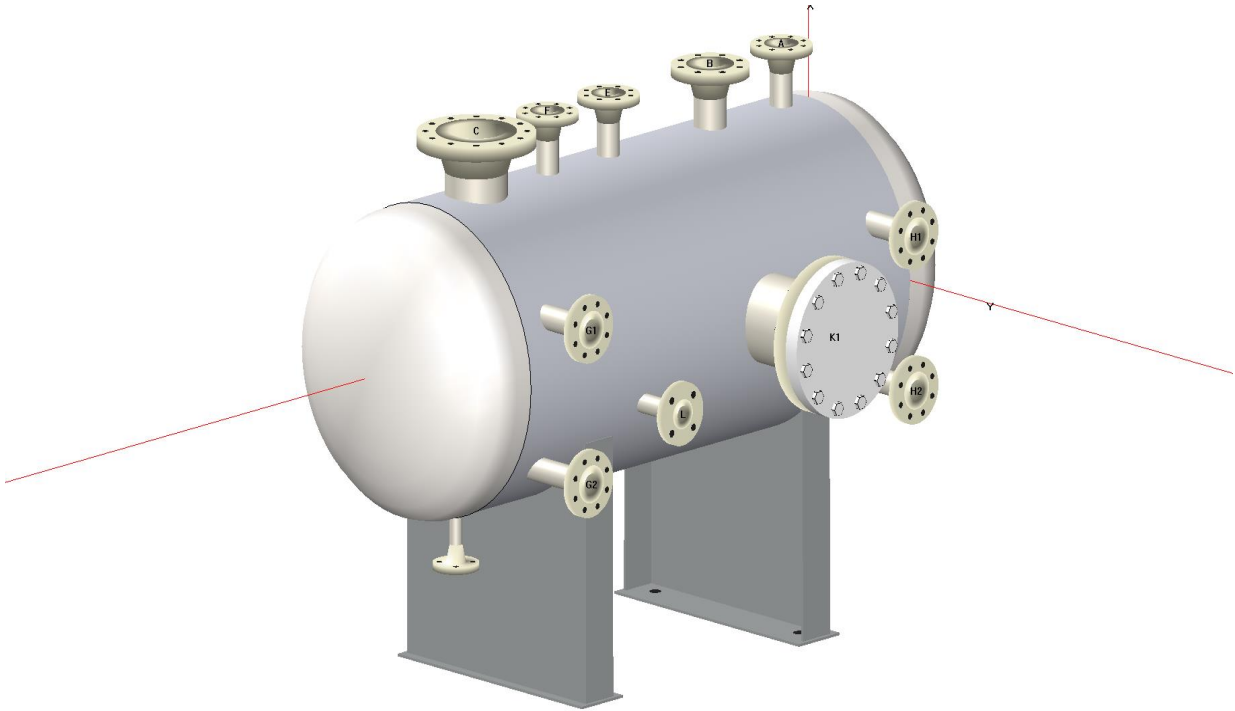


Houston Vessel Manufacturing, LLC

16250 Tomball Parkway

Houston, TX 77086



COMPRESS Pressure Vessel Design Calculations

Item: STEAM DRUM

PO#: 110862

Customer: BAYOTECH

Job#: HVM2112003A

Designer: Kevin Griffith

Date: Friday, January 14, 2022

REV 0

RELEASED FOR FABRICATION

TAG # 300-V-1001

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<u>Saddle #1</u>	86/91

Deficiencies Summary

No deficiencies found.

Nozzle Schedule

Specifications									
Nozzle mark	Identifier	Size	Materials		Impact Tested	Normalized	Fine Grain	Flange	Blind
A	TWO PHASE INLET #1	NPS 2 Sch 40S (Std)	Nozzle	SA-312 TP316 Wld pipe	No	No	No	NPS 2 Class 300 WN A182 F316	No
B	TWO PHASE INLET #2	NPS 3 Sch 80S (XS)	Nozzle	SA-312 TP316 Wld pipe	No	No	No	NPS 3 Class 300 WN A182 F316	No
C	STEAM OUTLET	NPS 6 Sch 80S (XS)	Nozzle	SA-312 TP316 Wld pipe	No	No	No	NPS 6 Class 300 WN A182 F316	No
D	REBOILER DRAW	NPS 2 Sch 40S (Std)	Nozzle	SA-312 TP316 Wld pipe	No	No	No	NPS 2 Class 300 WN A182 F316	No
E	PCV & PSV	NPS 2 Sch 40S (Std)	Nozzle	SA-312 TP316 Wld pipe	No	No	No	NPS 2 Class 300 WN A182 F316	No
E	PT	NPS 2 Sch 40S (Std)	Nozzle	SA-312 TP316 Wld pipe	No	No	No	NPS 2 Class 300 WN A182 F316	No
G1	BRIDLE / LT	NPS 2 Sch 40S (Std)	Nozzle	SA-312 TP316 Wld pipe	No	No	No	NPS 2 Class 300 WN A182 F316	No
G2	BRIDLE / LT	NPS 2 Sch 40S (Std)	Nozzle	SA-312 TP316 Wld pipe	No	No	No	NPS 2 Class 300 WN A182 F316	No
H1	LT CONNECTIONS	NPS 2 Sch 40S (Std)	Nozzle	SA-312 TP316 Wld pipe	No	No	No	NPS 2 Class 300 WN A182 F316	No
H2	LT CONNECTIONS	NPS 2 Sch 40S (Std)	Nozzle	SA-312 TP316 Wld pipe	No	No	No	NPS 2 Class 300 WN A182 F316	No
J	CONDENSATE BLOWDOWN	NPS 1 Sch 40S (Std)	Nozzle	SA-312 TP316 Wld pipe	No	No	No	NPS 1 Class 300 WN A182 F316	No
K1	HANDHOLE	NPS 8 Sch 40S (Std)	Nozzle	SA-312 TP316 Wld pipe	No	No	No	NPS 8 Class 300 WN A182 F316	NPS 8 Class 300 A182 F316
L	TE	NPS 1.5 Sch 80S (XS)	Nozzle	SA-312 TP316 Wld pipe	No	No	No	NPS 1 1/2 Class 300 WN A182 F316	No

Nozzle Summary

Dimensions												
Nozzle mark	OD (in)	t _n (in)	Req t _n (in)	A ₁ ?	A ₂ ?	Shell			Reinforcement Pad		Corr (in)	A _a /A _r (%)
						Nom t (in)	Design t (in)	User t (in)	Width (in)	t _{pad} (in)		
A	2.375	0.154	0.154	Yes	Yes	0.25	N/A		N/A	N/A	0	Exempt
B	3.5	0.3	0.2021	Yes	Yes	0.25	N/A		N/A	N/A	0	Exempt
C	6.625	0.432	0.2021	Yes	Yes	0.25	0.1768		N/A	N/A	0	104.0
D	2.375	0.154	0.154	Yes	Yes	0.25	N/A		N/A	N/A	0	Exempt
E	2.375	0.154	0.154	Yes	Yes	0.25	N/A		N/A	N/A	0	Exempt
F	2.375	0.154	0.154	Yes	Yes	0.25	N/A		N/A	N/A	0	Exempt
G1	2.375	0.154	0.154	Yes	Yes	0.25	N/A		N/A	N/A	0	Exempt
G2	2.375	0.154	0.154	Yes	Yes	0.25	N/A		N/A	N/A	0	Exempt
H1	2.375	0.154	0.154	Yes	Yes	0.25	N/A		N/A	N/A	0	Exempt
H2	2.375	0.154	0.154	Yes	Yes	0.25	N/A		N/A	N/A	0	Exempt
J	1.315	0.133	0.133	Yes	Yes	0.25	N/A		N/A	N/A	0	Exempt
K1	8.625	0.322	0.2021	Yes	Yes	0.25	0.1768		N/A	N/A	0	104.2
L	1.9	0.2	0.145	Yes	Yes	0.25	N/A		N/A	N/A	0	Exempt

Definitions	
t _n	Nozzle thickness
Req t _n	Nozzle thickness required per UG-45/UG-16 Increased for pipe to account for 12.5% pipe thickness tolerance
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
Ellipsoidal Head #1	225	425	225.01	-320	Note 1	No
Straight Flange on Ellipsoidal Head #1	225	425	270.97	-320	Note 2	No
Cylinder #1	225	425	270.97	-320	Note 2	No
Straight Flange on Ellipsoidal Head #2	225	425	270.97	-320	Note 2	No
Ellipsoidal Head #2	225	425	225.01	-320	Note 3	No
Saddle #1	225	425	225	N/A	N/A	N/A
TWO PHASE INLET #1 (A)	225	425	318.79	-55	Note 4	No
TWO PHASE INLET #2 (B)	225	425	318.79	-55	Note 4	No
STEAM OUTLET (C)	225	425	229.44	-55	Note 4	No
REBOILER DRAW (D)	225	425	318.79	-55	Note 4	No
PCV & PSV (E)	225	425	318.79	-55	Note 4	No
PT (F)	225	425	318.79	-55	Note 4	No
BRIDLE / LT (G1)	225	425	318.79	-55	Note 4	No
BRIDLE / LT (G2)	225	425	318.79	-55	Note 4	No
LT CONNECTIONS (H1)	225	425	318.79	-55	Note 4	No
LT CONNECTIONS (H2)	225	425	318.79	-55	Note 4	No
CONDENSATE BLOWDOWN (J)	225	425	318.79	-55	Note 4	No
HANDHOLE (K1)	225	425	229.66	-55	Note 4	No
TE (L)	225	425	318.79	-55	Note 4	No

Chamber Summary	
Design MDMT	-20 °F
Rated MDMT	-55 °F @ 225 psi
MAWP hot & corroded	225 psi @ 425 °F
(1) The MAWP is limited due to the MAWP limit set in the Calculations tab of the Set Mode dialog. (2) 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.	Straight Flange governs MDMT	
2.	Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320°F	
3.	Straight Flange governs MDMT	
4.	Flange rating governs: Flange rated MDMT per UHA-51(d)(1)(a) = -320°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

Revision History

Revisions			
No.	Date	Operator	Notes
0	6/ 8/2021	gcasco	New vessel created ASME Section VIII Division 1 [COMPRESS 2020 Build 8010]

Settings Summary

COMPRESS 2021 Build 8110	
ASME Section VIII Division 1, 2019 Edition	
Units	U.S. Customary
Datum Line Location	0.00" from right seam
Vessel Design Mode	Design Mode
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	225 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	1"
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	Yes
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	1.3 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	RT3
UG-116(f) Postweld heat treatment	None
Code Cases\Interpretations	
Use Appendix 46	No
Use UG-44(b)	No
Use Code Case 2955	No

Apply interpretation VIII-1-83-66	Yes
Apply interpretation VIII-1-86-175	Yes
Apply interpretation VIII-1-01-37	Yes
Apply interpretation VIII-1-01-150	Yes
Apply interpretation VIII-1-07-50	Yes
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
UG-22(j) Test pressure and coincident static head acting during the test:	No
Note: UG-22(b),(c) and (f) loads only considered when supports are present.	
Note 2: UG-22(d)(1),(e),(f)-snow,(g),(h),(i) are not considered. If these loads are present, additional calculations must be performed.	

License Information	
Company Name	Generon IGS
License	Commercial
License Key ID	23148
Support Expires	July 27, 2022

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	
Ellipsoidal Head #1	N/A	Seamless No RT	N/A	N/A	B	Spot UW-11(b) / Type 1	RT3
Cylinder #1	A	Spot UW-11(b) / Type 1	B	Spot UW-11(b) / Type 1	B	Spot UW-11(b) / Type 1	RT3
Ellipsoidal Head #2	N/A	Seamless No RT	B	Spot UW-11(b) / Type 1	N/A	N/A	RT3
Nozzle	Longitudinal Seam		Nozzle to Vessel Circumferential Seam		Nozzle free end Circumferential Seam		
STEAM OUTLET (C)	N/A	Welded pipe	D	N/A / Type 7	C	UW-11(b) exempt / Type 1	N/A
PCV & PSV (E)	N/A	Welded pipe	D	N/A / Type 7	C	UW-11(b) exempt / Type 1	N/A
TWO PHASE INLET #2 (B)	N/A	Welded pipe	D	N/A / Type 7	C	UW-11(b) exempt / Type 1	N/A
TWO PHASE INLET #1 (A)	N/A	Welded pipe	D	N/A / Type 7	C	UW-11(b) exempt / Type 1	N/A
PT (F)	N/A	Welded pipe	D	N/A / Type 7	C	UW-11(b) exempt / Type 1	N/A
REBOILER DRAW (D)	N/A	Welded pipe	D	N/A / Type 7	C	UW-11(b) exempt / Type 1	N/A
CONDENSATE BLOWDOWN (J)	N/A	Welded pipe	D	N/A / Type 7	C	UW-11(b) exempt / Type 1	N/A
BRIDLE / LT (G1)	N/A	Welded pipe	D	N/A / Type 7	C	UW-11(b) exempt / Type 1	N/A
BRIDLE / LT (G2)	N/A	Welded pipe	D	N/A / Type 7	C	UW-11(b) exempt / Type 1	N/A
LT CONNECTIONS (H1)	N/A	Welded pipe	D	N/A / Type 7	C	UW-11(b) exempt / Type 1	N/A
LT CONNECTIONS (H2)	N/A	Welded pipe	D	N/A / Type 7	C	UW-11(b) exempt / Type 1	N/A
HANDHOLE (K1)	N/A	Welded pipe	D	N/A / Type 7	C	UW-11(b) exempt / Type 1	N/A
TE (L)	N/A	Welded pipe	D	N/A / Type 7	C	UW-11(b) exempt / Type 1	N/A
Nozzle Flange	Longitudinal Seam		Flange Face		Nozzle to Flange Circumferential Seam		
ASME B16.5/16.47 flange attached to STEAM OUTLET (C)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(b) exempt / Type 1	N/A
ASME B16.5/16.47 flange attached to PCV & PSV (E)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(b) exempt / Type 1	N/A
ASME B16.5/16.47 flange attached to TWO PHASE INLET #2 (B)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(b) exempt / Type 1	N/A
ASME B16.5/16.47 flange attached to TWO PHASE INLET #1 (A)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(b) exempt / Type 1	N/A
ASME B16.5/16.47 flange attached to PT (F)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(b) exempt / Type 1	N/A
ASME B16.5/16.47 flange attached to REBOILER DRAW (D)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(b) exempt / Type 1	N/A
ASME B16.5/16.47 flange attached to CONDENSATE BLOWDOWN (J)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(b) exempt / Type 1	N/A
ASME B16.5/16.47 flange attached to BRIDLE / LT (G1)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(b) exempt / Type 1	N/A

ASME B16.5/16.47 flange attached to BRIDLE / LT (G2)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(b) exempt / Type 1	N/A
ASME B16.5/16.47 flange attached to LT CONNECTIONS (H1)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(b) exempt / Type 1	N/A
ASME B16.5/16.47 flange attached to LT CONNECTIONS (H2)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(b) exempt / Type 1	N/A
ASME B16.5/16.47 flange attached to HANDHOLE (K1)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(b) exempt / Type 1	N/A
ASME B16.5/16.47 flange attached to TE (L)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(b) exempt / Type 1	N/A
Interpretation VIII-1 01-150 has been applied.							
UG-116(e) Required Marking: RT3							

Thickness Summary

Component Data								
Component Identifier	Material	Diameter (in)	Length (in)	Nominal t (in)	Design t (in)	Total Corrosion (in)	Joint E	Load
Ellipsoidal Head #1	SA-240 316	30 OD	7.6032	0.2064*	0.2064	0	0.85	Internal
Straight Flange on Ellipsoidal Head #1	SA-240 316	30 OD	2	0.25	0.2079	0	0.85	Internal
Cylinder #1	SA-240 316	30 OD	56	0.25	0.2079	0	0.85	Internal
Straight Flange on Ellipsoidal Head #2	SA-240 316	30 OD	2	0.25	0.2079	0	0.85	Internal
Ellipsoidal Head #2	SA-240 316	30 OD	7.6032	0.2064*	0.2064	0	0.85	Internal
*Head minimum thickness after forming								

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

Weight Summary

Weight (lb) Contributed by Vessel Elements											
Component	Metal New*	Metal Corroded	Insulation	Insulation Supports	Lining	Piping + Liquid	Operating Liquid		Test Liquid		Surface Area ft ²
							New	Corroded	New	Corroded	
Ellipsoidal Head #1	75	75	0	0	0	0	0	0	171.7	171.7	9
Cylinder #1	369.2	369.2	0	0	0	0	0	0	1,396.5	1,396.5	36
Ellipsoidal Head #2	75	75	0	0	0	0	0	0	171.7	171.7	9
Saddle #1	126	126	0	0	0	0	0	0	0	0	25
TOTAL:	645.1	645.1	0	0	0	0	0	0	1,740	1,740	79
*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						
Ellipsoidal Head #1	0	0	0	0	0	0	0	0	0	0
Cylinder #1	0	0	343.1	343.1	0	0	0	0	0	15
Ellipsoidal Head #2	0	0	0	0	0	0	0	0	0	0
TOTAL:	0	0	343.1	343.1	0	0	0	0	0	15

Vessel Totals		
	New	Corroded
Operating Weight (lb)	988	988
Empty Weight (lb)	988	988
Test Weight (lb)	2,728	2,728
Surface Area (ft ²)	93	-
Capacity** (US gal)	207	207
**The vessel capacity does not include volume of nozzle, piping or other attachments.		

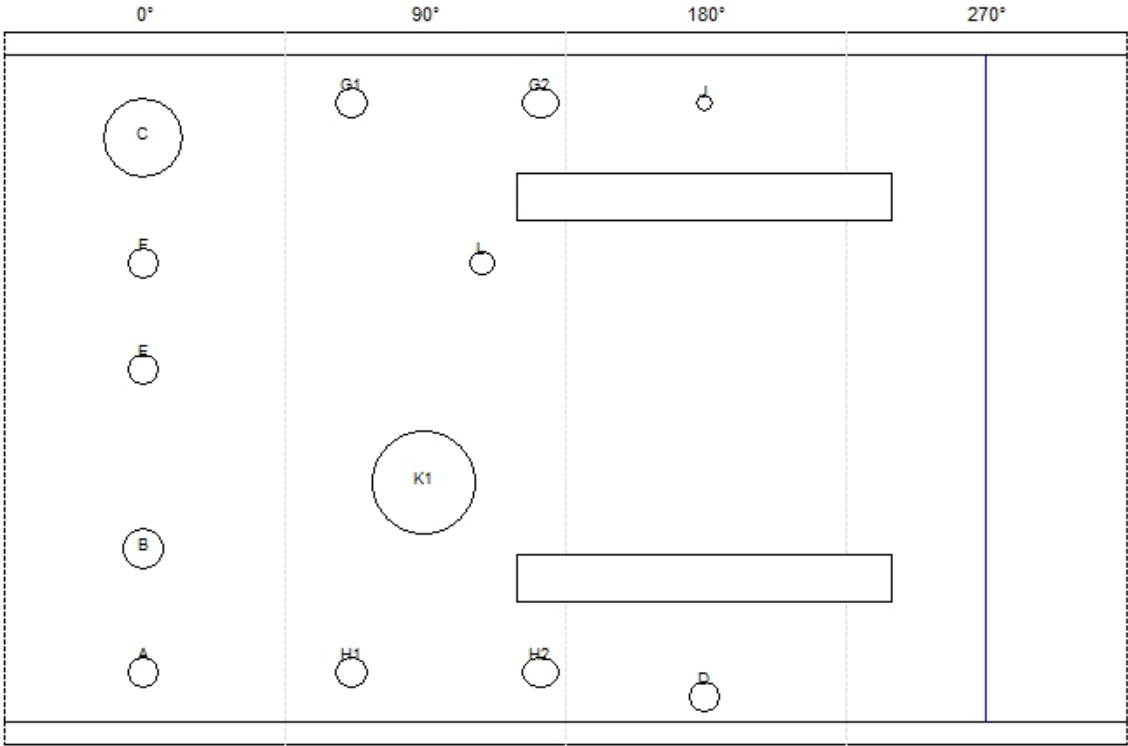
Vessel Lift Condition	
Vessel Lift Weight, New (lb)	988
Center of Gravity from Datum (in)	27.2059

Long Seam Summary

Shell Long Seam Angles	
Component	Seam 1
Cylinder #1	270°

Shell Plate Lengths		
Component	Starting Angle	Plate 1
Cylinder #1	270°	93.4624"

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



Hydrostatic Test

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

$$\begin{aligned}
 \text{Gauge pressure at } 70^{\circ}\text{F} &= \\
 &= 1.3 \cdot \text{MAWP} \cdot \text{LSR} \\
 &= 1.3 \cdot 225 \cdot 1.0526 \\
 &= 307.89 \text{ psi}
 \end{aligned}$$

Horizontal shop hydrostatic test				
Identifier	Local test pressure (psi)	Test liquid static head (psi)	UG-99(b) stress ratio	UG-99(b) pressure factor
Ellipsoidal Head #1 (1)	309.178	1.292	1.0526	1.30
Straight Flange on Ellipsoidal Head #1	309.176	1.291	1.0526	1.30
Cylinder #1	309.176	1.291	1.0526	1.30
Straight Flange on Ellipsoidal Head #2	309.176	1.291	1.0526	1.30
Ellipsoidal Head #2	309.178	1.292	1.0526	1.30
BRIDLE / LT (G1)	308.464	0.579	1.0559	1.30
BRIDLE / LT (G2)	309.006	1.12	1.0559	1.30
CONDENSATE BLOWDOWN (J)	309.402	1.516	1.0559	1.30
HANDHOLE (K1)	308.788	0.902	1.0559	1.30
LT CONNECTIONS (H1)	308.464	0.579	1.0559	1.30
LT CONNECTIONS (H2)	309.006	1.12	1.0559	1.30
PCV & PSV (E)	308.102	0.217	1.0559	1.30
PT (F)	308.102	0.217	1.0559	1.30
REBOILER DRAW (D)	309.366	1.48	1.0559	1.30
STEAM OUTLET (C)	308.102	0.217	1.0559	1.30
TE (L)	308.842	0.957	1.0559	1.30
TWO PHASE INLET #1 (A)	308.102	0.217	1.0559	1.30
TWO PHASE INLET #2 (B)	308.102	0.217	1.0559	1.30
(1) Ellipsoidal Head #1 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.

Foundation Load Summary

Saddle #1: Total Loading at Base (Right Fixed Saddle)				
Load	Vessel Condition	Longitudinal Base Shear (lb _f)	Transverse Base Shear (lb _f)	Vertical Force (lb _f)
Weight	Operating, Corroded	209	0	523

Saddle #1: Total Loading at Base (Left Sliding Saddle)				
Load	Vessel Condition	Longitudinal Base Shear (lb _f)	Transverse Base Shear (lb _f)	Vertical Force (lb _f)
Weight	Operating, Corroded	209	0	465

Shear and moment values reported above are presented without applicable load combination factors.

Support Information	
Support Type	Saddle
Number of Saddles	2
Base Plate Length	27.2"
Base Plate Width	6"
Base Plate Thickness	0.25"
Base Plate Separation Distance CL-to-CL	32"
Right Saddle Distance from Datum	12"
Number of Anchor Bolts Per Base Plate	2
Bolt Size and Type	1" series 8 bolt
Bolt Hole Clearance	0.25"
Slotted Hole Length	0.3125"
Center of Gravity (Distance from Datum)	27.2059"

Bill of Materials

Heads / Covers						
Item #	Type	Material	Thk [in]	Dia. [in]	Wt. [lb] (ea.)	Qty
H1	Ellipsoidal Head	SA-240 316	0.2064 (min.)	30 OD	75	2
H2	ASME B16.5/B16.47 Blind NPS 8 Class 300	A182 F316	1.62	15 OD	92	1

Shells							
Item #	Type	Material	Thk [in]	Dia. [in]	Length [in]	Wt. [lb] (ea.)	Qty
S1	Cylinder	SA-240 316	0.25	30 OD	56	379.5	1

Nozzles							
Item #	Type	Material	NPS	Thk [in]	Dia. [in]	Length [in]	Wt. [lb]
Noz1	Nozzle	SA-312 TP316 Wld pipe	NPS 6 Sch 80S (XS)	0.432	6.625 OD	2.7	6.7
Noz2	Nozzle	SA-312 TP316 Wld pipe	NPS 2 Sch 40S (Std)	0.154	2.375 OD	54.6	17
Noz3	Nozzle	SA-312 TP316 Wld pipe	NPS 3 Sch 80S (XS)	0.3	3.5 OD	3.2	2.8
Noz4	Nozzle	SA-312 TP316 Wld pipe	NPS 1 Sch 40S (Std)	0.133	1.315 OD	3.8	0.5
Noz5	Nozzle	SA-312 TP316 Wld pipe	NPS 8 Sch 40S (Std)	0.322	8.625 OD	6.5	15.9
Noz6	Nozzle	SA-312 TP316 Wld pipe	NPS 1.5 Sch 80S (XS)	0.2	1.9 OD	3.7	1.1

Flanges						
Item #	Type	Material	NPS	Dia. [in]	Wt. [lb] (ea.)	Qty
AF1	ASME B16.5 Welding Neck - Class 300	A182 F316	6	12.5 x 6.07	42	1
AF2	ASME B16.5 Welding Neck - Class 300	A182 F316	2	6.5 x 2.07	9	8
AF3	ASME B16.5 Welding Neck - Class 300	A182 F316	3	8.25 x 3.07	15	1
AF4	ASME B16.5 Welding Neck - Class 300	A182 F316	1	4.88 x 1.05	4	1
AF5	ASME B16.5 Welding Neck - Class 300	A182 F316	8	15 x 7.98	67	1
AF6	ASME B16.5 Welding Neck - Class 300	A182 F316	1 1/2	6.12 x 1.61	7	1

Gaskets				
Item #	Type	Size [in]	Thk [in]	Qty
G1	Flexitallic Flexpro PN 316L SS / PTFE (ASME B16.20 Kammprofile)	NPS 8 - Class 300	0.145	1

There are 12 flanges that do not include gasket information.

Fasteners				
Item #	Description	Material	Length [in]	Qty
FB1	3/4" coarse bolt	SA-193 B7 Bolt <= 2 1/2	4.3	12
FB2	5/8" coarse bolt	SA-193 B7 Bolt <= 2 1/2	3	64
FB3	3/4" coarse bolt	SA-193 B7 Bolt <= 2 1/2	3.5	8
FB4	5/8" coarse bolt	SA-193 B7 Bolt <= 2 1/2	2.5	4
FB5	7/8" coarse bolt	SA-193 B7 Bolt <= 2 1/2	4.8	12
FB6	3/4" coarse bolt	SA-193 B7 Bolt <= 2 1/2	3	4
SB1	1" series 8 bolt	Saddle bolt material	-	4
All listed flange bolts require associated nuts and washers in accordance with Division 1, UCS-11.				

Plates				
Item #	Material	Thk [in]	Wt. [lb]	Qty [ft²]
Plate1	SA-240-316	0.25	125.3	12.3
Plate1 - Note: Applies to saddle base plate, saddle web plate				

Ellipsoidal Head #1

ASME Section VIII Division 1, 2019 Edition				
Component		Ellipsoidal Head		
Material		SA-240 316 (II-D p. 72, ln. 43)		
Attached To		Cylinder #1		
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		225	425	-20
Static Liquid Head				
Condition		P _s (psi)	H _s (in)	SG
Test horizontal		1.29	35.7936	1
Dimensions				
Outer Diameter		30"		
Head Ratio		2		
Minimum Thickness		0.2064"		
Corrosion	Inner	0"		
	Outer	0"		
Length L _{sf}		2"		
Nominal Thickness t _{sf}		0.25"		
Weight and Capacity				
		Weight (lb) ¹		Capacity (US gal) ¹
New		74.97		20.59
Corroded		74.97		20.59
Radiography				
Category A joints		Seamless No RT		
Head to shell seam		Spot UW-11(b) Type 1		

¹ includes straight flange

Results Summary	
Governing condition	internal pressure
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	0.2064"
Maximum allowable working pressure (MAWP)	225.01 psi
Straight Flange governs MDMT	-320 °F

Factor K		
$K = (1/6) * [2 + (D / (2 * h))^2]$		
Corroded	$K = (1/6) * [2 + (29.5872 / (2 * 7.3968))^2]$	1
New	$K = (1/6) * [2 + (29.5872 / (2 * 7.3968))^2]$	1

Design thickness for internal pressure, (Corroded at 425 °F) Appendix 1-4(c)

$$\begin{aligned}
 t &= P * D_o * K / (2 * S * E + 2 * P * (K - 0.1)) + \text{Corrosion} \\
 &= 225 * 30 * 1 / (2 * 19,000 * 0.85 + 2 * 225 * (1 - 0.1)) + 0 \\
 &= \a href="#">0.2064"
 \end{aligned}$$

Maximum allowable working pressure, (Corroded at 425 °F) Appendix 1-4(c)

$$\begin{aligned}
 P &= 2 * S * E * t / (K * D_o - 2 * t * (K - 0.1)) - P_s \\
 &= 2 * 19,000 * 0.85 * 0.2064 / (1 * 30 - 2 * 0.2064 * (1 - 0.1)) - 0 \\
 &= \a href="#">225.01 \text{ psi}
 \end{aligned}$$

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

$$\begin{aligned}
 EFE &= (75 * t / R_f) * (1 - R_f / R_o) \\
 &= (75 * 0.25 / 5.1548) * (1 - 5.1548 / \infty) \\
 &= 3.6374\%
 \end{aligned}$$

ASME Section VIII Division 1 UG-81(a) Out-of-Roundness
Inside surface shall not deviate outside the shape by more than 1.25% of D
Inside surface shall not deviate inside the shape by more than 0.625% of D

Straight Flange on Ellipsoidal Head #1

ASME Section VIII Division 1, 2019 Edition				
Component		Cylinder		
Material		SA-240 316 (II-D p. 72, ln. 43)		
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		225	425	-20
Static Liquid Head				
Condition		P _s (psi)	H _s (in)	SG
Test horizontal		1.29	35.75	1
Dimensions				
Outer Diameter		30"		
Length		2"		
Nominal Thickness		0.25"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		Capacity (US gal)
New		13.55		5.92
Corroded		13.55		5.92
Radiography				
Longitudinal seam		Seamless No RT		
Right Circumferential seam		Spot UW-11(b) 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)	0.2079"
Maximum allowable working pressure (MAWP)	270.97 psi
Rated MDMT	-320 °F

UHA-51 Material Toughness Requirements	
$t_r = 225 \times 15 / (20,000 \times 0.85 + 0.4 \times 225) =$	0.1975"
Stress ratio $= t_r \times E^* / (t_n - c) = 0.1975 \times 0.85 / (0.25 - 0) =$	0.6714
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F	
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Design thickness, (at 425 °F) Appendix 1-1

$$\begin{aligned}
 t &= P \times R_o / (S \times E + 0.40 \times P) + \text{Corrosion} \\
 &= 225 \times 15 / (19,000 \times 0.85 + 0.40 \times 225) + 0 \\
 &= \underline{0.2079"}
 \end{aligned}$$

Maximum allowable working pressure, (at 425 °F) Appendix 1-1

$$\begin{aligned}
 P &= S \times E \times t / (R_o - 0.40 \times t) - P_s \\
 &= 19,000 \times 0.85 \times 0.25 / (15 - 0.40 \times 0.25) - 0 \\
 &= \underline{270.97} \text{ psi}
 \end{aligned}$$

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

$$\begin{aligned}
 EFE &= (50 \times t / R_f) \times (1 - R_f / R_o) \\
 &= (50 \times 0.25 / 14.875) \times (1 - 14.875 / \infty) \\
 &= 0.8403\%
 \end{aligned}$$

ASME Section VIII Division 1 UG-80(a) Out-of-Roundness
$(D_{\max} - D_{\min})$ shall not exceed 1% of D
When the cross section passes through an opening or within 1 I.D. of the opening, $(D_{\max} - D_{\min})$ shall not exceed 1% of D + 2% of the inside diameter of the opening

Cylinder #1

ASME Section VIII Division 1, 2019 Edition				
Component		Cylinder		
Material		SA-240 316 (II-D p. 72, ln. 43)		
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		225	425	-20
Static Liquid Head				
Condition		P _s (psi)	H _s (in)	SG
Test horizontal		1.29	35.75	1
Dimensions				
Outer Diameter		30"		
Length		56"		
Nominal Thickness		0.25"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		Capacity (US gal)
New		369.15		165.7
Corroded		369.15		165.7
Radiography				
Longitudinal seam		Spot UW-11(b) Type 1		
Left Circumferential seam		Spot UW-11(b) Type 1		
Right Circumferential seam		Spot UW-11(b) 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)	0.2079"
Maximum allowable working pressure (MAWP)	270.97 psi
Rated MDMT	-320 °F

UHA-51 Material Toughness Requirements	
$t_r = 225 \times 15 / (20,000 \times 0.85 + 0.4 \times 225) =$	0.1975"
Stress ratio $= t_r \times E^* / (t_n - c) = 0.1975 \times 0.85 / (0.25 - 0) =$	0.6714
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F	
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Design thickness, (at 425 °F) Appendix 1-1

$$\begin{aligned}
 t &= P \times R_o / (S \times E + 0.40 \times P) + \text{Corrosion} \\
 &= 225 \times 15 / (19,000 \times 0.85 + 0.40 \times 225) + 0 \\
 &= \underline{0.2079"}
 \end{aligned}$$

Maximum allowable working pressure, (at 425 °F) Appendix 1-1

$$\begin{aligned}
 P &= S \times E \times t / (R_o - 0.40 \times t) - P_s \\
 &= 19,000 \times 0.85 \times 0.25 / (15 - 0.40 \times 0.25) - 0 \\
 &= \underline{270.97} \text{ psi}
 \end{aligned}$$

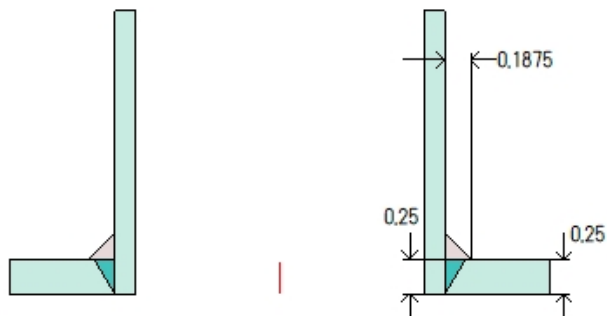
% Forming strain - UHA-44(a)(2)

$$\begin{aligned}
 EFE &= (50 \times t / R_f) \times (1 - R_f / R_o) \\
 &= (50 \times 0.25 / 14.875) \times (1 - 14.875 / \infty) \\
 &= 0.8403\%
 \end{aligned}$$

ASME Section VIII Division 1 UG-80(a) Out-of-Roundness
$(D_{\max} - D_{\min})$ shall not exceed 1% of D
When the cross section passes through an opening or within 1 I.D. of the opening, $(D_{\max} - D_{\min})$ shall not exceed 1% of D + 2% of the inside diameter of the opening

BRIDLE / LT (G1)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	90°
Nozzle center line offset to datum line	52"
End of nozzle to shell center	20"
Offset from center, Lo	-6"
Passes through a Category A joint	No

Nozzle

Description	NPS 2 Sch 40S (Std)
Access opening	No
Material specification	SA-312 TP316 Wld pipe (II-D p. 76, ln. 7)
Inside diameter, new	2.067"
Pipe nominal wall thickness	0.154"
Pipe minimum wall thickness ¹	0.1348"
Corrosion allowance	0"
Opening chord length	2.2613"
Projection available outside vessel, Lpr	3.043"
Projection available outside vessel to flange face, Lf	5.793"
Local vessel minimum thickness	0.25"
Liquid static head included	0 psi

Welds

Inner fillet, Leg ₄₁	0.1875"
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Nozzle to vessel groove weld	0.25"
Radiography	
Longitudinal seam	Welded pipe
Circumferential seam	None UW-11(c) Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 2 Class 300 WN A182 F316
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, ln. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	506.25 psi @ 425°F
MAP rating	720 psi @ 70°F
Hydrotest rating	1,100 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Circumferential joint radiography	None UW-11(c) Type 1
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 225 \cdot 1.0335 / (17,000 \cdot 1 - 0.6 \cdot 225) =$	0.0138"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0138 \cdot 1 / (0.1348 - 0) =$	0.1023
Impact test exempt per UHA-51(g) (coincident ratio = 0.1023)	
Rated MDMT =	-320°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement check in the plane parallel to the longitudinal axis

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement check in the plane parallel to the longitudinal axis

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

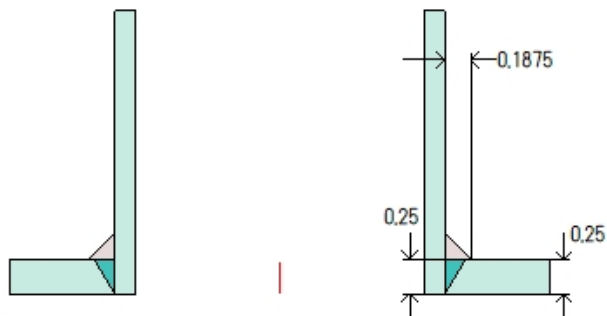
UG-41 Weld Failure Path Analysis Summary	
The nozzle is exempt from weld strength calculations per UW-15(b)(2)	

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.1313	weld size is adequate

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

BRIDLE / LT (G2)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	90°
Nozzle center line offset to datum line	52"
End of nozzle to shell center	20"
Offset from center, Lo	9"
Passes through a Category A joint	No

Nozzle

Description	NPS 2 Sch 40S (Std)
Access opening	No
Material specification	SA-312 TP316 Wld pipe (II-D p. 76, ln. 7)
Inside diameter, new	2.067"
Pipe nominal wall thickness	0.154"
Pipe minimum wall thickness ¹	0.1348"
Corrosion allowance	0"
Opening chord length	2.6057"
Projection available outside vessel, Lpr	4.4451"
Projection available outside vessel to flange face, Lf	7.1951"
Local vessel minimum thickness	0.25"
Liquid static head included	0 psi

Welds

Inner fillet, Leg ₄₁	0.1875"
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Nozzle to vessel groove weld	0.25"
Radiography	
Longitudinal seam	Welded pipe
Circumferential seam	None UW-11(c) Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 2 Class 300 WN A182 F316
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, ln. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	506.25 psi @ 425°F
MAP rating	720 psi @ 70°F
Hydrotest rating	1,100 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Circumferential joint radiography	None UW-11(c) Type 1
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 225 \cdot 1.0335 / (17,000 \cdot 1 - 0.6 \cdot 225) =$	0.0138"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0138 \cdot 1 / (0.1348 - 0) =$	0.1023
Impact test exempt per UHA-51(g) (coincident ratio = 0.1023)	
Rated MDMT =	-320°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement check in the plane parallel to the longitudinal axis

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement check in the plane parallel to the longitudinal axis

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

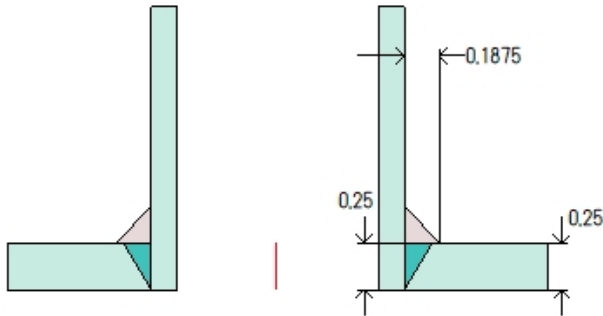
UG-41 Weld Failure Path Analysis Summary	
The nozzle is exempt from weld strength calculations per UW-15(b)(2)	

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.1313	weld size is adequate

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

CONDENSATE BLOWDOWN (J)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	180°
Nozzle center line offset to datum line	52"
End of nozzle to shell center	21"
Passes through a Category A joint	No

Nozzle

Description	NPS 1 Sch 40S (Std)
Access opening	No
Material specification	SA-312 TP316 Wld pipe (II-D p. 76, In. 7)
Inside diameter, new	1.049"
Pipe nominal wall thickness	0.133"
Pipe minimum wall thickness ¹	0.1164"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	3.56"
Projection available outside vessel to flange face, L _f	6"
Local vessel minimum thickness	0.25"
Liquid static head included	0 psi

Welds

Inner fillet, Leg ₄₁	0.1875"
Nozzle to vessel groove weld	0.25"

Radiography

Longitudinal seam	Welded pipe
Circumferential seam	None UW-11(c) Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 1 Class 300 WN A182 F316
Bolt Material	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 398, ln. 32)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	506.25 psi @ 425 °F
MAP rating	720 psi @ 70 °F
Hydrotest rating	1,100 psi @ 70 °F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Circumferential joint radiography	None UW-11(c) Type 1
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 225 \cdot 0.5245 / (17,000 \cdot 1 - 0.6 \cdot 225) =$	0.007"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.007 \cdot 1 / (0.1164 - 0) =$	0.0601
Impact test exempt per UHA-51(g) (coincident ratio = 0.0601)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1164	0.1164

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)	0.0931	0.1313	weld size is adequate

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

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1164	0.1164

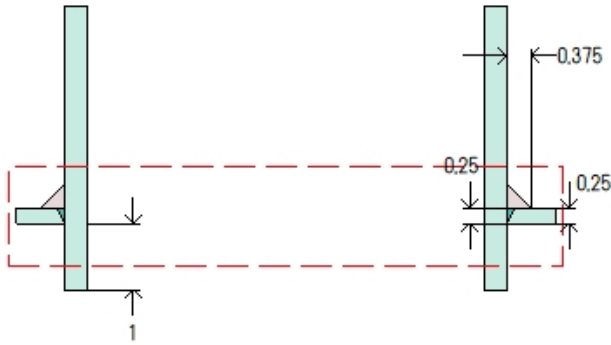
UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.0931	0.1313	weld size is adequate

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

HANDHOLE (K1)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	90°
Nozzle center line offset to datum line	20"
End of nozzle to shell center	24"
Passes through a Category A joint	No

Nozzle

Description	NPS 8 Sch 40S (Std)
Access opening	No
Material specification	SA-312 TP316 Wld pipe (II-D p. 76, In. 7)
Inside diameter, new	7.981"
Pipe nominal wall thickness	0.322"
Pipe minimum wall thickness ¹	0.2818"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	4.62"
Internal projection, h _{new}	1"
Projection available outside vessel to flange face, L _f	9"
Local vessel minimum thickness	0.25"
Liquid static head included	0 psi

Welds

Inner fillet, Leg ₄₁	0.375"
Lower fillet, Leg ₄₃	0"

Nozzle to vessel groove weld	0.25"
Radiography	
Longitudinal seam	Welded pipe
Circumferential seam	None UW-11(c) Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 8 Class 300 WN A182 F316
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, ln. 32)
Blind included	Yes
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	506.25 psi @ 425°F
MAP rating	720 psi @ 70°F
Hydrotest rating	1,100 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Circumferential joint radiography	None UW-11(c) Type 1
Gasket	
Type	ASME B16.20 Kammprofile
Description	Flexitallic Flexpro PN 316L SS / PTFE
Factor, m	2
Seating Stress, y	2,500 psi
Thickness, T	0.145"
Inner Diameter	9"
Outer Diameter	10.5"
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 225 \times 15 / (20,000 \times 1 + 0.4 \times 225) =$	0.168"
Stress ratio $= t_r \times E^* / (t_n - c) = 0.168 \times 1 / (0.25 - 0) =$	0.672
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F	
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.411	1.4704	0.5843	0.343	0.4025	--	0.1406	0.1768	0.2818

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)	0.175	0.2625	weld size is adequate

Reinforcement Calculations for MAWP

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

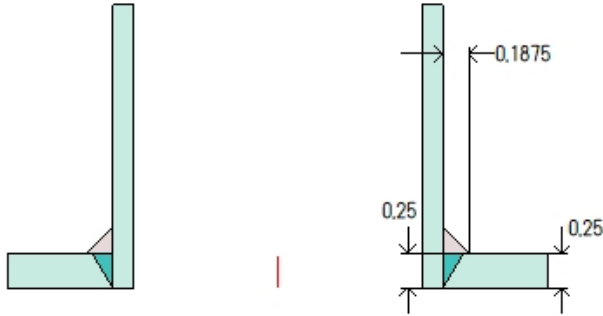
UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 229.66 psi @ 425 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.4401	1.4401	0.5552	0.3418	0.4025	--	0.1406	0.1804	0.2818

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)	0.175	0.2625	weld size is adequate

LT CONNECTIONS (H1)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	90°
Nozzle center line offset to datum line	4"
End of nozzle to shell center	20"
Offset from center, Lo	-6"
Passes through a Category A joint	No

Nozzle

Description	NPS 2 Sch 40S (Std)
Access opening	No
Material specification	SA-312 TP316 Wld pipe (II-D p. 76, ln. 7)
Inside diameter, new	2.067"
Pipe nominal wall thickness	0.154"
Pipe minimum wall thickness ¹	0.1348"
Corrosion allowance	0"
Opening chord length	2.2613"
Projection available outside vessel, L _{pr}	3.043"
Projection available outside vessel to flange face, L _f	5.793"
Local vessel minimum thickness	0.25"
Liquid static head included	0 psi

Welds

Inner fillet, Leg ₄₁	0.1875"
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Nozzle to vessel groove weld	0.25"
Radiography	
Longitudinal seam	Welded pipe
Circumferential seam	None UW-11(c) Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 2 Class 300 WN A182 F316
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, ln. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	506.25 psi @ 425°F
MAP rating	720 psi @ 70°F
Hydrotest rating	1,100 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Circumferential joint radiography	None UW-11(c) Type 1
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 225 \cdot 1.0335 / (17,000 \cdot 1 - 0.6 \cdot 225) =$	0.0138"
$\text{Stress ratio} = t_r \cdot E^* / (t_n - c) = 0.0138 \cdot 1 / (0.1348 - 0) =$	0.1023
Impact test exempt per UHA-51(g) (coincident ratio = 0.1023)	
Rated MDMT =	-320°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement check in the plane parallel to the longitudinal axis

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement check in the plane parallel to the longitudinal axis

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

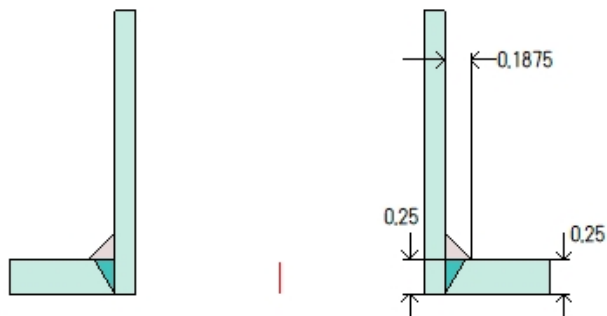
UG-41 Weld Failure Path Analysis Summary	
The nozzle is exempt from weld strength calculations per UW-15(b)(2)	

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.1313	weld size is adequate

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

LT CONNECTIONS (H2)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	90°
Nozzle center line offset to datum line	4"
End of nozzle to shell center	20"
Offset from center, Lo	9"
Passes through a Category A joint	No

Nozzle

Description	NPS 2 Sch 40S (Std)
Access opening	No
Material specification	SA-312 TP316 Wld pipe (II-D p. 76, ln. 7)
Inside diameter, new	2.067"
Pipe nominal wall thickness	0.154"
Pipe minimum wall thickness ¹	0.1348"
Corrosion allowance	0"
Opening chord length	2.6057"
Projection available outside vessel, L _{pr}	4.4451"
Projection available outside vessel to flange face, L _f	7.1951"
Local vessel minimum thickness	0.25"
Liquid static head included	0 psi

Welds

Inner fillet, Leg ₄₁	0.1875"
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Nozzle to vessel groove weld	0.25"
Radiography	
Longitudinal seam	Welded pipe
Circumferential seam	None UW-11(c) Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 2 Class 300 WN A182 F316
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, ln. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	506.25 psi @ 425°F
MAP rating	720 psi @ 70°F
Hydrotest rating	1,100 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Circumferential joint radiography	None UW-11(c) Type 1
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 225 * 1.0335 / (17,000 * 1 - 0.6 * 225) =$	0.0138"
$\text{Stress ratio} = t_r * E^* / (t_n - c) = 0.0138 * 1 / (0.1348 - 0) =$	0.1023
Impact test exempt per UHA-51(g) (coincident ratio = 0.1023)	
Rated MDMT =	-320°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement check in the plane parallel to the longitudinal axis

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement check in the plane parallel to the longitudinal axis

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

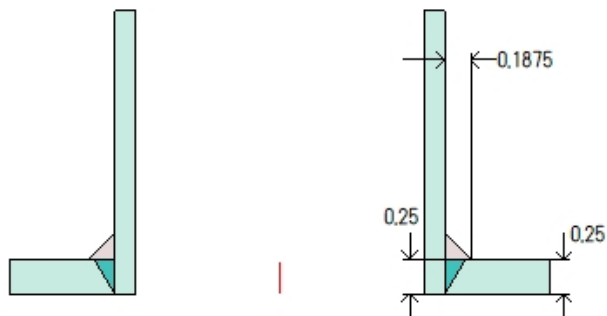
UG-41 Weld Failure Path Analysis Summary	
The nozzle is exempt from weld strength calculations per UW-15(b)(2)	

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.1313	weld size is adequate

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

PCV & PSV (E)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	0°
Nozzle center line offset to datum line	29.5"
End of nozzle to shell center	21"
Passes through a Category A joint	No

Nozzle

Description	NPS 2 Sch 40S (Std)
Access opening	No
Material specification	SA-312 TP316 Wld pipe (II-D p. 76, ln. 7)
Inside diameter, new	2.067"
Pipe nominal wall thickness	0.154"
Pipe minimum wall thickness ¹	0.1348"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	3.25"
Projection available outside vessel to flange face, L _f	6"
Local vessel minimum thickness	0.25"
Liquid static head included	0 psi

Welds

Inner fillet, Leg ₄₁	0.1875"
Nozzle to vessel groove weld	0.25"

Radiography

Longitudinal seam	Welded pipe
Circumferential seam	None UW-11(c) Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 2 Class 300 WN A182 F316
Bolt Material	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 398, ln. 32)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	506.25 psi @ 425 °F
MAP rating	720 psi @ 70 °F
Hydrotest rating	1,100 psi @ 70 °F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Circumferential joint radiography	None UW-11(c) Type 1
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 225 \cdot 1.0335 / (17,000 \cdot 1 - 0.6 \cdot 225) =$	0.0138"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0138 \cdot 1 / (0.1348 - 0) =$	0.1023
Impact test exempt per UHA-51(g) (coincident ratio = 0.1023)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

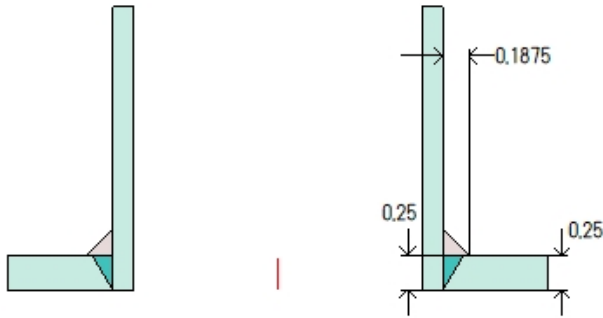
UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.1313	weld size is adequate

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

PT (F)

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

Location and Orientation

Located on	Cylinder #1
Orientation	0°
Nozzle center line offset to datum line	38.5"
End of nozzle to shell center	21"
Passes through a Category A joint	No

Nozzle

Description	NPS 2 Sch 40S (Std)
Access opening	No
Material specification	SA-312 TP316 Wld pipe (II-D p. 76, In. 7)
Inside diameter, new	2.067"
Pipe nominal wall thickness	0.154"
Pipe minimum wall thickness ¹	0.1348"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	3.25"
Projection available outside vessel to flange face, L _f	6"
Local vessel minimum thickness	0.25"
Liquid static head included	0 psi

Welds

Inner fillet, Leg ₄₁	0.1875"
Nozzle to vessel groove weld	0.25"

Radiography

Longitudinal seam	Welded pipe
Circumferential seam	None UW-11(c) Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 2 Class 300 WN A182 F316
Bolt Material	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 398, ln. 32)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	506.25 psi @ 425 °F
MAP rating	720 psi @ 70 °F
Hydrotest rating	1,100 psi @ 70 °F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Circumferential joint radiography	None UW-11(c) Type 1
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 225 \cdot 1.0335 / (17,000 \cdot 1 - 0.6 \cdot 225) =$	0.0138"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0138 \cdot 1 / (0.1348 - 0) =$	0.1023
Impact test exempt per UHA-51(g) (coincident ratio = 0.1023)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

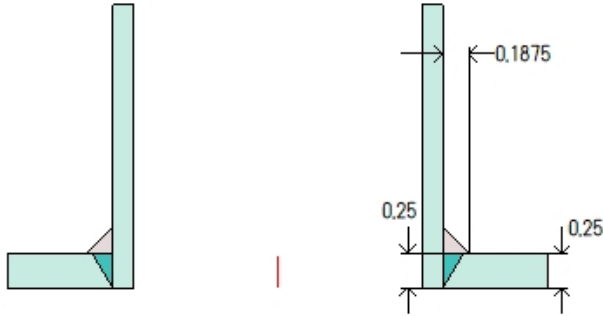
UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.1313	weld size is adequate

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

REBOILER DRAW (D)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	180°
Nozzle center line offset to datum line	2"
End of nozzle to shell center	20"
Passes through a Category A joint	No

Nozzle

Description	NPS 2 Sch 40S (Std)
Access opening	No
Material specification	SA-312 TP316 Wld pipe (II-D p. 76, In. 7)
Inside diameter, new	2.067"
Pipe nominal wall thickness	0.154"
Pipe minimum wall thickness ¹	0.1348"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	2.25"
Projection available outside vessel to flange face, L _f	5"
Local vessel minimum thickness	0.25"
Liquid static head included	0 psi

Welds

Inner fillet, Leg ₄₁	0.1875"
Nozzle to vessel groove weld	0.25"

Radiography

Longitudinal seam	Welded pipe
Circumferential seam	None UW-11(c) Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 2 Class 300 WN A182 F316
Bolt Material	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 398, ln. 32)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	506.25 psi @ 425 °F
MAP rating	720 psi @ 70 °F
Hydrotest rating	1,100 psi @ 70 °F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Circumferential joint radiography	None UW-11(c) Type 1
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 225 \cdot 1.0335 / (17,000 \cdot 1 - 0.6 \cdot 225) =$	0.0138"
$\text{Stress ratio} = t_r \cdot E^* / (t_n - c) = 0.0138 \cdot 1 / (0.1348 - 0) =$	0.1023
Impact test exempt per UHA-51(g) (coincident ratio = 0.1023)	
Rated MDMT =	-320 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

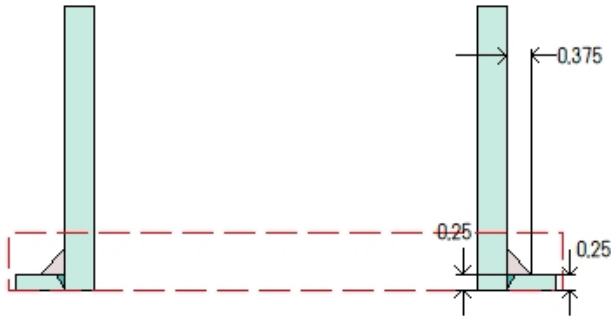
UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.1313	weld size is adequate

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

STEAM OUTLET (C)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	0°
Nozzle center line offset to datum line	49"
End of nozzle to shell center	21"
Passes through a Category A joint	No

Nozzle

Description	NPS 6 Sch 80S (XS)
Access opening	No
Material specification	SA-312 TP316 Wld pipe (II-D p. 76, In. 7)
Inside diameter, new	5.761"
Pipe nominal wall thickness	0.432"
Pipe minimum wall thickness ¹	0.378"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	2.12"
Projection available outside vessel to flange face, L _f	6"
Local vessel minimum thickness	0.25"
Liquid static head included	0 psi

Welds

Inner fillet, Leg ₄₁	0.375"
Nozzle to vessel groove weld	0.25"

Radiography

Longitudinal seam	Welded pipe
Circumferential seam	None UW-11(c) Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 6 Class 300 WN A182 F316
Bolt Material	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 398, ln. 32)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	506.25 psi @ 425 °F
MAP rating	720 psi @ 70 °F
Hydrotest rating	1,100 psi @ 70 °F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Circumferential joint radiography	None UW-11(c) Type 1
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 225 \cdot 15 / (20,000 \cdot 1 + 0.4 \cdot 225) =$	0.168"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.168 \cdot 1 / (0.25 - 0) =$	0.672
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F	
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.0185	1.0594	0.4218	0.497	--	--	0.1406	0.1768	0.378

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)	0.175	0.2625	weld size is adequate

Reinforcement Calculations for MAWP

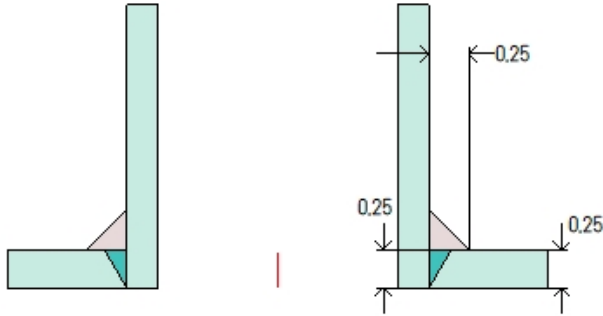
Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 229.44 psi @ 425 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
1.0385	1.0386	0.4018	0.4962	--	--	0.1406	0.1803	0.378

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)	0.175	0.2625	weld size is adequate

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	90°
Nozzle center line offset to datum line	38.5"
End of nozzle to shell center	20"
Offset from center, Lo	4.75"
Passes through a Category A joint	No

Nozzle

Description	NPS 1.5 Sch 80S (XS)
Access opening	No
Material specification	SA-312 TP316 Wld pipe (II-D p. 76, ln. 7)
Inside diameter, new	1.5"
Pipe nominal wall thickness	0.2"
Pipe minimum wall thickness ¹	0.175"
Corrosion allowance	0"
Opening chord length	1.5836"
Projection available outside vessel, L _{pr}	2.7993"
Projection available outside vessel to flange face, L _f	5.4893"
Local vessel minimum thickness	0.25"
Liquid static head included	0 psi

Welds

Inner fillet, Leg ₄₁	0.25"
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Nozzle to vessel groove weld	0.25"
Radiography	
Longitudinal seam	Welded pipe
Circumferential seam	Spot UW-11(a)(5)(b) only Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 1.5 Class 300 WN A182 F316
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, ln. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	506.25 psi @ 425°F
MAP rating	720 psi @ 70°F
Hydrotest rating	1,100 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Circumferential joint radiography	Spot UW-11(a)(5)(b) only Type 1
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 225 \cdot 0.75 / (17,000 \cdot 1 - 0.6 \cdot 225) =$	0.01"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.01 \cdot 1 / (0.175 - 0) =$	0.0572
Impact test exempt per UHA-51(g) (coincident ratio = 0.0572)	
Rated MDMT =	-320°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1269	0.175

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)	0.14	0.175	weld size is adequate

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

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1269	0.175

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)	0.14	0.175	weld size is adequate

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

Reinforcement check in the plane parallel to the longitudinal axis

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1269	0.175

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)	0.14	0.175	weld size is adequate

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

Reinforcement check in the plane parallel to the longitudinal axis

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1269	0.175

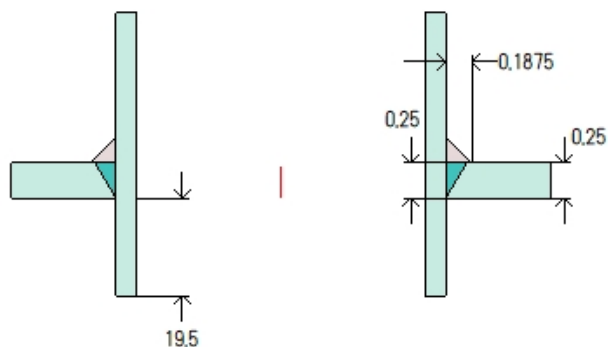
UG-41 Weld Failure Path Analysis Summary	
The nozzle is exempt from weld strength calculations per UW-15(b)(2)	

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.14	0.175	weld size is adequate

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

TWO PHASE INLET #1 (A)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	0°
Nozzle center line offset to datum line	4"
End of nozzle to shell center	21"
Passes through a Category A joint	No

Nozzle

Description	NPS 2 Sch 40S (Std)
Access opening	No
Material specification	SA-312 TP316 Wld pipe (II-D p. 76, In. 7)
Inside diameter, new	2.067"
Pipe nominal wall thickness	0.154"
Pipe minimum wall thickness ¹	0.1348"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	3.25"
Internal projection, h _{new}	19.5"
Projection available outside vessel to flange face, L _f	6"
Local vessel minimum thickness	0.25"
Liquid static head included	0 psi

Welds

Inner fillet, Leg ₄₁	0.1875"
Lower fillet, Leg ₄₃	0"

Nozzle to vessel groove weld	0.25"
Radiography	
Longitudinal seam	Welded pipe
Circumferential seam	None UW-11(c) Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 2 Class 300 WN A182 F316
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, ln. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	506.25 psi @ 425°F
MAP rating	720 psi @ 70°F
Hydrotest rating	1,100 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Circumferential joint radiography	None UW-11(c) Type 1
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 225 * 1.0335 / (17,000 * 1 - 0.6 * 225) =$	0.0138"
Stress ratio = $t_r * E^* / (t_n - c) = 0.0138 * 1 / (0.1348 - 0) =$	0.1023
Impact test exempt per UHA-51(g) (coincident ratio = 0.1023)	
Rated MDMT =	-320°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

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)	0.1078	0.1313	weld size is adequate

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

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.1348

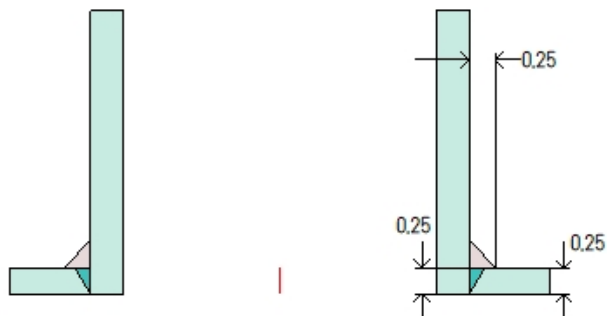
UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.1313	weld size is adequate

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

TWO PHASE INLET #2 (B)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	0°
Nozzle center line offset to datum line	14.5"
End of nozzle to shell center	21"
Passes through a Category A joint	No

Nozzle

Description	NPS 3 Sch 80S (XS)
Access opening	No
Material specification	SA-312 TP316 Wld pipe (II-D p. 76, In. 7)
Inside diameter, new	2.9"
Pipe nominal wall thickness	0.3"
Pipe minimum wall thickness ¹	0.2625"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	2.88"
Projection available outside vessel to flange face, L _f	6"
Local vessel minimum thickness	0.25"
Liquid static head included	0 psi

Welds

Inner fillet, Leg ₄₁	0.25"
Nozzle to vessel groove weld	0.25"

Radiography

Longitudinal seam	Welded pipe
Circumferential seam	None UW-11(c) Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 3 Class 300 WN A182 F316
Bolt Material	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 398, ln. 32)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	506.25 psi @ 425 °F
MAP rating	720 psi @ 70 °F
Hydrotest rating	1,100 psi @ 70 °F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Circumferential joint radiography	None UW-11(c) Type 1
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UHA-51 Material Toughness Requirements Nozzle	
$t_r = 225 \cdot 15 / (20,000 \cdot 1 + 0.4 \cdot 225) =$	0.168"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.168 \cdot 1 / (0.25 - 0) =$	0.672
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F	
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 225 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1768	0.2625

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)	0.175	0.175	weld size is adequate

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

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 318.79 psi @ 425 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.189	0.2625

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)	0.175	0.175	weld size is adequate

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

Straight Flange on Ellipsoidal Head #2

ASME Section VIII Division 1, 2019 Edition				
Component		Cylinder		
Material		SA-240 316 (II-D p. 72, ln. 43)		
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		225	425	-20
Static Liquid Head				
Condition		P _s (psi)	H _s (in)	SG
Test horizontal		1.29	35.75	1
Dimensions				
Outer Diameter		30"		
Length		2"		
Nominal Thickness		0.25"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		Capacity (US gal)
New		13.55		5.92
Corroded		13.55		5.92
Radiography				
Longitudinal seam		Seamless No RT		
Left Circumferential seam		Spot UW-11(b) 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)	0.2079"
Maximum allowable working pressure (MAWP)	270.97 psi
Rated MDMT	-320 °F

UHA-51 Material Toughness Requirements	
$t_r = 225 \times 15 / (20,000 \times 0.85 + 0.4 \times 225) =$	0.1975"
Stress ratio $= t_r \times E^* / (t_n - c) = 0.1975 \times 0.85 / (0.25 - 0) =$	0.6714
Rated MDMT per UHA-51(d)(1)(a), (carbon content does not exceed 0.10%) = -320 °F	
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Design thickness, (at 425 °F) Appendix 1-1

$$\begin{aligned}
 t &= P \times R_o / (S \times E + 0.40 \times P) + \text{Corrosion} \\
 &= 225 \times 15 / (19,000 \times 0.85 + 0.40 \times 225) + 0 \\
 &= \underline{0.2079"}
 \end{aligned}$$

Maximum allowable working pressure, (at 425 °F) Appendix 1-1

$$\begin{aligned}
 P &= S \times E \times t / (R_o - 0.40 \times t) - P_s \\
 &= 19,000 \times 0.85 \times 0.25 / (15 - 0.40 \times 0.25) - 0 \\
 &= \underline{270.97} \text{ psi}
 \end{aligned}$$

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

$$\begin{aligned}
 EFE &= (50 \times t / R_f) \times (1 - R_f / R_o) \\
 &= (50 \times 0.25 / 14.875) \times (1 - 14.875 / \infty) \\
 &= 0.8403\%
 \end{aligned}$$

ASME Section VIII Division 1 UG-80(a) Out-of-Roundness
$(D_{\max} - D_{\min})$ shall not exceed 1% of D
When the cross section passes through an opening or within 1 I.D. of the opening, $(D_{\max} - D_{\min})$ shall not exceed 1% of D + 2% of the inside diameter of the opening

Ellipsoidal Head #2

ASME Section VIII Division 1, 2019 Edition				
Component		Ellipsoidal Head		
Material		SA-240 316 (II-D p. 72, In. 43)		
Attached To		Cylinder #1		
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		225	425	-20
Static Liquid Head				
Condition		P _s (psi)	H _s (in)	SG
Test horizontal		1.29	35.7936	1
Dimensions				
Outer Diameter		30"		
Head Ratio		2		
Minimum Thickness		0.2064"		
Corrosion	Inner	0"		
	Outer	0"		
Length L _{sf}		2"		
Nominal Thickness t _{sf}		0.25"		
Weight and Capacity				
		Weight (lb) ¹		Capacity (US gal) ¹
New		74.97		20.59
Corroded		74.97		20.59
Radiography				
Category A joints		Seamless No RT		
Head to shell seam		Spot UW-11(b) Type 1		

¹ includes straight flange

Results Summary	
Governing condition	internal pressure
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	0.2064"
Maximum allowable working pressure (MAWP)	225.01 psi
Straight Flange governs MDMT	-320 °F

Factor K		
$K = (1/6) * [2 + (D / (2 * h))^2]$		
Corroded	$K = (1/6) * [2 + (29.5872 / (2 * 7.3968))^2]$	1
New	$K = (1/6) * [2 + (29.5872 / (2 * 7.3968))^2]$	1

Design thickness for internal pressure, (Corroded at 425 °F) Appendix 1-4(c)

$$\begin{aligned}
 t &= P * D_o * K / (2 * S * E + 2 * P * (K - 0.1)) + \text{Corrosion} \\
 &= 225 * 30 * 1 / (2 * 19,000 * 0.85 + 2 * 225 * (1 - 0.1)) + 0 \\
 &= \a href="#">0.2064"
 \end{aligned}$$

Maximum allowable working pressure, (Corroded at 425 °F) Appendix 1-4(c)

$$\begin{aligned}
 P &= 2 * S * E * t / (K * D_o - 2 * t * (K - 0.1)) - P_s \\
 &= 2 * 19,000 * 0.85 * 0.2064 / (1 * 30 - 2 * 0.2064 * (1 - 0.1)) - 0 \\
 &= \a href="#">225.01 \text{ psi}
 \end{aligned}$$

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

$$\begin{aligned}
 EFE &= (75 * t / R_f) * (1 - R_f / R_o) \\
 &= (75 * 0.25 / 5.1548) * (1 - 5.1548 / \infty) \\
 &= 3.6374\%
 \end{aligned}$$

ASME Section VIII Division 1 UG-81(a) Out-of-Roundness
Inside surface shall not deviate outside the shape by more than 1.25% of D
Inside surface shall not deviate inside the shape by more than 0.625% of D

Saddle #1

ASME Section VIII Division 1, 2019 Edition		
Saddle Material	SA-240-316	
Saddle Construction	Web at edge of rib	
Welded to Vessel	Yes	
Saddle Allowable Stress, S_s	20,000 psi	
Saddle Yield Stress, S_y	38,000 psi	
Foundation Allowable Stress	1,658 psi	
Design Pressure	Left Saddle	Right Saddle
Operating	225 psi	
Test	309.18 psi	
Dimensions		
Right saddle distance to datum	12"	
Tangent To Tangent Length, L	60"	
Saddle separation, L_s	32"	
Vessel Radius, R	15"	
Tangent Distance Left, A_l	14"	
Tangent Distance Right, A_r	14"	
Saddle Height, H_s	33"	
Saddle Contact Angle, θ	120 °	
Web Plate Thickness, t_s	0.25"	
Base Plate Length, E	27.2"	
Base Plate Width, F	6"	
Base Plate Thickness, t_b	0.25"	
Number of Stiffening Ribs, n	2	
Largest Stiffening Rib Spacing, d_i	25.95"	
Stiffening Rib Thickness, t_w	0.25"	
Saddle Width, b	4"	
Bolting		
Material		
Bolt Allowable Shear	15,000 psi	
Description	1" series 8 threaded	
Corrosion on root	0"	
Anchor Bolts per Saddle	2	

Base coefficient of friction, μ	0.45	
Hole Diameter	1.25"	
Slotted Hole in Which Saddle	Left Saddle	
Slotted Hole Length	0.3125"	
Weight		
	Operating, Corroded	Hydrotest
Weight on Left Saddle	402 lb	1,272 lb
Weight on Right Saddle	460 lb	1,330 lb
Weight of Saddle Pair	126 lb	

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

Stress Summary										
Load	Condition	Saddle	Bending + pressure between saddles (psi)				Bending + pressure at the saddle (psi)			
			S ₁ (+)	allow (+)	S ₁ (-)	allow (-)	S ₂ (+)	allow (+)	S ₂ (-)	allow (-)
Weight	Operating	Right Saddle	6.638	19,000	0	10,366	6.722	19,000	84	10,366
		Left Saddle					6,722	19,000	84	10,366
	Test	Right Saddle	9,121	27,000	0	11,790	9,375	27,000	255	11,790
		Left Saddle					9,375	27,000	255	11,790

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	71	15,200	-1,108	28,500	428	10,550	75	13,333
		Left Saddle	53	15,200	-968	28,500	374	10,550	65	13,333
	Test	Right Saddle	196	21,600	-3,203	27,000	1,237	27,000	217	34,200
		Left Saddle	178	21,600	-3,063	27,000	1,183	27,000	207	34,200

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

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

$$= 3 \cdot 0.0016 \cdot 460 \cdot (60 / 12) / (\pi \cdot 14.875^2 \cdot 0.25)$$

$$= 0 \text{ psi}$$

$$S_p = P \cdot R / (2 \cdot t)$$

$$= 225 \cdot 14.75 / (2 \cdot 0.25)$$

$$= 6,638 \text{ psi}$$

Maximum tensile stress $S_{1t} = S_1 + S_p = \text{6,638 psi}$
Maximum compressive stress (shut down) $S_{1c} = S_1 = 0 \text{ psi}$

Tensile stress is acceptable ($\leq S \cdot E = 19,000 \text{ psi}$)
Compressive stress is acceptable ($\leq S_c = 10,366 \text{ psi}$)

Longitudinal stress at the right saddle (Weight, Operating)

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

$$= 2 \cdot 7.6032 / 3 + 60 + 2 \cdot 7.6032 / 3$$

$$= 70.1376 \text{ in}$$

$$w = W_t / L_e = 862 / 70.1376 = 12.29 \text{ lb/in}$$

Bending moment at the right saddle:

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

$$= 12.29 \cdot (2 \cdot 7.6032 \cdot 14 / 3 + 14^2 / 2 - (15^2 - 7.6032^2) / 4)$$

$$= 1,562.9 \text{ lb}_f\text{-in}$$

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

$$= 1,562.9 \cdot 9.3799 / (\pi \cdot 14.875^2 \cdot 0.25)$$

$$= 84 \text{ psi}$$

$$S_p = P \cdot R / (2 \cdot t)$$

$$= 225 \cdot 14.75 / (2 \cdot 0.25)$$

$$= 6,638 \text{ psi}$$

Maximum tensile stress $S_{2t} = S_2 + S_p = \text{6,722 psi}$
Maximum compressive stress (shut down) $S_{2c} = S_2 = \text{84 psi}$

Tensile stress is acceptable ($\leq S = 19,000 \text{ psi}$)
Compressive stress is acceptable ($\leq S_c = 10,366 \text{ psi}$)

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

$$\begin{aligned}
 Q_{\text{shear}} &= Q - w \cdot (a + 2 \cdot H / 3) \\
 &= 460 - 12.29 \cdot (14 + 2 \cdot 7.6032 / 3) \\
 &= 225.64 \text{ lb}_f
 \end{aligned}$$

$$\begin{aligned}
 S_3 &= K_{2.2} \cdot Q_{\text{shear}} / (R \cdot t) \\
 &= 1.1707 \cdot 225.64 / (14.875 \cdot 0.25) \\
 &= 71 \text{ psi}
 \end{aligned}$$

Tangential shear stress is acceptable ($\leq 0.8 \cdot S = 15,200 \text{ psi}$)

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

$$\begin{aligned}
 S_4 &= -Q / (4 \cdot t \cdot (b + 1.56 \cdot \text{Sqr}(R_o \cdot t))) - 12 \cdot K_3 \cdot Q \cdot R / (L \cdot t^2) \\
 &= -460 / (4 \cdot 0.25 \cdot (4 + 1.56 \cdot \text{Sqr}(15 \cdot 0.25))) - 12 \cdot 0.0476 \cdot 460 \cdot 14.875 / (60 \cdot 0.25^2) \\
 &= -1.108 \text{ psi}
 \end{aligned}$$

Circumferential stress at saddle horns is acceptable ($\leq 1.5 \cdot S_a = 28,500 \text{ psi}$)

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

$$\begin{aligned}
 S_5 &= K_5 \cdot Q / (t \cdot (t_s + 1.56 \cdot \text{Sqr}(R_o \cdot t_c))) \\
 &= 0.7603 \cdot 460 / (0.25 \cdot (0.25 + 1.56 \cdot \text{Sqr}(15 \cdot 0.25))) \\
 &= 428 \text{ psi}
 \end{aligned}$$

Ring compression in shell is acceptable ($\leq 0.5 \cdot S_y = 10,550 \text{ psi}$)

Saddle splitting load (right, Weight, Operating)

Area resisting splitting force = Web area + wear plate area

$$\begin{aligned}
 A_e &= H_{\text{eff}} \cdot t_s + t_p \cdot W_p \\
 &= 5 \cdot 0.25 + 0 \cdot 0 \\
 &= 1.25 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 S_6 &= K_8 \cdot Q / A_e \\
 &= 0.2035 \cdot 460 / 1.25 \\
 &= 75 \text{ psi}
 \end{aligned}$$

Stress in saddle is acceptable ($\leq (2 / 3) \cdot S_s = 13,333 \text{ psi}$)

Shear stress in anchor bolting, one end slotted

Maximum seismic or wind base shear = 0 lb_f

Thermal expansion base shear = $W \cdot \mu = 465 \cdot 0.45 = 209.25 \text{ lb}_f$
 Corroded root area for a 1" series 8 threaded bolt = 0.551 in² (2 per saddle)

Bolt shear stress = $209.25 / (0.551 \cdot 1 \cdot 2) = 190 \text{ psi}$

Anchor bolt stress is acceptable ($\leq 15,000 \text{ psi}$)

Shear stress in anchor bolting, transverse

Maximum seismic or wind base shear = 0 lb_f
 Corroded root area for a 1" series 8 threaded bolt = 0.551 in² (2 per saddle)

$$\text{Bolt shear stress} = 0 / (0.551 \times 2 \times 2) = 0 \text{ psi}$$

Anchor bolt stress is acceptable ($\leq 15,000$ psi)

Web plate buckling check (Escoe pg 251)

Allowable compressive stress S_c is the lesser of 20,000 or 3,114 psi: (3,114)

$$\begin{aligned} S_c &= K_1 \pi^2 E / (12(1 - 0.3^2)(d_i / t_s)^2) \\ &= 1.28 \pi^2 29 \times 10^6 / (12(1 - 0.3^2)(25.95 / 0.25)^2) \\ &= 3,114 \text{ psi} \end{aligned}$$

Allowable compressive load on the saddle

$$\begin{aligned} b_e &= d_i t_s / (d_i t_s + 2 t_w (b - 1)) \\ &= 25.95 \times 0.25 / (25.95 \times 0.25 + 2 \times 0.25 (4 - 1)) \\ &= 0.8122 \end{aligned}$$

$$\begin{aligned} F_b &= n(A_s + 2 b_e t_s) S_c \\ &= 2(0.9375 + 2 \times 0.8122 \times 0.25) \times 3,114 \\ &= 8,367.42 \text{ lb}_f \end{aligned}$$

Saddle loading of 1,393 lb_f is $\leq F_b$; satisfactory.

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

$$\begin{aligned} \sigma_b &= V(H_s - x_o)y / I + Q / A \\ &= 0(33 - 12.4049) \times 2.7212 / 5.38 + 460 / 8.3702 \\ &= 55 \text{ psi} \end{aligned}$$

The primary bending + axial stress in the saddle $\leq S_s = 20,000$ psi; satisfactory.

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

$$\begin{aligned} \sigma_b &= V(H_s - x_o)y / I + Q / A \\ &= 209.25(33 - 12.4049) \times 2.7212 / 5.38 + 402 / 8.3702 \\ &= 2,229 \text{ psi} \end{aligned}$$

The secondary bending + axial stress in the saddle $\leq 2 S_y = 76,000$ psi; satisfactory.

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

where $a = 25.95$, $b = 5.75$ in

$$\begin{aligned} t_b &= (\beta_1 q b^2 / (1.5 S_a))^{0.5} \\ &= (3 \times 9 \times 5.75^2 / (1.5 \times 20,000))^{0.5} \\ &= 0.168 \text{ in} \end{aligned}$$

The base plate thickness of 0.25 in is adequate.

Foundation bearing check

$$\begin{aligned} S_f &= Q_{\max} / (F \times E) \\ &= 1,393 / (6 \times 27.2) \\ &= 9 \text{ psi} \end{aligned}$$

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

Slotted hole length (Process Industry Practices VEFV1100)

$$\begin{aligned}\Delta_t &= \max[\text{abs}(T_{\text{amb}} - T_s) , \text{abs}(T_{\text{amb}} - \text{MDMT})] \\ &= \max[\text{abs}(70 - 425) , \text{abs}(70 - -20)] \\ &= 355^\circ\text{F}\end{aligned}$$

$$\begin{aligned}S_L &= 2 * L_s * \alpha * \Delta_t \\ &= 2 * 32 * 9.55\text{E-}06 * 355 \\ &= 0.217''\end{aligned}$$

Actual slot length is greater than or equal to the minimum ($0.3125'' \geq 0.217''$); satisfactory.