573 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

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

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

Required thickness t_r from UG-37(a)

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

Area required per UG-37(c)

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

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

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

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

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0.0053} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2.38 \cdot (1 \cdot 0.573 - 1 \cdot 0.5708) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.5708) \cdot (1 - 0.9563) \\ &= 0.0053 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (0.573 + 0.31) \cdot (1 \cdot 0.573 - 1 \cdot 0.5708) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.5708) \cdot (1 - 0.9563) \\ &= 0.0039 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{0.4342} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.31 - 0.0171) \cdot 0.9563 \cdot 0.573 \\ &= 0.8025 \text{ in}^2 \\ &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.31 - 0.0171) \cdot 0.9563 \cdot 0.31 \\ &= 0.4342 \text{ in}^2 \end{aligned}$$

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

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0.0053 + 0.4342 + 0.0949 \\ &= \underline{0.5344} \text{ in}^2 \end{aligned}$$

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

UW-16(c) Weld Check

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

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

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

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

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

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

Available nozzle wall thickness new, $t_n = 0.31 \text{ in}$

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 = 173.17 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}
0.9533	0.9533	0.4164	0.442	--	--	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 (Leg ₄₁)	0.217	0.2205	weld size is adequate

Calculations for internal pressure 173.17 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.573 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.573 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
 t_{rn} &= P*R_n / (S_n*E - 0.6*P) \\
 &= 173.172*1.19 / (17,500*1 - 0.6*173.172) \\
 &= 0.0118 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (S*E + 0.4*P) \\
 &= 173.172*42.0079 / (18,300*1 + 0.4*173.172) \\
 &= 0.396 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

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

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

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

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 2.38 \cdot 0.396 \cdot 1 + 2 \cdot 0.31 \cdot 0.396 \cdot 1 \cdot (1 - 0.9563) \\ &= \underline{0.9533} \text{ in}^2 \end{aligned}$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0.4164} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2.38 \cdot (1 \cdot 0.573 - 1 \cdot 0.396) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.396) \cdot (1 - 0.9563) \\ &= 0.4164 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (0.573 + 0.31) \cdot (1 \cdot 0.573 - 1 \cdot 0.396) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.396) \cdot (1 - 0.9563) \\ &= 0.3078 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{0.442} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.31 - 0.0118) \cdot 0.9563 \cdot 0.573 \\ &= 0.817 \text{ in}^2 \\ &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.31 - 0.0118) \cdot 0.9563 \cdot 0.31 \\ &= 0.442 \text{ in}^2 \end{aligned}$$

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

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0.4164 + 0.442 + 0.0949 \\ &= \underline{0.9533} \text{ in}^2 \end{aligned}$$

As $\text{Area} \geq A$ the reinforcement is adequate.

UW-16(c) Weld Check

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

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

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

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

$$\begin{aligned} t_{a \text{ App } 1-1} &= P*R_o / (S_n*E + 0.4*P) + \text{Corrosion} \\ &= 173.172*1.5 / (17,500*1 + 0.4*173.172) + 0 \\ &= 0.0148 \text{ in} \end{aligned}$$

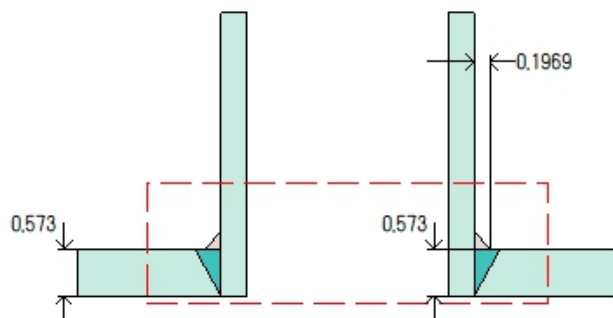
$$\begin{aligned} t_{a \text{ UG-44}} &= \max[t_{a \text{ App } 1-1} , t_{b \text{ UG16}}] \\ &= \max[0.0148 , 0.0625] \\ &= 0.0625 \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.31 \text{ in}$

The nozzle neck thickness is adequate.

Alivio de presión (N8)

ASME Section VIII Division 1, 1995 Edition



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"
Local vessel minimum thickness	0.573"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.1969"
Nozzle to vessel groove weld	0.573"

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 166.5 \times 1.19 / (17,500 \times 1 - 0.6 \times 166.5) =$	0.0114"
Stress ratio $= t_r \times E^* / (t_n - c) = 0.0114 \times 1 / (0.31 - 0) =$	0.0367
Stress ratio ≤ 0.4 , MDMT per UCS-66(b)(3) =	-150°F
Material is exempt from impact testing at the Design MDMT of 6°F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 250 psi @ 125 °F <i>The opening is NOT adequately reinforced</i>							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	0.4766	0.0053	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 (Leg ₄₁)	0.217	0.1378	weld size is NOT adequate

Calculations for internal pressure 250 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.573 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.573 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

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

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

Required thickness t_r from UG-37(a)

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

Area required per UG-37(c)

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

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

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

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

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0.0053} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2.38 \cdot (1 \cdot 0.573 - 1 \cdot 0.5708) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.5708) \cdot (1 - 0.9563) \\ &= 0.0053 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (0.573 + 0.31) \cdot (1 \cdot 0.573 - 1 \cdot 0.5708) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.5708) \cdot (1 - 0.9563) \\ &= 0.0039 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{0.4342} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.31 - 0.0171) \cdot 0.9563 \cdot 0.573 \\ &= 0.8025 \text{ in}^2 \\ &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.31 - 0.0171) \cdot 0.9563 \cdot 0.31 \\ &= 0.4342 \text{ in}^2 \end{aligned}$$

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

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0.0053 + 0.4342 + 0.0371 \\ &= \underline{0.4766} \text{ in}^2 \end{aligned}$$

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

UW-16(c) Weld Check

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

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

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

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

UG-44 Thickness Check - ASME B16.11 Coupling

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

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

Available nozzle wall thickness new, $t_n = 0.31 \text{ in}$

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 = 167.88 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}
0.9243	0.9244	0.4448	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 (Leg ₄₁)	0.217	0.1378	weld size is NOT adequate

Calculations for internal pressure 167.88 psi @ 125 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.38, 1.19 + (0.31 - 0) + (0.573 - 0)) \\
 &= 2.38 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.573 - 0), 2.5*(0.31 - 0) + 0) \\
 &= 0.775 \text{ in}
 \end{aligned}$$

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

$$\begin{aligned}
 t_{rn} &= P*R_n / (S_n*E - 0.6*P) \\
 &= 167.8848*1.19 / (17,500*1 - 0.6*167.8848) \\
 &= 0.0115 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (S*E + 0.4*P) \\
 &= 167.8848*42.0079 / (18,300*1 + 0.4*167.8848) \\
 &= 0.384 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

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

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

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

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 2.38 \cdot 0.384 \cdot 1 + 2 \cdot 0.31 \cdot 0.384 \cdot 1 \cdot (1 - 0.9563) \\ &= \underline{0.9243} \text{ in}^2 \end{aligned}$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0.4448} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2.38 \cdot (1 \cdot 0.573 - 1 \cdot 0.384) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.384) \cdot (1 - 0.9563) \\ &= 0.4448 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (0.573 + 0.31) \cdot (1 \cdot 0.573 - 1 \cdot 0.384) - 2 \cdot 0.31 \cdot (1 \cdot 0.573 - 1 \cdot 0.384) \cdot (1 - 0.9563) \\ &= 0.3287 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{0.4425} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (0.31 - 0.0115) \cdot 0.9563 \cdot 0.573 \\ &= 0.8178 \text{ in}^2 \\ &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.31 - 0.0115) \cdot 0.9563 \cdot 0.31 \\ &= 0.4425 \text{ in}^2 \end{aligned}$$

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

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0.4448 + 0.4425 + 0.0371 \\ &= \underline{0.9244} \text{ in}^2 \end{aligned}$$

As $\text{Area} \geq A$ the reinforcement is adequate.

UW-16(c) Weld Check

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

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

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

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

UG-44 Thickness Check - ASME B16.11 Coupling

$$\begin{aligned} t_{a \text{ App 1-1}} &= P*R_o / (S_n*E + 0.4*P) + \text{Corrosion} \\ &= 167.8848*1.5 / (17,500*1 + 0.4*167.8848) + 0 \\ &= 0.0143 \text{ in} \end{aligned}$$

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

Available nozzle wall thickness new, $t_n = 0.31 \text{ in}$

The nozzle neck thickness is adequate.

Liquid Level bounded by C-02

ASME Section VIII Division 1, 1995 Edition	
Location from Center Line (in)	29.7507
Operating Liquid Specific Gravity	0.5368

PT (Cuna 1 y 2)

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	167.88 psi	
Test	252.86 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	19,431 lb	33,098 lb
Weight on Right Saddle	19,609 lb	33,791 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	5.952	18,300	-118	14,330	7.747	18,300	1.677	14,330
		Left Saddle					7.675	18,300	1.605	14,330
	Test	Right Saddle	8.941	33,300	-201	14,330	12.015	33,300	2.873	14,330
		Left Saddle					11.893	33,300	2.751	14,330

Stress Summary										
Load	Condition	Saddle	Tangential shear (psi)		Circumferential stress (psi)		Stress over saddle (psi)		Splitting (psi)	
			S ₃	allow	S ₄ (horns)	allow (+/-)	S ₅	allow	S ₆	allow
Weight	Operating	Right Saddle	322	14,640	-7,425	27,450	1,795	18,000	645	13,749
		Left Saddle	326	14,640	-7,357	27,450	1,779	18,000	639	13,749
	Test	Right Saddle	561	26,640	-12,795	33,300	3,094	32,400	1,112	32,400
		Left Saddle	549	26,640	-12,532	33,300	3,030	32,400	1,089	32,400

Load Case 1: Weight, Operating

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

$$\begin{aligned}
 S_1 &= \pm 3 \cdot K_1 \cdot Q \cdot (L / 12) / (\pi \cdot R^2 \cdot t) \\
 &= 3 \cdot 0.3369 \cdot 19,431 \cdot (226.2992 / 12) / (\pi \cdot 41.7214^2 \cdot 0.573) \\
 &= -118 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 S_p &= P \cdot R / (2 \cdot t) \\
 &= 167.88 \cdot 41.4349 / (2 \cdot 0.573) \\
 &= 6,070 \text{ psi}
 \end{aligned}$$

Maximum tensile stress $S_{1t} = S_1 + S_p = \text{5,952}$ psi
Maximum compressive stress (shut down) $S_{1c} = S_1 = \text{-118}$ psi

Tensile stress is acceptable ($\leq S \cdot E = 18,300$ psi)
Compressive stress is acceptable ($\leq S_c = 14,330$ psi)

Longitudinal stress at the right saddle (Weight, Operating)

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

$$w = W_t / L_e = 39,040 / 282.3097 = 138.29 \text{ lb}_f/\text{in}$$

Bending moment at the right saddle:

$$\begin{aligned}
 M_q &= w \cdot (2 \cdot H \cdot A_r / 3 + A_r^2 / 2 - (R^2 - H^2) / 4) \\
 &= 138.29 \cdot (2 \cdot 42.0079 \cdot 66.2598 / 3 + 66.2598^2 / 2 - (42.0079^2 - 42.0079^2) / 4) \\
 &= 560,177.2 \text{ lb}_f\text{-in}
 \end{aligned}$$

$$\begin{aligned}
 S_2 &= \pm M_q \cdot K_1' / (\pi \cdot R^2 \cdot t) \\
 &= 560,177.2 \cdot 9.3799 / (\pi \cdot 41.7214^2 \cdot 0.573) \\
 &= 1,677 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 S_p &= P \cdot R / (2 \cdot t) \\
 &= 167.88 \cdot 41.4349 / (2 \cdot 0.573) \\
 &= 6,070 \text{ psi}
 \end{aligned}$$

Maximum tensile stress $S_{2t} = S_2 + S_p = \text{7,747}$ psi
Maximum compressive stress (shut down) $S_{2c} = S_2 = \text{1,677}$ psi

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

Compressive stress is acceptable ($\leq S_c = 14,330$ psi)

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

$$\begin{aligned} Q_{\text{shear}} &= Q - w \cdot (a + 2 \cdot H / 3) \\ &= 19,609 - 138.29 \cdot (66.2598 + 2 \cdot 42.0079 / 3) \\ &= 6,573.28 \text{ lb}_f \end{aligned}$$

$$\begin{aligned} S_3 &= K_{2.2} \cdot Q_{\text{shear}} / (R \cdot t) \\ &= 1.1707 \cdot 6,573.28 / (41.7214 \cdot 0.573) \\ &= \underline{322} \text{ psi} \end{aligned}$$

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

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

$$\begin{aligned} S_4 &= -Q / (4 \cdot t \cdot (b + 1.56 \cdot \text{Sqr}(R_o \cdot t))) - 12 \cdot K_3 \cdot Q \cdot R / (L \cdot t^2) \\ &= -19,609 / (4 \cdot 0.573 \cdot (12.0079 + 1.56 \cdot \text{Sqr}(42.0079 \cdot 0.573))) - 12 \cdot 0.0529 \cdot 19,609 \cdot 41.7214 / (226.2992 \cdot 0.573^2) \\ &= \underline{-7,425} \text{ psi} \end{aligned}$$

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_4 because the wear plate width is not at least $\{b + 1.56 \cdot (R_o \cdot t)^{0.5}\} = 19.6615$ in

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

$$\begin{aligned} S_5 &= K_5 \cdot Q / ((t + t_p) \cdot (t_s + 1.56 \cdot \text{Sqr}(R_o \cdot t_c))) \\ &= 0.7603 \cdot 19,609 / ((0.573 + 0.2756) \cdot (0.4724 + 1.56 \cdot \text{Sqr}(42.0079 \cdot 0.8486))) \\ &= \underline{1,795} \text{ psi} \end{aligned}$$

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

Saddle splitting load (right, Weight, Operating)

Area resisting splitting force = Web area + wear plate area

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

$$\begin{aligned} S_6 &= K_8 \cdot Q / A_e \\ &= 0.2035 \cdot 19,609 / 6.1861 \\ &= \underline{645} \text{ psi} \end{aligned}$$

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

Longitudinal stress at the left saddle (Weight, Operating)

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

$$w = W_t / L_e = 39,040 / 282.3097 = 138.29 \text{ lb}_f/\text{in}$$

Bending moment at the left saddle:

$$M_q = w \cdot (2 \cdot H \cdot A_t / 3 + A_t^2 / 2 - (R^2 - H^2) / 4)$$

$$= 138.29 * (2 * 42.0079 * 64.4094 / 3 + 64.4094^2 / 2 - (42.0079^2 - 42.0079^2) / 4)$$

$$= 536,292.7 \text{ lb}_f\text{-in}$$

$$S_2 = \pm M_0 * K_1' / (\pi * R^2 * t)$$

$$= 536,292.7 * 9.3799 / (\pi * 41.7214^2 * 0.573)$$

$$= 1,605 \text{ psi}$$

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

$$= 167.88 * 41.4349 / (2 * 0.573)$$

$$= 6,070 \text{ psi}$$

Maximum tensile stress $S_{2t} = S_2 + S_p = 7,675 \text{ psi}$
 Maximum compressive stress (shut down) $S_{2c} = S_2 = 1,605 \text{ psi}$

Tensile stress is acceptable ($\leq S = 18,300 \text{ psi}$)
 Compressive stress is acceptable ($\leq S_c = 14,330 \text{ psi}$)

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

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

$$= 19,431 - 138.29 * (64.4094 + 2 * 42.0079 / 3)$$

$$= 6,651.17 \text{ lb}_f$$

$$S_3 = K_{2.2} * Q_{\text{shear}} / (R * t)$$

$$= 1.1707 * 6,651.17 / (41.7214 * 0.573)$$

$$= 326 \text{ psi}$$

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

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

$$S_4 = -Q / (4 * t * (b + 1.56 * \text{Sqr}(R_o * t))) - 12 * K_3 * Q * R / (L * t^2)$$

$$= -19,431 / (4 * 0.573 * (12.0079 + 1.56 * \text{Sqr}(42.0079 * 0.573))) - 12 * 0.0529 * 19,431 * 41.7214 / (226.2992 * 0.573^2)$$

$$= -7,357 \text{ psi}$$

Circumferential stress at saddle horns is acceptable ($\leq 1.5 * S_a = 27,450 \text{ psi}$)
 The wear plate was not considered in the calculation of S_4 because the wear plate width is not at least $\{b + 1.56 * (R_o * t)^{0.5}\} = 19.6615 \text{ in}$

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

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

$$= 0.7603 * 19,431 / ((0.573 + 0.2756) * (0.4724 + 1.56 * \text{Sqr}(42.0079 * 0.8486)))$$

$$= 1,779 \text{ psi}$$

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

Saddle splitting load (left, Weight, Operating)

Area resisting splitting force = Web area + wear plate area

$$A_e = H_{\text{eff}} * t_s + t_p * W_p$$

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

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

$$S_6 = K_8 * Q / A_e$$

$$= 0.2035 * 19,431 / 6.1861$$

$$= 639 \text{ psi}$$

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

Load Case 2: Weight, Test

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

$$\begin{aligned} S_1 &= \pm 3 \cdot K_1 \cdot Q \cdot (L/12) / (\pi \cdot R^2 \cdot t) \\ &= 3 \cdot -0.3369 \cdot 33,098 \cdot (226.2992/12) / (\pi \cdot 41.7214^2 \cdot 0.573) \\ &= -201 \text{ psi} \end{aligned}$$

$$\begin{aligned} S_p &= P \cdot R / (2 \cdot t) \\ &= 252.86 \cdot 41.4349 / (2 \cdot 0.573) \\ &= 9,142 \text{ psi} \end{aligned}$$

Maximum tensile stress $S_{1t} = S_1 + S_p = 8,941 \text{ psi}$
Maximum compressive stress (shut down) $S_{1c} = S_1 = -201 \text{ psi}$

Tensile stress is acceptable ($\leq 0.9 \cdot S_y \cdot E = 33,300 \text{ psi}$)
Compressive stress is acceptable ($\leq S_c = 14,330 \text{ psi}$)

Longitudinal stress at the right saddle (Weight, Test)

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

$$w = W_t / L_e = 66,889 / 282.3097 = 236.93 \text{ lb}_f/\text{in}$$

Bending moment at the right saddle:

$$\begin{aligned} M_q &= w \cdot (2 \cdot H \cdot A_r / 3 + A_r^2 / 2 - (R^2 - H^2) / 4) \\ &= 236.93 \cdot (2 \cdot 42.0079 \cdot 66.2598 / 3 + 66.2598^2 / 2 - (42.0079^2 - 42.0079^2) / 4) \\ &= 959,776.9 \text{ lb}_f\text{-in} \end{aligned}$$

$$\begin{aligned} S_2 &= \pm M_q \cdot K_1' / (\pi \cdot R^2 \cdot t) \\ &= 959,776.9 \cdot 9.3799 / (\pi \cdot 41.7214^2 \cdot 0.573) \\ &= 2,873 \text{ psi} \end{aligned}$$

$$\begin{aligned} S_p &= P \cdot R / (2 \cdot t) \\ &= 252.86 \cdot 41.4349 / (2 \cdot 0.573) \\ &= 9,142 \text{ psi} \end{aligned}$$

Maximum tensile stress $S_{2t} = S_2 + S_p = 12,015 \text{ psi}$
Maximum compressive stress (shut down) $S_{2c} = S_2 = 2,873 \text{ psi}$

Tensile stress is acceptable ($\leq 0.9 \cdot S_y = 33,300 \text{ psi}$)
Compressive stress is acceptable ($\leq S_c = 14,330 \text{ psi}$)

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

$$\begin{aligned} Q_{\text{shear}} &= Q - w \cdot (a + 2 \cdot H / 3) \\ &= 33,791 - 236.93 \cdot (66.2598 + 2 \cdot 42.0079 / 3) \\ &= 11,456.32 \text{ lb}_f \end{aligned}$$

$$S_3 = K_{2.2} \cdot Q_{\text{shear}} / (R \cdot t)$$

$$= 1.1707 * 11,456.32 / (41.7214 * 0.573)$$

$$= 561 \text{ psi}$$

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

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

$$S_4 = -Q / (4 * t * (b + 1.56 * \text{Sqr}(R_o * t))) - 12 * K_3 * Q * R / (L * t^2)$$

$$= -33,791 / (4 * 0.573 * (12.0079 + 1.56 * \text{Sqr}(42.0079 * 0.573))) - 12 * 0.0529 * 33,791 * 41.7214 / (226.2992 * 0.573^2)$$

$$= -12.795 \text{ psi}$$

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

The wear plate was not considered in the calculation of S_4 because the wear plate width is not at least $\{b + 1.56 * (R_o * t)^{0.5}\} = 19.6615 \text{ in}$

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

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

$$= 0.7603 * 33,791 / ((0.573 + 0.2756) * (0.4724 + 1.56 * \text{Sqr}(42.0079 * 0.8486)))$$

$$= 3.094 \text{ psi}$$

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

Saddle splitting load (right, Weight, Test)

Area resisting splitting force = Web area + wear plate area

$$A_e = H_{eff} * t_s + t_p * W_p$$

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

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

$$S_6 = K_8 * Q / A_e$$

$$= 0.2035 * 33,791 / 6.1861$$

$$= 1.112 \text{ psi}$$

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

Longitudinal stress at the left saddle (Weight, Test)

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

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

$$= 282.3097 \text{ in}$$

$$w = W_t / L_e = 66,889 / 282.3097 = 236.93 \text{ lb/in}$$

Bending moment at the left saddle:

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

$$= 236.93 * (2 * 42.0079 * 64.4094 / 3 + 64.4094^2 / 2 - (42.0079^2 - 42.0079^2) / 4)$$

$$= 918,854.6 \text{ lb-in}$$

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

$$= 918,854.6 * 9.3799 / (\pi * 41.7214^2 * 0.573)$$

$$= 2,751 \text{ psi}$$

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

$$= 252.86 * 41.4349 / (2 * 0.573)$$

$$= 9,142 \text{ psi}$$

$$\text{Maximum tensile stress } S_{2t} = S_2 + S_p = 11.893 \text{ psi}$$

$$\text{Maximum compressive stress (shut down) } S_{2c} = S_2 = 2.751 \text{ psi}$$

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

$$\text{Compressive stress is acceptable (} \leq S_c = 14,330 \text{ psi)}$$

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

$$\begin{aligned} Q_{\text{shear}} &= Q - w \cdot (a + 2 \cdot H / 3) \\ &= 33,098 - 236.93 \cdot (64.4094 + 2 \cdot 42.0079 / 3) \\ &= 11,201.74 \text{ lb}_f \end{aligned}$$

$$\begin{aligned} S_3 &= K_{2.2} \cdot Q_{\text{shear}} / (R \cdot t) \\ &= 1.1707 \cdot 11,201.74 / (41.7214 \cdot 0.573) \\ &= 549 \text{ psi} \end{aligned}$$

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

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

$$\begin{aligned} S_4 &= -Q / (4 \cdot t \cdot (b + 1.56 \cdot \text{Sqr}(R_o \cdot t))) - 12 \cdot K_3 \cdot Q \cdot R / (L \cdot t^2) \\ &= -33,098 / (4 \cdot 0.573 \cdot (12.0079 + 1.56 \cdot \text{Sqr}(42.0079 \cdot 0.573))) - 12 \cdot 0.0529 \cdot 33,098 \cdot 41.7214 / (226.2992 \cdot 0.573^2) \\ &= -12.532 \text{ psi} \end{aligned}$$

$$\text{Circumferential stress at saddle horns is acceptable (} \leq 0.9 \cdot S_y = 33,300 \text{ psi)}$$

The wear plate was not considered in the calculation of S_4 because the wear plate width is not at least $\{b + 1.56 \cdot (R_o \cdot t)^{0.5}\} = 19.6615 \text{ in}$

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

$$\begin{aligned} S_5 &= K_5 \cdot Q / ((t + t_p) \cdot (t_s + 1.56 \cdot \text{Sqr}(R_o \cdot t_c))) \\ &= 0.7603 \cdot 33,098 / ((0.573 + 0.2756) \cdot (0.4724 + 1.56 \cdot \text{Sqr}(42.0079 \cdot 0.8486))) \\ &= 3.030 \text{ psi} \end{aligned}$$

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

Saddle splitting load (left, Weight, Test)

Area resisting splitting force = Web area + wear plate area

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

$$\begin{aligned} S_6 &= K_8 \cdot Q / A_e \\ &= 0.2035 \cdot 33,098 / 6.1861 \\ &= 1.089 \text{ psi} \end{aligned}$$

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

Shear stress in anchor bolting, one end slotted

$$\text{Maximum seismic or wind base shear} = 0 \text{ lb}_f$$

$$\text{Thermal expansion base shear} = W \cdot \mu = 20,052 \cdot 0.45 = 9,023.4 \text{ lb}_f$$

Corroded root area for a 0.625" coarse threaded bolt = 0.202 in² (2 per saddle)

Bolt shear stress = 9,023.4 / (0.202*1*2) = 22,335 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 psi

Anchor bolt stress is acceptable (≤ 18,800 psi)

Web plate buckling check (Escoe pg 251)

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

$$\begin{aligned} S_c &= K_i \pi^2 E / (12(1 - 0.3^2)(d_i / t_s)^2) \\ &= 1.28 \pi^2 29E+06 / (12(1 - 0.3^2)(26.9414 / 0.4724)^2) \\ &= 10,317 \text{ psi} \end{aligned}$$

Allowable compressive load on the saddle

$$\begin{aligned} b_e &= d_i t_s / (d_i t_s + 2 t_w (b - 1)) \\ &= 26.9414 * 0.4724 / (26.9414 * 0.4724 + 2 * 0.4724 * (12.0079 - 1)) \\ &= 0.5503 \end{aligned}$$

$$\begin{aligned} F_b &= n(A_s + 2 b_e t_s) S_c \\ &= 4(5.4498 + 2 * 0.5503 * 0.4724) * 10,317 \\ &= 246,352.69 \text{ lb}_f \end{aligned}$$

Saddle loading of 34,234 lb_f is ≤ F_b ; satisfactory.

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

$$\begin{aligned} \sigma_b &= V(H_s - x_o)y / I + Q / A \\ &= 0(47.5591 - 34.7402) * 7.6325 / 485.97 + 19,609 / 56.1739 \\ &= 349 \text{ psi} \end{aligned}$$

The primary bending + axial stress in the saddle ≤ $S_s = 20,624$ psi; satisfactory.

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

$$\begin{aligned} \sigma_b &= V(H_s - x_o)y / I + Q / A \\ &= 9,023.4(47.5591 - 34.7402) * 7.6325 / 485.97 + 19,609 / 56.1739 \\ &= 2,166 \text{ psi} \end{aligned}$$

The secondary bending + axial stress in the saddle ≤ $2S_y = 72,000$ psi; satisfactory.

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

where $a = 26.9414$, $b = 11.5354$ in

$$\begin{aligned} t_b &= (\beta_1 q b^2 / (1.5 S_a))^{0.5} \\ &= (2.0208 * 38 * 11.5354^2 / (1.5 * 20,624))^{0.5} \\ &= 0.5769 \text{ in} \end{aligned}$$

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

Foundation bearing check

$$\begin{aligned} S_f &= Q_{\max} / (F \cdot E) \\ &= 34,234 / (12.0079 \cdot 74.4488) \\ &= 38 \text{ psi} \end{aligned}$$

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