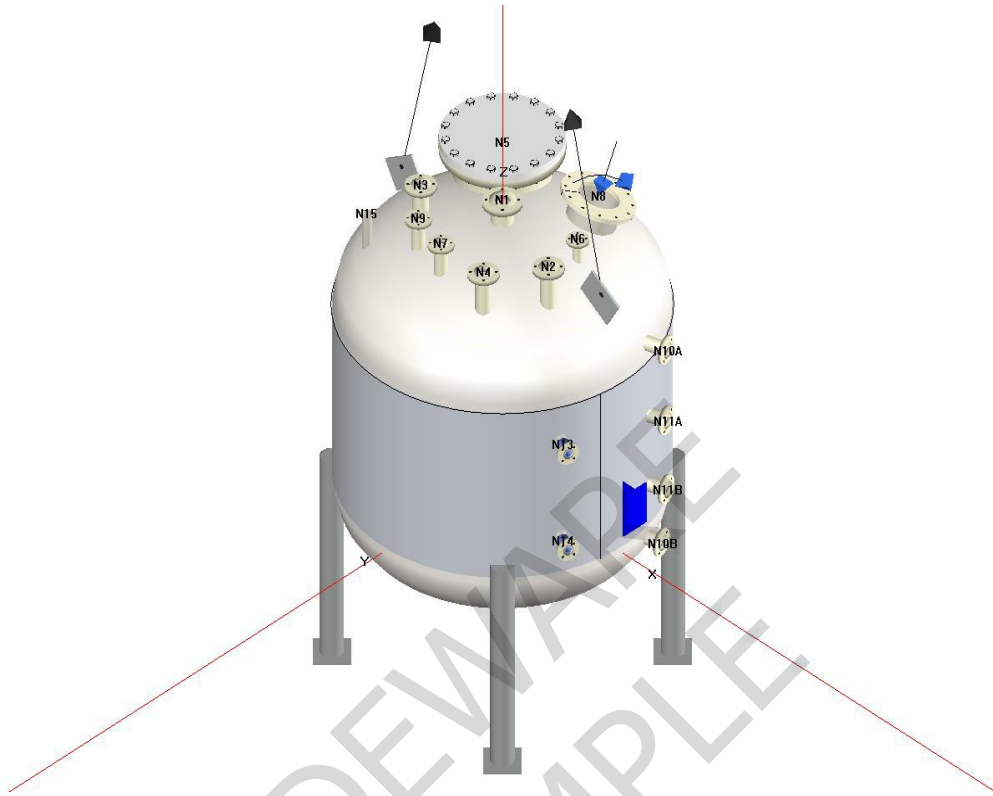


Progressive Recovery, Inc.

Your Company Address



COMPRESS Pressure Vessel Design Calculations

Item: Treatment Tank

Designer: CD

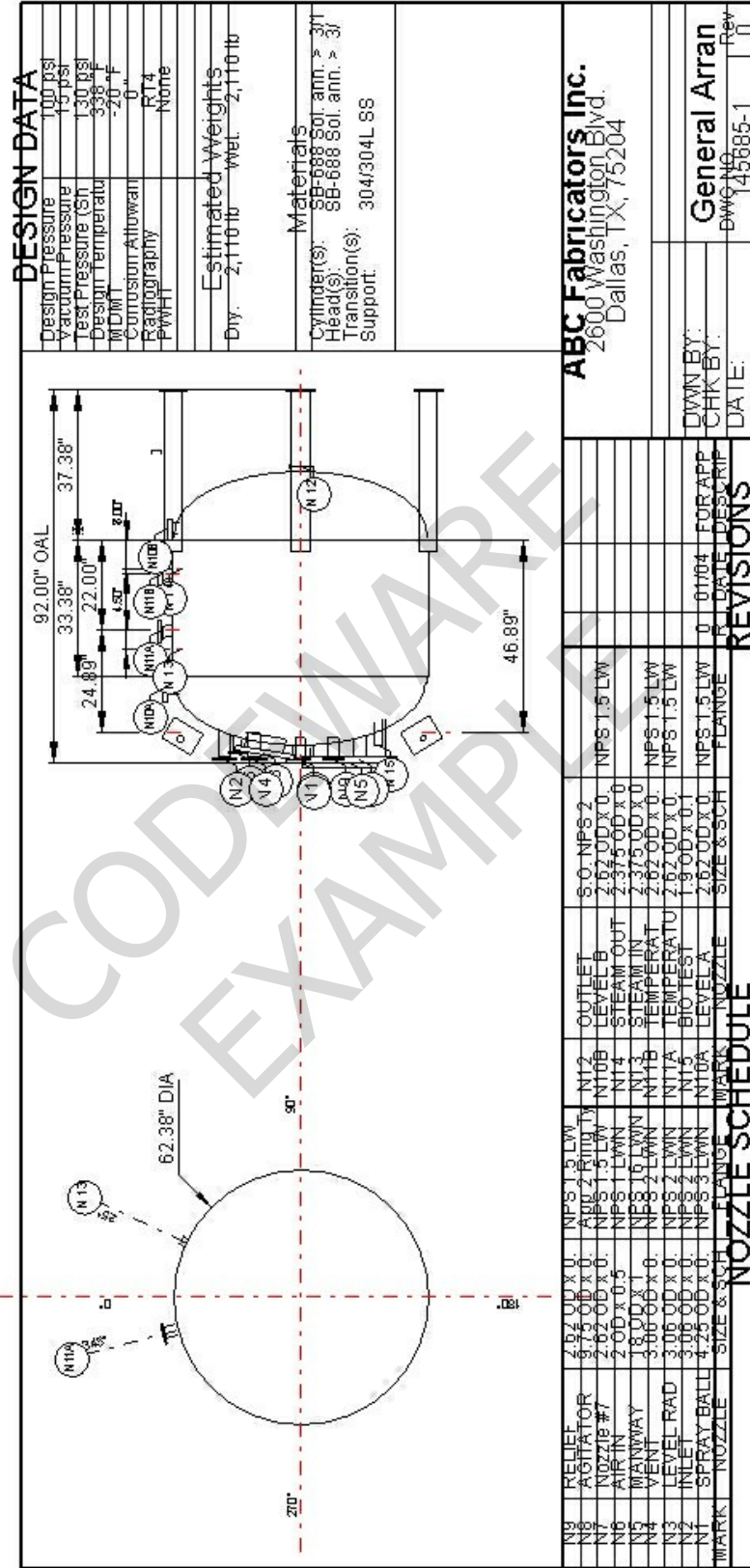
Date: Tuesday, January 04, 2022

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Cylinder #1	80
Legs #1	84
STEAM IN (N13)	92
B16.9 Reducer #1 (N13)	95
STEAM OUT (N14)	98
B16.9 Reducer #1 (N14)	101
TEMPERATURE A (N11A)	104
TEMPERATURE B (N11B)	108
Straight Flange on Ellipsoidal Head #2	112
Ellipsoidal Head #2	115
LEVEL B (N10B)	117
OUTLET (N12)	121

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EXAMPLE



DESIGN DATA

Design Pressure	100 psi
Vacuum Pressure	10 psi
Test Pressure (Sh)	130 psi
Design Temperature	338 F
MDMT	-20 F
Corrosion Allowance	0"
Radiography	RT4
PMHT	None

Estimated Weights	
Dry	2,110 lb
Wet	2,110 lb

Materials	
Cylinder(s)	SB-688 Sol. ann. > 3/1
Head(s)	SB-688 Sol. ann. > 3/1
Transition(s)	Support
Support	304/304L SS

ABC Fabricators Inc.
2600 Washington Blvd.
Dallas, TX, 75204

General Arran	
Drawn By:	DWG: NS-145685-1
Checked By:	Rev: 0
Date:	Preparation: rank: CW7

MARK	NOZZLE SCHEDULE	MARK	NOZZLE SCHEDULE	MARK	NOZZLE SCHEDULE	MARK	NOZZLE SCHEDULE
N9	RELIEF	2.62 OD x 0	NPS 1.5 LW	N12	OUTLET	S.O. NPS-2	
N8	AIRATOR	3.75 OD x 0	NPS 2.5 LW	N10B	LEVEL B	2.62 OD x 0	NPS 1.5 LW
N7	NOZZLE #7	2.62 OD x 0	NPS 1.5 LW	N14	STEAM IN	2.375 OD x 0	
N6	AIR IN	2.00 x 0.5	NPS 1.5 LW	N13	STEAM OUT	2.375 OD x 0	
N5	MAINWAY	3.00 OD x 1	NPS 2.5 LW	N11A	TEMPERAT	2.62 OD x 0	NPS 1.5 LW
N4	VENT	3.00 OD x 0	NPS 2.5 LW	N15	BIO TEST	1.9 OD x 0.1	
N3	LEVEL RAD	3.06 OD x 0	NPS 2.5 LW	N10A	LEVEL A	2.62 OD x 0	NPS 1.5 LW
N2	INLET	3.06 OD x 0	NPS 2.5 LW		MARK	NOZZLE	
N1	SPRAY BALL	4.25 OD x 0	NPS 3 LW		NOZZLE	FLANGE	
	NOZZLE	SIZE & SCH			NOZZLE	FLANGE	

REVISIONS

0	01/04	FOR APP	
1		DATE	
2		DESCRIP	

CODEWARE
EXAMPLE

Deficiencies Summary

Deficiencies for **AGITATOR (N8)**

Load case 1: WRC 537: $\rho = T / t < 0.25$ (ratio not covered by WRC 537; $T / t = 0.25$ used)

Deficiencies for **Lifting Lug #1**

The load ratio for the EN13445 calculation exceeds 1.
Lift load 1,753 lb_f exceeds maximum allowable load 1,701 lb_f.

Deficiencies for **Lifting Lug #2**

The load ratio for the EN13445 calculation exceeds 1.
Lift load 1,753 lb_f exceeds maximum allowable load 1,701 lb_f.

Warnings Summary

Warnings for **AGITATOR (N8)**

A full penetration nozzle to shell weld is recommended for nozzles with external loadings. (warning)

Warnings for **Flange #1**

TEMA Table D-5: Current bolt circle (13 in) does not provide sufficient wrench clearance, 13.75 in recommended. (warning)

Warnings for **Lifting Lug #1**

Lift lugs are out of plane with center of gravity. Vessel may tilt during lift and lugs may experience weak axis bending. Lugs should be at 56.16° and 236.16°. (warning)

Warnings for **Lifting Lug #2**

Lift lugs are out of plane with center of gravity. Vessel may tilt during lift and lugs may experience weak axis bending. Lugs should be at 56.16° and 236.16°. (warning)

Warnings for **TEMPERATURE A (N11A)**

The attached ASME B16.5 flange limits the nozzle MAWP. (warning)
The attached ASME B16.5 flange limits the nozzle MAP. (warning)

Warnings for **TEMPERATURE B (N11B)**

The attached ASME B16.5 flange limits the nozzle MAWP. (warning)
The attached ASME B16.5 flange limits the nozzle MAP. (warning)

ASME B16.5 / B16.47 Flange Warnings Summary

Flange	Applicable Warnings
SPRAY BALL (N1)	1
INLET (N2)	1
LEVEL RADAR (N3)	1
VENT (N4)	1
MANWAY (N5)	1
AIR IN (N6)	1
Nozzle #7 (N7)	1
RELIEF (N9)	1
LEVEL A (N10A)	1
TEMPERATURE A (N11A)	1
TEMPERATURE B (N11B)	1
Right end of B16.9 Reducer #1 (N13)	1
Right end of B16.9 Reducer #1 (N14)	1
LEVEL B (N10B)	1

No.	Warning
1	For Class 150 flanges, ASME B16.5 para. 5.4.3 recommends gaskets to be in accordance with Nonmandatory Appendix B, Table B1, Group No. I.

Nozzle Schedule

Specifications										
Nozzle mark	Identifier	Size	Service	Materials		Impact Tested	Normalized	Fine Grain	Flange	Blind
N1	SPRAY BALL	4.25 OD x 0.625		Nozzle	SB-462 Solution ann. Forgings N06022	No	No	No	NPS 3 Class 150 LWN B462 N06022	No
N10A	LEVEL A	2.62 OD x 0.56	LEVEL	Nozzle	SB-462 Solution ann. Forgings N06022	No	No	No	NPS 1 1/2 Class 150 LWN B462 N06022	No
N10B	LEVEL B	2.62 OD x 0.56	LEVEL	Nozzle	SB-462 Solution ann. Forgings N06022	No	No	No	NPS 1 1/2 Class 150 LWN B462 N06022	No
N11A	TEMPERATURE A	2.62 OD x 0.56	T/C	Nozzle	SB-462 Solution ann. Forgings N06022	No	No	No	NPS 1 1/2 Class 150 LWN B462 N06022	No
N11B	TEMPERATURE B	2.62 OD x 0.56	T/C	Nozzle	SB-462 Solution ann. Forgings N06022	No	No	No	NPS 1 1/2 Class 150 LWN B462 N06022	No
N12	OUTLET	Studding Outlet NPS 2 Class 150	OUTLET	Nozzle	SB-462 Solution ann. Forgings N06022	No	No	No	N/A	No
N13	STEAM IN	2.375 OD x 0.154	INLET	Nozzle	SA-182 F304 <= 5	No	No	No	N/A	No
	B16.9 Reducer #1 (N13)	NPS 2 x 1 (Thk = 0.172")		B16.9 Reducer	SA-403 304LN WP	No	No	No	NPS 1 Class 150 SO A240 304L	No
N14	STEAM OUT	2.375 OD x 0.154	OUTLET	Nozzle	SA-182 F304 <= 5	No	No	No	N/A	No
	B16.9 Reducer #1 (N14)	NPS 2 x 1 Sch 40S (Std)		B16.9 Reducer	SA-403 304L	No	No	No	NPS 1 Class 150 SO B462 N06022	No
N15	BIO TEST	1.9 OD x 0.145		Nozzle	SA-479 316L Bar	No	No	No	N/A	No
N2	INLET	3.06 OD x 0.53	INLET	Nozzle	SB-462 Solution ann. Forgings N06022	No	No	No	NPS 2 Class 150 LWN B462 N06022	No
N3	LEVEL RADAR	3.06 OD x 0.53	LEVEL	Nozzle	SB-462 Solution ann. Forgings N06022	No	No	No	NPS 2 Class 150 LWN B462 N06022	No
N4	VENT	3.06 OD x 0.53	VENT	Nozzle	SB-462 Solution ann. Forgings N06022	No	No	No	NPS 2 Class 150 LWN B462 N06022	No
N5	MANWAY	18 OD x 1	MW	Nozzle	SA-182 F304 <= 5	No	No	No	NPS 16 Class 150 LWN A182 F304	NPS 16 Class 150 A182 F304
N6	AIR IN	2 OD x 0.5	INLET	Nozzle	SB-462 Solution ann. Forgings N06022	No	No	No	NPS 1 Class 150 LWN B462 N06022	No
N7	Nozzle #7	2.62 OD x 0.56		Nozzle	SB-462 Solution ann. Forgings N06022	No	No	No	NPS 1 1/2 Class 150 LWN B462 N06022	No
N8	AGITATOR	9.75 OD x 0.875		Nozzle	SB-462 Solution ann. Forgings N06022	No	No	No	App 2 Ring Type Integral SA-516 70	No
N9	RELIEF	2.62 OD x 0.56		Nozzle	SB-462 Solution ann. Forgings N06022	No	No	No	NPS 1 1/2 Class 150 LWN B462 N06022	No

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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)		
N1	4.25	0.625	0.2074	Yes	Yes	0.1875*	N/A		N/A	N/A	0	Exempt
N10A	2.62	0.56	0.1776	Yes	Yes	0.1875*	N/A		N/A	N/A	0	Exempt
N10B	2.62	0.56	0.1776	Yes	Yes	0.1875*	N/A		N/A	N/A	0	Exempt
N11A	2.62	0.56	0.1776	Yes	Yes	0.375	N/A		N/A	N/A	0	Exempt
N11B	2.62	0.56	0.1776	Yes	Yes	0.375	N/A		N/A	N/A	0	Exempt
N12	6	2	0.2083	Yes	Yes	0.1875*	N/A		N/A	N/A	0	Exempt
N13	2.375	0.154	0.1348	Yes	Yes	0.375	N/A		N/A	N/A	0	Exempt
N14	2.375	0.154	0.1348	Yes	Yes	0.375	N/A		N/A	N/A	0	Exempt
N15	1.9	0.145	0.1269	Yes	Yes	0.1875*	N/A		N/A	N/A	0	Exempt
N2	3.06	0.53	0.189	Yes	Yes	0.1875*	N/A		N/A	N/A	0	Exempt
N3	3.06	0.53	0.189	Yes	Yes	0.1875*	N/A		N/A	N/A	0	Exempt
N4	3.06	0.53	0.189	Yes	Yes	0.1875*	N/A		N/A	N/A	0	Exempt
N5	18	1	0.0508	Yes	Yes	0.1875*	0.1237		N/A	N/A	0	100.0
N6	2	0.5	0.1348	Yes	Yes	0.1875*	N/A		N/A	N/A	0	Exempt
N7	2.62	0.56	0.1776	Yes	Yes	0.1875*	N/A		N/A	N/A	0	Exempt
N8	9.75	0.875	0.1363	Yes	Yes	0.1875*	0.1227		N/A	N/A	0	100.0
N9	2.62	0.56	0.1776	Yes	Yes	0.1875*	N/A		N/A	N/A	0	Exempt

*Head minimum thickness after forming

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

Pressure Summary

Component Summary									
Identifier	P Design (psi)	T Design (°F)	MAWP (psi)	MAP (psi)	MAEP (psi)	T _e external (°F)	MDMT (°F)	MDMT Exemption	Impact Tested
Ellipsoidal Head #1	100	338	129.99	139.24	18.56	338	-325	Note 1	No
Straight Flange on Ellipsoidal Head #1	100	338	172.59	184.87	28.9	338	-325	Note 2	No
Cylinder #1	100	338	235.81	276.64	63.87	338	-325	Note 2	No
Straight Flange on Ellipsoidal Head #2	100	338	172.59	184.87	28.9	338	-325	Note 2	No
Ellipsoidal Head #2	100	338	129.99	139.24	18.56	338	-325	Note 3	No
Legs #1	100	338	100	N/A	N/A	N/A	N/A	N/A	N/A
SPRAY BALL (N1)	100	338	169.91	182	18.56	338	-55	Note 4	No
LEVEL A (N10A)	100	338	152.93	163.81	18.56	338	-55	Note 4	No
LEVEL B (N10B)	100	338	152.93	163.81	18.56	338	-55	Note 4	No
TEMPERATURE A (N11A)	100	338	218.6	290	63.87	338	-55	Note 4	No
TEMPERATURE B (N11B)	100	338	218.6	290	63.87	338	-55	Note 4	No
OUTLET (N12)	100	338	169.91	182	18.56	338	-55	Note 5	No
STEAM IN (N13)	100	338	277.42	325.46	63.87	338	-320	Note 6	No
B16.9 Reducer #1 (N13)	100	338	169.3	230	957.93	338	-55	Note 7, 8	No
STEAM OUT (N14)	100	338	277.42	325.46	63.87	338	-320	Note 6	No
B16.9 Reducer #1 (N14)	100	338	218.6	290	683.14	338	-55	Note 9, 10	No
BIO TEST (N15)	100	338	152.93	163.81	18.56	338	-320	Note 11	No
INLET (N2)	100	338	169.91	182	18.56	338	-55	Note 4	No
LEVEL RADAR (N3)	100	338	169.91	182	18.56	338	-55	Note 4	No
VENT (N4)	100	338	169.91	182	18.56	338	-55	Note 4	No
MANWAY (N5)	100	338	100.94	108.06	17.12	338	-55	Note 12	No
AIR IN (N6)	100	338	169.91	182	18.56	338	-55	Note 4	No
Nozzle #7 (N7)	100	338	169.91	182	18.56	338	-55	Note 4	No
AGITATOR (N8)	100	338	100	119.09	18.56	338	-325	Note 2	No
Flange #1	100	338	349.07	349.07	2,146.55	338	-55	Note 13	No
RELIEF (N9)	100	338	169.91	182	18.56	338	-55	Note 4	No

Chamber Summary	
Design MDMT	-20 °F
Rated MDMT	-20 °F @ 100 psi
MAWP hot & corroded	100 psi @ 338 °F
MAP cold & new	108.06 psi @ 70 °F
MAEP	17.12 psi @ 338 °F
(1) The rated MDMT is limited to the design MDMT based on the setting in the Calculations tab of the Set Mode dialog.	

Notes for MDMT Rating		
Note #	Exemption	Details
1.	Straight Flange governs MDMT	
2.	Rated MDMT per UNF-65 = -325°F	
3.	Straight Flange governs MDMT	
4.	Flange rating governs: Flange rated MDMT per UNF-65 = -325°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	
5.	Rated MDMT per UNF-65 = -325°F	Bolts rated MDMT per Fig UCS-66 note (c) = -55°F
6.	Impact test exempt per UHA-51(g) (coincident ratio = 0.0337)	
7.	Impact test exempt per UHA-51(g) (coincident ratio = 0.0394)	
8.	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
9.	Impact test exempt per UHA-51(g) (coincident ratio = 0.0526)	
10.	Flange rating governs: Flange rated MDMT per UNF-65 = -325°F	Bolts rated MDMT per Fig UCS-66 note (c) = -55°F
11.	Impact test exempt per UHA-51(g) (coincident ratio = 0.0334)	
12.	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	
13.	UCS-66(b)(1)(b) has been applied. Flange is impact test exempt to -155°F per UCS-66(b)(3) (coincident ratio = 0.2865)	Bolts rated MDMT per Fig UCS-66 note (c) = -55°F

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 EXAMPLE

Revision History

Revisions			
No.	Date	Operator	Notes
0	1/4/2022	christian.dionisio	New vessel created ASME Section VIII Division 1 [COMPRESS 2022 Build 8200]
1	1/4/2022	christian.dionisio	Converted from ASME Section VIII Division 1, 2021 Edition to ASME Section VIII Division 1, 2019 Edition. During the conversion, changes may have been made to your vessel (some may be listed above). Please check your vessel carefully.
2	1/5/2022	christian.dionisio	Due to size or thickness limitations, SB-688 Sol. ann. > 3/16 N08367 was changed to SB-688 Sol. ann. <= 3/16 N08367.
3	1/5/2022	christian.dionisio	Due to size or thickness limitations, SB-688 Sol. ann. <= 3/16 N08367 was changed to SB-688 Sol. ann. > 3/16 N08367.

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EXAMPLE

Settings Summary

COMPRESS 2022 Build 8200	
ASME Section VIII Division 1, 2019 Edition	
Units	U.S. Customary
Datum Line Location	-1.50" from bottom 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
Design nozzles for	Design P only
Corrosion weight loss	100% of theoretical loss
UG-23 Stress Increase	1.00
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 $\leq 1.50"$ thick	No
UG-37(a) shell tr calculation considers longitudinal stress	No
Cylindrical shells made from pipe are entered as minimum thickness	No
Nozzles made from pipe are entered as minimum thickness	No
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	1.3 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	RT4
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	Codeware, Inc.
License	Commercial
License Key ID	23740
Support Expires	July 03, 2022

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Radiography Summary

UG-116 Radiography							
Component	Longitudinal Seam		Top Circumferential Seam		Bottom Circumferential Seam		Mark
	Category (Fig UW-3)	Radiography / Joint Type	Category (Fig UW-3)	Radiography / Joint Type	Category (Fig UW-3)	Radiography / Joint Type	
Ellipsoidal Head #1	N/A	Seamless No RT	N/A	N/A	B	Spot UW-11(b) / Type 1	RT3
Cylinder #1	A	Full UW-11(a) / Type 1	B	Spot UW-11(b) / Type 1	B	Spot UW-11(b) / Type 1	RT4
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		
SPRAY BALL (N1)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
INLET (N2)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
LEVEL RADAR (N3)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
VENT (N4)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
MANWAY (N5)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
AIR IN (N6)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
Nozzle #7 (N7)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
AGITATOR (N8)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
RELIEF (N9)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
LEVEL A (N10A)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
BIO TEST (N15)	N/A	Seamless No RT	D	N/A / Type 7	B	UW-11(a)(4) exempt	N/A
TEMPERATURE A (N11A)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
TEMPERATURE B (N11B)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
STEAM IN (N13)	N/A	Seamless No RT	D	N/A / Type 7	B	UW-11(a)(4) exempt / Type 1	N/A
B16.9 Reducer #1 (N13)	N/A	Seamless No RT	B	UW-11(a)(4) exempt	C	N/A / Type 4	N/A
STEAM OUT (N14)	N/A	Seamless No RT	D	N/A / Type 7	B	UW-11(a)(4) exempt / Type 1	N/A
B16.9 Reducer #1 (N14)	N/A	Seamless No RT	B	UW-11(a)(4) exempt	C	N/A / Type 4	N/A
LEVEL B (N10B)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
OUTLET (N12)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
Nozzle Flange	Longitudinal Seam		Flange Face		Nozzle to Flange Circumferential Seam		
ASME B16.5/16.47 flange attached to SPRAY BALL (N1)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to INLET (N2)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to LEVEL RADAR (N3)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to VENT (N4)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to MANWAY (N5)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to AIR IN (N6)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to Nozzle #7 (N7)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
Flange #1	A	Full UW-11(a) / Type 1	N/A	N/A / Gasketed	C	N/A	RT1
ASME B16.5/16.47 flange attached to RELIEF (N9)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to LEVEL A (N10A)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to TEMPERATURE A (N11A)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to TEMPERATURE B (N11B)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to right end of B16.9 Reducer #1 (N13)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A / Type 4	N/A

ASME B16.5/16.47 flange attached to right end of B16.9 Reducer #1 (N14)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A / Type 4	N/A
ASME B16.5/16.47 flange attached to LEVEL B (N10B)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
UG-116(e) Required Marking: RT4							

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 EXAMPLE

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	SB-688 Sol. ann. > 3/16 N08367	62 ID	15.6875	0.1875*	0.1633	0	0.85	External
Straight Flange on Ellipsoidal Head #1	SB-688 Sol. ann. > 3/16 N08367	62 ID	1.5	0.25	0.1779	0	0.85	External
Cylinder #1	SB-688 Sol. ann. > 3/16 N08367 (low stress)	62 ID	33.375	0.375	0.1783	0	0.85	External
Straight Flange on Ellipsoidal Head #2	SB-688 Sol. ann. > 3/16 N08367	62 ID	1.5	0.25	0.1779	0	0.85	External
Ellipsoidal Head #2	SB-688 Sol. ann. > 3/16 N08367	62 ID	15.6875	0.1875*	0.1633	0	0.85	External

*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

CODEWARE
EXAMPLE

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	243.6	243.6	0	0	0	0	0	0	1,337.4	1,337.4	32
Cylinder #1	711.5	711.5	0	0	0	0	0	0	3,638.2	3,638.2	46
Ellipsoidal Head #2	262.9	262.9	0	0	0	0	0	0	1,289.9	1,289.9	35
Legs #1	171.3	171.3	0	0	0	0	0	0	0	0	17
TOTAL:	1,389.4	1,389.4	0	0	0	0	0	0	6,265.5	6,265.5	130

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

Weight (lb) Contributed by Attachments											
Component	Body Flanges		Nozzles & Flanges		Packed Beds	Ladders & Platforms	Trays	Tray Supports	Rings & Clips	Vertical Loads	Surface Area ft ²
	New	Corroded	New	Corroded							
Ellipsoidal Head #1	0	0	660.2	660.2	0	0	0	0	13.7	0	13
Cylinder #1	0	0	22.5	22.5	0	0	0	0	5.2	0	1
Ellipsoidal Head #2	0	0	18.8	18.8	0	0	0	0	0	0	0
Legs #1	0	0	0	0	0	0	0	0	0	0	0
TOTAL:	0	0	701.5	701.5	0	0	0	0	18.9	0	15

Vessel Totals		
	New	Corroded
Operating Weight (lb)	2,110	2,110
Empty Weight (lb)	2,110	2,110
Test Weight (lb)	8,375	8,375
Surface Area (ft ²)	144	-
Capacity** (US gal)	746	746

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

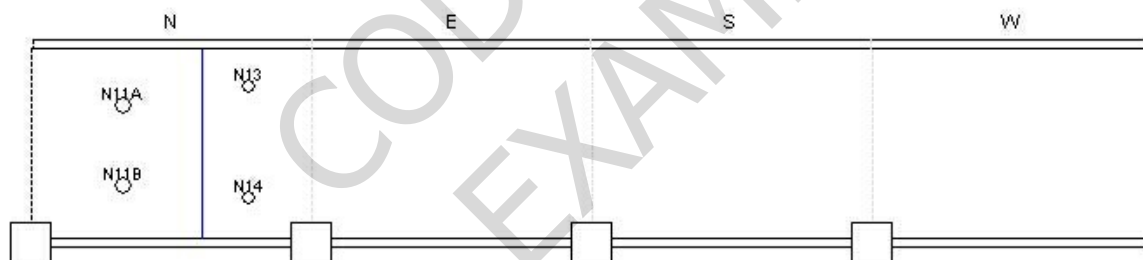
Vessel Lift Condition	
Vessel Lift Weight, New (lb)	2,110
Center of Gravity from Datum (in)	25.0798

Long Seam Summary

Shell Long Seam Angles	
Component	Seam 1
Cylinder #1	10°

Shell Plate Lengths		
Component	Starting Angle	Plate 1
Cylinder #1	10°	195.9568"

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



Shell Rollout

Hydrostatic Test

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

$$\begin{aligned}
 \text{Gauge pressure at } 70^{\circ}\text{F} &= 1.3 \cdot MAWP \cdot LSR \\
 &= 1.3 \cdot 100 \cdot 1 \\
 &= 130 \text{ psi}
 \end{aligned}$$

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	132.353	2.353	1.0711	1.30
Straight Flange on Ellipsoidal Head #1	132.353	2.353	1.0711	1.30
Cylinder #1	132.353	2.353	1.1732	1.30
Straight Flange on Ellipsoidal Head #2	132.353	2.353	1.0711	1.30
Ellipsoidal Head #2	132.353	2.353	1.0711	1.30
Flange #1 (1)	131.051	1.051	1	1.30
AGITATOR (N8)	131.051	1.051	1.0288	1.30
AIR IN (N6)	130.694	0.694	1.0288	1.30
B16.9 Reducer #1 (N13)	130.19	0.19	1.0695	1.30
B16.9 Reducer #1 (N14)	130.191	0.191	1.0183	1.30
BIO TEST (N15)	131.954	1.954	1.0245	1.30
INLET (N2)	130.592	0.592	1.0288	1.30
LEVEL A (N10A)	130.159	0.159	1.0288	1.30
LEVEL B (N10B)	130.159	0.159	1.0288	1.30
LEVEL RADAR (N3)	131.793	1.793	1.0288	1.30
MANWAY (N5)	131.957	1.957	1.0695	1.30
Nozzle #7 (N7)	131.261	1.261	1.0288	1.30
OUTLET (N12)	131.27	1.27	1.0288	1.30
RELIEF (N9)	131.55	1.55	1.0288	1.30
SPRAY BALL (N1)	131.288	1.288	1.0288	1.30
STEAM IN (N13)	130.223	0.223	1.0695	1.30
STEAM OUT (N14)	130.223	0.223	1.0695	1.30
TEMPERATURE A (N11A)	130.147	0.147	1.0288	1.30
TEMPERATURE B (N11B)	130.147	0.147	1.0288	1.30
VENT (N4)	130.856	0.856	1.0288	1.30

(1) Flange #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.

The test temperature of 70 °F is warmer than the minimum recommended temperature of -25 °F so the brittle fracture provision of UG-99(h) has been met.

Component Commentary Report

[BIO TEST \(N15\)](#)

Commentary for BIO TEST (N15)

FURRULE CONNECTION

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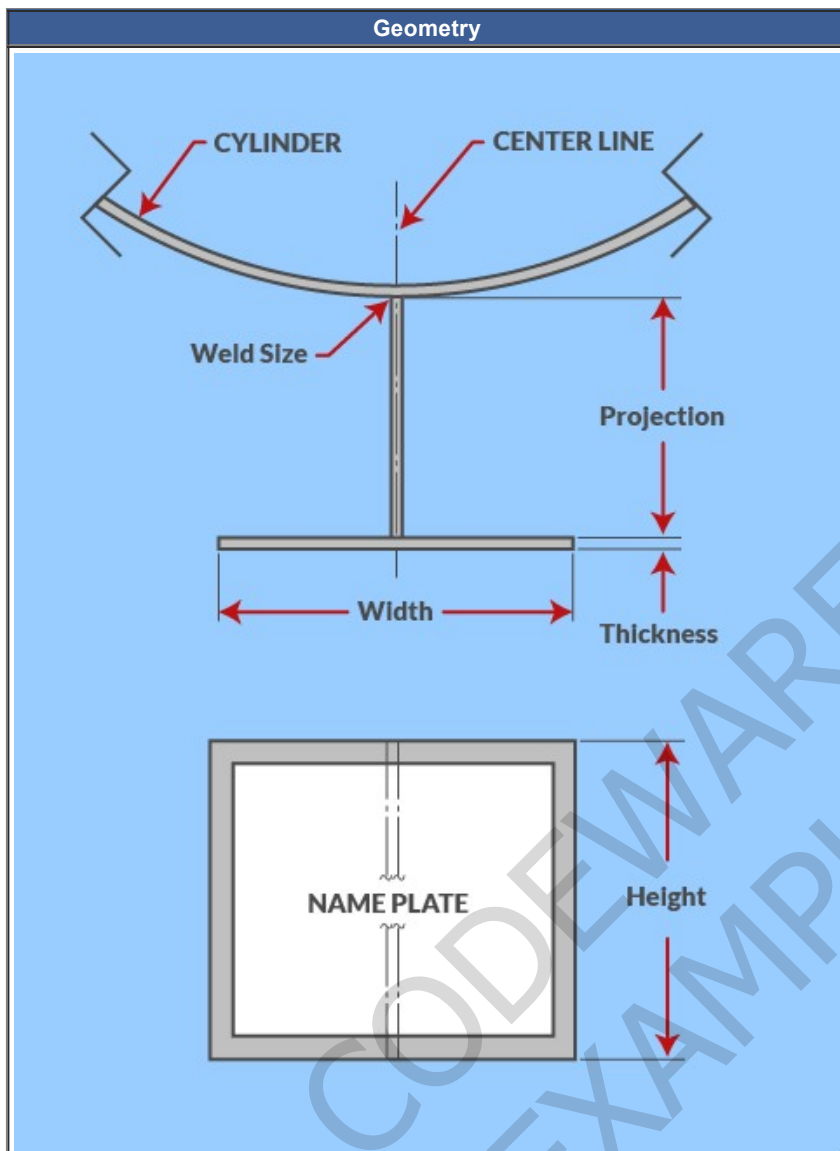
CODEWARE
EXAMPLE

Vacuum Summary

Largest Unsupported Length Le			
Component	Line of Support	Elevation above Datum (in)	Length Le (in)
Ellipsoidal Head #1	-	52.0625	N/A
-	1/3 depth of Ellipsoidal Head #1	41.5417	N/A
Straight Flange on Ellipsoidal Head #1 Top	-	36.375	46.7083
Straight Flange on Ellipsoidal Head #1 Bottom	-	34.875	46.7083
Cylinder #1 Top	-	34.875	46.7083
Cylinder #1 Bottom	-	1.5	46.7083
Straight Flange on Ellipsoidal Head #2 Top	-	1.5	46.7083
Straight Flange on Ellipsoidal Head #2 Bottom	-	0	46.7083
-	1/3 depth of Ellipsoidal Head #2	-5.1667	N/A
Ellipsoidal Head #2	-	-15.6875	N/A

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EXAMPLE

Nameplate Summary



Orientation	Longitudinal
Projection	3"
Height	8"
Width	6"
Thickness	0.25"
Weld Size	0.1875"
Material	304 SS
Attached To	Cylinder #1 (5" from bottom end)
Angle	0°

Nameplate Content	
National Board Number	*
Certification Mark Designator	U
Manufacturer's Serial Number	Ex: 3236-1
Certified by	CW Example
Notes	Nameplate Notes
Construction Type	
Special Service	
Non Destructive Examination	RT4
PWHT	None
MAWP	100 psi @ 338 °F
MDMT	-20 °F @ 100 psi
MAEP	17.12 psi @ 338 °F

CODEWARE
EXAMPLE

Foundation Load Summary

Legs #1: Total Loading at Base				
Load	Vessel Condition	Base Shear (lb _f)	Base Moment (lb _f -ft)	Vertical Force (lb _f)
Weight	Operating, Corroded	0	613	2,108
Weight	Operating, New	0	613	2,108

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

Support Information	
Support Type	Legs
Number of Support Elements (Base Plates)	4
Base Plate Length	7"
Base Plate Width	7"
Base Plate Thickness	0.5"
Number of Anchor Bolts Per Base Plate	1
Bolt Circle Diameter	64.75"
Bolt Size and Type	3/8" coarse bolt
Bolt Hole Clearance	0.375"
Center of Gravity (Distance from Support Base)	60.9548"

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EXAMPLE

Bill of Materials

Heads / Covers						
Item #	Type	Material	Thk [in]	Dia. [in]	Wt. [lb] (ea.)	Qty
H1	Ellipsoidal Head	SB-688 Sol. ann. > 3/16 N08367	0.1875 (min.)	62 ID	264.8	2
H2	ASME B16.5/B16.47 Blind NPS 16 Class 150	A182 F304	1.44	23.5 OD	200	1

Shells							
Item #	Type	Material	Thk [in]	Dia. [in]	Length [in]	Wt. [lb] (ea.)	Qty
S1	Cylinder	SB-688 Sol. ann. > 3/16 N08367 (low stress)	0.375	62 ID	33.4	713.7	1

Legs						
Item #	Type	Material	Thk [in]	Length [in]	Wt. [lb]	Qty
L1	4 inch sch 40 pipe	304/304L SS	0.237	40	42.8	4

Nozzles							
Item #	Type	Material	NPS	Thk [in]	Dia. [in]	Length [in]	Wt. [lb]
Noz1	Nozzle	SB-462 Solution ann. Forgings N06022	-	0.875	9.75 OD	4	30.3
Noz2	Nozzle	SA-479 316L Bar	-	0.145	1.9 OD	47	10.9
Noz3	Nozzle	SA-182 F304 <= 5	-	0.154	2.375 OD	2.8	0.9

Nozzles - Studding Outlets							
Item #	Type	Material	# Bolts	Thk [in]	Dia. [in]	Wt. [lb]	Qty
SP1	Studding Outlet NPS 2 Class 150 - Contoured Base	SB-462 Solution ann. Forgings N06022	4	1.5	6 OD x 2 ID	11.4	1

ASME B16.9 Fittings				
Item #	Type	Material	Size [in]	Qty
RED1	B16.9 Reducer	SA-403 304LN WP	NPS 2 x 1 (Thk = 0.172")	1
RED2	B16.9 Reducer	SA-403 304L	NPS 2 x 1 Sch 40S (Std)	1

Flanges							
Item #	Type	Material	NPS	Dia. [in]	Wt. [lb] (ea.)	Qty	
AF1	ASME B16.5 Long Weld Neck - Class 150 - 4.3" len.	B462 N06022	3	Flange 7.5 x 3; Nozzle 0.625 thk. x 4.25 OD dia.	10	1	
AF2	ASME B16.5 Long Weld Neck - Class 150 - 7.8" len.	B462 N06022	2	Flange 6 x 2; Nozzle 0.53 thk. x 3.06 OD dia.	6	2	
AF3	ASME B16.5 Long Weld Neck - Class 150 - 6.2" len.	B462 N06022	2	Flange 6 x 2; Nozzle 0.53 thk. x 3.06 OD dia.	6	1	
AF4	ASME B16.5 Long Weld Neck - Class 150 - 11.4" len.	A182 F304	16	Flange 23.5 x 16; Nozzle 1 thk. x 18 OD dia.	140	1	
AF5	ASME B16.5 Long Weld Neck - Class 150 - 4.5" len.	B462 N06022	1	Flange 4.25 x 1; Nozzle 0.5 thk. x 2 OD dia.	3	1	
AF6	ASME B16.5 Long Weld Neck - Class 150 - 6.1" len.	B462 N06022	1 1/2	Flange 5 x 1.5; Nozzle 0.56 thk. x 2.62 OD dia.	4	2	
AF7	ASME B16.5 Long Weld Neck - Class 150 - 4.7" len.	B462 N06022	1 1/2	Flange 5 x 1.5; Nozzle 0.56 thk. x 2.62 OD dia.	4	1	
AF8	ASME B16.5 Long Weld Neck - Class 150 - 4.2" len.	B462 N06022	1 1/2	Flange 5 x 1.5; Nozzle 0.56 thk. x 2.62 OD dia.	4	2	
AF9	ASME B16.5 Slip On - Class 150	A240 304L	1	4.25 x 1.36	2	1	
AF10	ASME B16.5 Slip On - Class 150	B462 N06022	1	4.25 x 1.36	2	1	
AF11	ASME B16.5 Long Weld Neck - Class 150 - 3.7" len.	B462 N06022	1 1/2	Flange 5 x 1.5; Nozzle 0.56 thk. x 2.62 OD dia.	4	1	
CF1	Ring type integral	SA-516 70	-	14.5 x 8	28.4	1	

Gaskets				
Item #	Type	Size [in]	Thk [in]	Qty
G1	Corrugated metal Iron or soft steel (Corrugated Metal)	10.75 x 9.75	0.175	1

There are 14 flanges that do not include gasket information.

Fasteners				
Item #	Description	Material	Length [in]	Qty
FB1	Studding Outlet Bolts 0.625" dia.	SA-193 B7 Bolt <= 2 1/2	-	4
FB2	5/8" coarse bolt	SA-193 B7 Bolt <= 2 1/2	3	4
FB3	5/8" coarse bolt	SA-193 B7 Bolt <= 2 1/2	2.8	24
FB4	1" series 8 bolt	SA-193 B7 Bolt <= 2 1/2	4.5	16
FB5	1/2" coarse bolt	SA-193 B7 Bolt <= 2 1/2	2.3	12
FB6	1/2" coarse bolt	SA-193 B7 Bolt <= 2 1/2	2.5	24
SB1	3/8" coarse bolt	Support Leg 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	304/304L SS	0.5	27.7	1.36
Plate1 - Note: Applies to support leg base plates				
Plate2	304 SS	0.5	13.4	0.64
Plate2 - Note: Applies to lift lug plates				
Plate3	304 SS	0.25	5.2	0.5
Plate3 - Note: Applies to nameplate front, nameplate projection				

CODEWARE
EXAMPLE

Ellipsoidal Head #1

ASME Section VIII Division 1, 2019 Edition				
Component		Ellipsoidal Head		
Material		SB-688 Sol. ann. > 3/16 N08367 (II-D p. 240, ln. 26)		
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		100	338	-20
External		15	338	
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Test horizontal		2.35	65.1826	1
Dimensions				
Inner Diameter		62"		
Head Ratio		2		
Minimum Thickness		0.1875"		
Corrosion	Inner	0"		
	Outer	0"		
Length L_{sf}		1.5"		
Nominal Thickness t_{sf}		0.25"		
Weight and Capacity				
		Weight (lb)¹	Capacity (US gal)¹	
New		243.63	154.66	
Corroded		243.63	154.66	
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	external pressure
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	0.1443"
Design thickness due to external pressure (t _e)	0.1633"
Maximum allowable working pressure (MAWP)	129.99 psi
Maximum allowable pressure (MAP)	139.24 psi
Maximum allowable external pressure (MAEP)	18.56 psi
Straight Flange governs MDMT	-325°F

Design thickness for internal pressure, (Corroded at 338 °F) UG-32(c)(1)

$$t = \frac{P \cdot D}{2 \cdot S \cdot E - 0.2 \cdot P} + \text{Corrosion} = \frac{100 \cdot 62}{2 \cdot 25,300 \cdot 0.85 - 0.2 \cdot 100} + 0 = \underline{0.1442"}$$

Maximum allowable working pressure, (Corroded at 338 °F) UG-32(c)(1)

$$P = \frac{2 \cdot S \cdot E \cdot t}{D + 0.2 \cdot t} - P_s = \frac{2 \cdot 25,300 \cdot 0.85 \cdot 0.1875}{62 + 0.2 \cdot 0.1875} - 0 = \underline{129.99} \text{ psi}$$

Maximum allowable pressure, (New at 70 °F) UG-32(c)(1)

$$P = \frac{2 \cdot S \cdot E \cdot t}{D + 0.2 \cdot t} - P_s = \frac{2 \cdot 27,100 \cdot 0.85 \cdot 0.1875}{62 + 0.2 \cdot 0.1875} - 0 = 139.24 \text{ psi}$$

Design thickness for external pressure, (Corroded at 338 °F) UG-33(d)

Equivalent outside spherical radius

$$R_o = K_o \cdot D_o = 0.8946 \cdot 62.375 = 55.802 \text{ in}$$

$$A = \frac{0.125}{R_o / t} = \frac{0.125}{55.802 / 0.163273} = 0.000366$$

A falls to left of chart

$$P_a = \frac{0.0625 \cdot E}{(R_o / t)^2} = \frac{0.0625 \cdot 2.8034E+07}{(55.802 / 0.1633)^2} = 15 \text{ psi}$$

$$t = 0.1633'' + \text{Corrosion} = 0.1633'' + 0'' = 0.1633''$$

Check the external pressure per UG-33(a)(1) UG-32(c)(1)

$$t = \frac{1.67 \cdot P_e \cdot D}{2 \cdot S \cdot E - 0.2 \cdot 1.67 \cdot P_e} + \text{Corrosion} = \frac{1.67 \cdot 15 \cdot 62}{2 \cdot 25,300 \cdot 1 - 0.2 \cdot 1.67 \cdot 15} + 0 = 0.0307''$$

The head external pressure design thickness (t_e) is 0.1633''.**Maximum Allowable External Pressure, (Corroded at 338 °F) UG-33(d)**

Equivalent outside spherical radius

$$R_o = K_o \cdot D_o = 0.8946 \cdot 62.375 = 55.802 \text{ in}$$

$$A = \frac{0.125}{R_o / t} = \frac{0.125}{55.802 / 0.1875} = 0.00042$$

From Table NFN-12: B = 5,523.4179 psi

$$P_a = \frac{B}{R_o / t} = \frac{5,523.4179}{55.802 / 0.1875} = 18.5592 \text{ psi}$$

Check the Maximum External Pressure, UG-33(a)(1) UG-32(c)(1)

$$P = \frac{2 \cdot S \cdot E \cdot t}{(D + 0.2 \cdot t) \cdot 1.67} = \frac{2 \cdot 25,300 \cdot 1 \cdot 0.1875}{(62 + 0.2 \cdot 0.1875) \cdot 1.67} = 91.58 \text{ psi}$$

The maximum allowable external pressure (MAEP) is 18.56 psi.**% Forming strain - UNF-79(a)(2)**

$$EFE = \left(\frac{75 \cdot t}{R_f} \right) \cdot \left(1 - \frac{R_f}{R_o} \right) = \left(\frac{75 \cdot 0.25}{10.665} \right) \cdot \left(1 - \frac{10.665}{\infty} \right) = 1.7581 \%$$

Straight Flange on Ellipsoidal Head #1

ASME Section VIII Division 1, 2019 Edition				
Component		Cylinder		
Material		SB-688 Sol. ann. > 3/16 N08367 (II-D p. 240, In. 26)		
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		100	338	-20
External		15	338	
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Test horizontal		2.35	65.1826	1
Dimensions				
Inner Diameter		62"		
Length		1.5"		
Nominal Thickness		0.25"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)	Capacity (US gal)	
New		21.34	19.6	
Corroded		21.34	19.6	
Radiography				
Longitudinal seam		Seamless No RT		
Bottom Circumferential seam		Spot UW-11(b) Type 1		

Results Summary	
Governing condition	External pressure
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	0.1446"
Design thickness due to external pressure (t _e)	0.1779"
Design thickness due to combined loadings + corrosion	0.0719"
Maximum allowable working pressure (MAWP)	172.59 psi
Maximum allowable pressure (MAP)	184.87 psi
Maximum allowable external pressure (MAEP)	28.9 psi
Rated MDMT	-325 °F

UNF-65 Material Toughness Requirements	
Rated MDMT =	-325°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Design thickness, (at 338 °F) UG-27(c)(1)

$$t = \frac{P \cdot R}{S \cdot E - 0.60 \cdot P} + \text{Corrosion} = \frac{100 \cdot 31}{25,300 \cdot 0.85 - 0.60 \cdot 100} + 0 = \underline{0.1446"}$$

Maximum allowable working pressure, (at 338 °F) UG-27(c)(1)

$$P = \frac{S \cdot E \cdot t}{R + 0.60 \cdot t} - P_s = \frac{25,300 \cdot 0.85 \cdot 0.25}{31 + 0.60 \cdot 0.25} - 0 = \underline{172.59} \text{ psi}$$

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

$$P = \frac{S \cdot E \cdot t}{R + 0.60 \cdot t} = \frac{27,100 \cdot 0.85 \cdot 0.25}{31 + 0.60 \cdot 0.25} = \underline{184.87} \text{ psi}$$

External Pressure, (Corroded & at 338 °F) UG-28(c)

$$\frac{L}{D_o} = \frac{46.7083}{62.5} = 0.7473$$

$$\frac{D_o}{t} = \frac{62.5}{0.1779} = 351.2576$$

From table G: $A = 0.000282$

$$P_a = \frac{2 \cdot A \cdot E}{3 \cdot \left(\frac{D_o}{t}\right)} = \frac{2 \cdot 0.000282 \cdot 28034000}{3 \cdot \left(\frac{62.5}{0.1779}\right)} = 15 \text{ psi}$$

Design thickness for external pressure $P_a = 15$ psi

$$t_a = t + \text{Corrosion} = 0.1779 + 0 = \underline{0.1779}''$$

Maximum Allowable External Pressure, (Corroded & at 338 °F) UG-28(c)

$$\frac{L}{D_o} = \frac{46.7083}{62.5} = 0.7473$$

$$\frac{D_o}{t} = \frac{62.5}{0.25} = 250.0000$$

From table G: $A = 0.000454$

From table NFN-12: $B = 5,418.2556$ psi

$$P_a = \frac{4 \cdot B}{3 \cdot (D_o/t)} = \frac{4 \cdot 5,418.26}{3 \cdot (62.5/0.25)} = \underline{28.9} \text{ psi}$$

% Forming strain - UNF-79(a)(2)

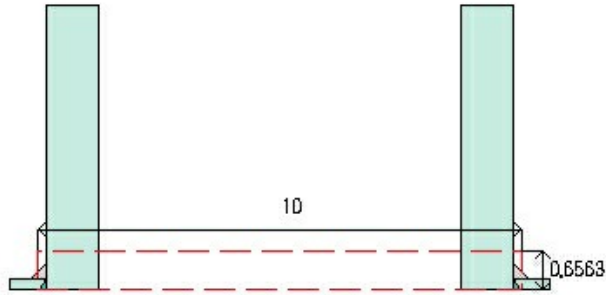
$$EFE = \left(\frac{50 \cdot t}{R_f}\right) \cdot \left(1 - \frac{R_f}{R_o}\right) = \left(\frac{50 \cdot 0.25}{31.125}\right) \cdot \left(1 - \frac{31.125}{\infty}\right) = 0.4016 \%$$

Thickness Required Due to Pressure + External Loads								
Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S _t	S _c					
Operating, Hot & Corroded	100	25,300	8,619	338	0	Weight	0.0719	0.0717
Operating, Hot & New	100	25,300	8,619	338	0	Weight	0.0719	0.0717
Hot Shut Down, Corroded	0	25,300	8,619	338	0	Weight	0.0002	0.0008
Hot Shut Down, New	0	25,300	8,619	338	0	Weight	0.0002	0.0008
Empty, Corroded	0	27,100	9,697	70	0	Weight	0.0002	0.0007
Empty, New	0	27,100	9,697	70	0	Weight	0.0002	0.0007
Vacuum	-15	25,300	8,619	338	0	Weight	0.0272	0.0278
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0	25,300	8,619	338	0	Weight	0.0002	0.0008

CODEWARE
EXAMPLE

AGITATOR (N8)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation	
Located on	Ellipsoidal Head #1
Orientation	300°
End of nozzle to datum line	53.625"
Calculated as hillside	No
Distance to head center, R	17.0625"
Passes through a Category A joint	No
Nozzle	
Access opening	No
Material specification	SB-462 Solution ann. Forgings N06022 (II-D p. 208, In. 40)
Inside diameter, new	8"
Nominal wall thickness	0.875"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	2.4723"
Projection available outside vessel to flange face, L _f	4.5973"
Local vessel minimum thickness	0.1875"
User input radial limit of reinforcement	5"
Liquid static head included	0 psi
Welds	
Inner fillet, Leg ₄₁	0.25"
Nozzle to vessel groove weld	0.1875"
Radiography	
Longitudinal seam	Seamless No RT

UNF-65 Material Toughness Requirements Nozzle

Rated MDMT =	-325°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 = 100 psi @ 338 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.8826	1.0081	0.1544	0.8068	--	--	0.0469	0.1226	0.875

UG-41 Weld Failure Path Analysis Summary (lb _f)				
All failure paths are stronger than the applicable weld loads				
Weld load W	Weld load W _{1,1}	Path 1-1 strength	Weld load W _{2,2}	Path 2-2 strength
21,839.59	21,598.61	284,843.1	29,900.17	101,228.15

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

WRC 537												
Load Case	P (psi)	P _r (lb _f)	M ₁ (lb _f -in)	V ₂ (lb _f)	M ₂ (lb _f -in)	V ₁ (lb _f)	M _t (lb _f -in)	Max Comb Stress (psi)	Allow Comb Stress (psi)	Max Local Primary Stress (psi)	Allow Local Primary Stress (psi)	Over stressed
Load case 1	100	50	28,581	100	300	1,000	5,000	75,899	75,900	23,328	37,950	No
Load case 1 (Hot Shut Down)	0	50	35,323	100	300	1,000	5,000	-75,899	75,900	-10,471	37,950	No

Reinforcement Calculations for MAWP

Local stresses at the nozzle OD per WRC 537 govern the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100 psi @ 338 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.8826	1.0081	0.1544	0.8068	--	--	0.0469	0.1226	0.875

UG-41 Weld Failure Path Analysis Summary (lb _f)				
All failure paths are stronger than the applicable weld loads				
Weld load W	Weld load W _{1,1}	Path 1-1 strength	Weld load W _{2,2}	Path 2-2 strength
21,839.59	21,598.61	284,843.1	29,900.17	101,228.15

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

WRC 537												
Load Case	P (psi)	P _r (lb _f)	M ₁ (lb _f -in)	V ₂ (lb _f)	M ₂ (lb _f -in)	V ₁ (lb _f)	M _t (lb _f -in)	Max Comb Stress (psi)	Allow Comb Stress (psi)	Max Local Primary Stress (psi)	Allow Local Primary Stress (psi)	Over stressed
Load case 1	100	50	28,581	100	300	1,000	5,000	75,899	75,900	23,328	37,950	No

Reinforcement Calculations for MAP

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

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 119.09 psi @ 70 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.9813	0.9813	0.1297	0.8047	–	–	0.0469	0.1363	0.875

UG-41 Weld Failure Path Analysis Summary (lb _f)				
All failure paths are stronger than the applicable weld loads				
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength
26,152.86	23,078.36	295,051.12	31,970.55	108,430.16

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 338 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.6531	0.894	0.0485	0.7986	–	–	0.0469	0.0625	0.875

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 18.56 psi @ 338 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.75	0.8436	–	0.7967	–	–	0.0469	0.0625	0.875

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check ($t_1 + t_2$)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

CODEWARE
EXAMPLE

Flange #1

ASME Section VIII Division 1, 2019 Edition , Appendix 2 Flange Calculations				
Flange Type		Ring type integral		
Attachment Type		Figure UW-13.2 sketch (n)		
Flange Material		SA-516 70 (II-D p. 20, ln. 33)		
Attached To		AGITATOR (N8)		
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		100	338	-20
External		15	338	
Static Liquid Head				
Condition		P_s (psi)		
Operating		0		
Dimensions				
Flange OD, A	14.5"			
Flange ID, B	8"			
Bolt Circle, C	13"			
Gasket OD	10.75"			
Gasket ID	9.75"			
Flange Thickness, t	0.875"			
Hub Thickness, g₁	2.125"			
Hub Thickness, g₀	0.875"			
Fillet Weld, h	1.25"			
Groove Weld, w	0.875"			
Edge Distance, t_p	0.25"			
Corrosion Bore	0"			
Corrosion Flange	0"			
Bolting				
Material	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 398, ln. 32)			
Description	12 - 0.625" coarse threaded			
Corrosion on root	0"			
Gasket				
Type	Corrugated Metal			
Description	Corrugated metal Iron or soft steel			
Factor, m	3.25			
Seating Stress, y	5,500 psi			
Thickness, T	0.175"			
Weight (lb)				
New	28.4 lb			
Corroded	28.4 lb			
Radiography				
Longitudinal seam	Full UW-11(a) Type 1			
Left Circumferential seam	N/A			

Results Summary	
Flange design thickness:	0.875"
Maximum allowable working pressure, MAWP:	349.07 psi @ 338 °F
Maximum allowable pressure, MAP:	349.07 psi @ 70 °F
Maximum allowable external pressure, MAEP:	2,146.55 psi @ 338 °F
Rated MDMT	-55 °F
ASME PCC-1 bolt torque, T _b	360.6 lb _f -ft

Note: this flange is an optional type calculated as integral.

The following values are used in the calculations: g₀ = shell/nozzle wall thickness, h = actual length of flange hub plus fillet weld leg attaching hub to shell/nozzle

UCS-66 Material Toughness Requirements	
Stress ratio per UCS-66(b)(1)(b) = $\frac{100}{349.07} =$	0.2865
Stress ratio ≤ 0.35, MDMT per UCS-66(b)(3) =	-155°F
Bolts rated MDMT per Fig UCS-66 note (c) =	-55°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Stress Summary										
			P (psi)	S _H (psi)	Allow (psi)	S _R (psi)	S _T (psi)	(S _H + S _R) / 2 (psi)	(S _H + S _T) / 2 (psi)	Allow (psi)
Design P	Weight Only	Oper	100	1,388	30,000	5,583	1,117	3,485	1,253	20,000
		Seating		4,842	30,000	19,481	3,899	12,162	4,371	20,000
Design P _e	Weight Only	Oper	15	21	30,000	86	17	54	19	20,000
		Seating		4,842	30,000	19,481	3,899	12,162	4,371	20,000

Bolt Summary						
			P (psi)	W (lb _f)	A _m (in ²)	A _b (in ²)
Design P	Weight Only	Oper	100	13,477.47	0.54	2.42
		Seating		44,254.38	1.77	
Design P _e	Weight Only	Oper	15	2,021.62	0	2.42
		Seating		44,254.38	1.77	

Rigidity Summary					
			P (psi)	J	Allow
Design P	Weight Only	Oper	100	0.0152	1
		Seating		0.0507	1
Design P _e	Weight Only	Oper	15	2.3456E-04	1
		Seating		0.0507	1

Figure UW-13.2 Weld Sizing

$$a + b \geq 3t_n + C_{i,shell} + \frac{C_{o,shell}}{0.7}$$

$$h \geq \frac{\min [t_n, t_x] + C_{o,shell}}{0.7}$$

$$t_p \geq \min [t_n, 0.25"] + C_o$$

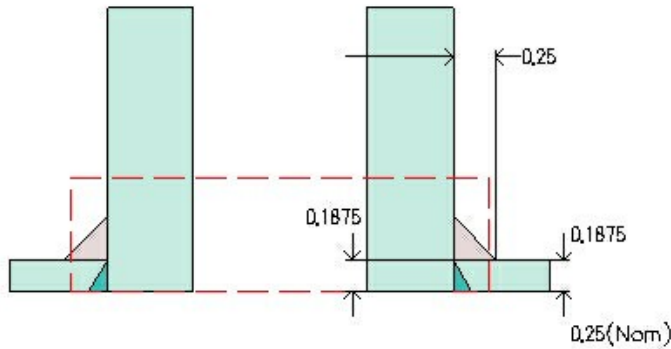
Results

$a + b =$	2.75"	\geq	$3 \cdot 0.875 + 0 + \frac{0}{0.7} =$	2.625"	✓
$h =$	1.25"	\geq	$\frac{\min [0.875, 1.75] + 0}{0.7} =$	1.25"	✓
$g_1 - g_0 =$	1.25"	\geq	$\frac{\min [0.875, 1.75] + 0}{0.7} =$	1.25"	✓
$t_p =$	0.25"	\geq	$\min [0.875, 0.25] + 0 =$	0.25"	✓

CODEWARE
EXAMPLE

AIR IN (N6)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Ellipsoidal Head #1
Orientation	345°
End of nozzle to datum line	53.875"
Calculated as hillside	Yes
Distance to head center, R	16"
Passes through a Category A joint	No

Nozzle

Service	Inlet (INLET)
Access opening	No
Material specification	SB-462 Solution ann. Forgings N06022 (II-D p. 208, In. 40)
Inside diameter, new	1"
Nominal wall thickness	0.5"
Corrosion allowance	0"
Opening chord length	1.0444"
Projection available outside vessel, L _{pr}	3.1861"
Projection available outside vessel to flange face, L _f	3.7461"
Local vessel minimum thickness	0.1875"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
-------------------	----------------

ASME B16.5-2013 Flange	
Description	NPS 1 Class 150 LWN B462 N06022
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, In. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	218.6 psi @ 338°F
MAP rating	290 psi @ 70°F
Hydrotest rating	450 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Notes	
Flange rated MDMT per UNF-65 = -325°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UNF-65 Material Toughness Requirements Nozzle	
Rated MDMT =	-325°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 = 100 psi @ 338 °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)							0.1226	0.5

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	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 = 169.91 psi @ 338 °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	0.5

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 182 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.5

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 338 °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)							0.0625	0.5

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 18.56 psi @ 338 °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)							0.0625	0.5

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

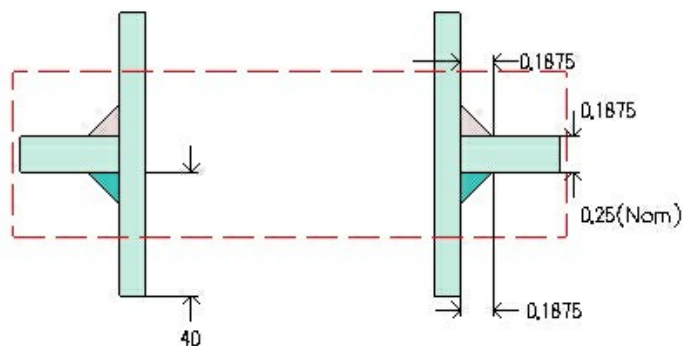
UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

CODEWARE
EXAMPLE

BIO TEST (N15)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Ellipsoidal Head #1
Orientation	140°
End of nozzle to datum line	51.875"
Calculated as hillside	Yes
Distance to head center, R	25"
Passes through a Category A joint	No

Nozzle

Access opening	No
Material specification	SA-479 316L Bar (II-D p. 72, ln. 17)
Inside diameter, new	1.61"
Nominal wall thickness	0.145"
Corrosion allowance	0"
Opening chord length	1.9481"
Projection available outside vessel, L _{pr}	5.5124"
Internal projection, h _{new}	40"
Local vessel minimum thickness	0.1875"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
Circumferential seam	Spot UW-11(a)(5)(b) only Type 1

[See Component Commentary](#)

UHA-51 Material Toughness Requirements Nozzle	
$t_r = \frac{100 \cdot 0.805}{16,700 \cdot 1 - 0.6 \cdot 100} =$	0.0048"
Stress ratio = $\frac{t_r \cdot E^*}{t_n - c} = \frac{0.0048 \cdot 1}{0.145 - 0} =$	0.0334
Impact test exempt per UHA-51(g) (coincident ratio = 0.0334)	
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 = 100 psi @ 338 °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)							0.1226	0.145

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)	0.1015	0.1313	weld size is adequate
Nozzle to inside shell fillet (Leg ₄₃)	0.1015	0.1313	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.1812	0.2625	weld size is adequate

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

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 152.93 psi @ 338 °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	0.145

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)	0.1015	0.1313	weld size is adequate
Nozzle to inside shell fillet (Leg ₄₃)	0.1015	0.1313	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.1812	0.2625	weld size is adequate

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

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 163.81 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1269	0.145

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 338 °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)							0.0625	0.145

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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1015	0.1313	weld size is adequate
Nozzle to inside shell fillet (Leg ₄₃)	0.1015	0.1313	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.1812	0.2625	weld size is adequate

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 18.56 psi @ 338 °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)							0.0625	0.145

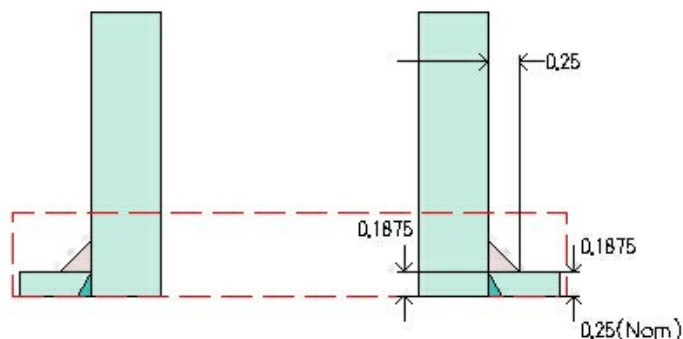
UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1015	0.1313	weld size is adequate
Nozzle to inside shell fillet (Leg ₄₃)	0.1015	0.1313	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.1812	0.2625	weld size is adequate

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

INLET (N2)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Ellipsoidal Head #1
Orientation	20°
End of nozzle to datum line	55.375"
Calculated as hillside	Yes
Distance to head center, R	20"
Passes through a Category A joint	No

Nozzle

Service	Inlet (INLET)
Access opening	No
Material specification	SB-462 Solution ann. Forgings N06022 (II-D p. 208, In. 40)
Inside diameter, new	2"
Nominal wall thickness	0.53"
Corrosion allowance	0"
Opening chord length	2.171"
Projection available outside vessel, Lpr	5.6094"
Projection available outside vessel to flange face, Lf	6.3594"
Local vessel minimum thickness	0.1875"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
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ASME B16.5-2013 Flange	
Description	NPS 2 Class 150 LWN B462 N06022
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, In. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	218.6 psi @ 338°F
MAP rating	290 psi @ 70°F
Hydrotest rating	450 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Notes	
Flange rated MDMT per UNF-65 = -325°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UNF-65 Material Toughness Requirements Nozzle	
Rated MDMT =	-325°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 = 100 psi @ 338 °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)							0.1226	0.53

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	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 = 169.91 psi @ 338 °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	0.53

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 182 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.189	0.53

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 338 °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)							0.0625	0.53

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 18.56 psi @ 338 °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)							0.0625	0.53

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

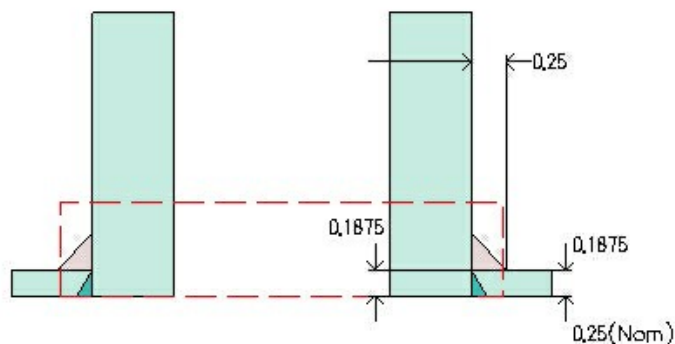
UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

CODEWARE
EXAMPLE

LEVEL A (N10A)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Ellipsoidal Head #1
Orientation	345°
Nozzle center line offset to datum line	37.875"
Calculated as hillside	Yes (perpendicular)
Distance to head center, R	35.1875"
Passes through a Category A joint	No

Nozzle

Service	Level Indicator (LEVEL)
Access opening	No
Material specification	SB-462 Solution ann. Forgings N06022 (II-D p. 208, In. 40)
Inside diameter, new	1.5"
Nominal wall thickness	0.56"
Corrosion allowance	0"
Opening chord length	1.5277"
Projection available outside vessel, L _{pr}	3.3123"
Projection available outside vessel to flange face, L _f	4.0023"
Local vessel minimum thickness	0.1875"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
-------------------	----------------

ASME B16.5-2013 Flange	
Description	NPS 1.5 Class 150 LWN B462 N06022
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, In. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	218.6 psi @ 338°F
MAP rating	290 psi @ 70°F
Hydrotest rating	450 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Notes	
Flange rated MDMT per UNF-65 = -325°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UNF-65 Material Toughness Requirements Nozzle	
Rated MDMT =	-325°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 = 100 psi @ 338 °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)							0.1226	0.56

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	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 = 152.93 psi @ 338 °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)							0.1776	0.56

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 163.81 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1776	0.56

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 338 °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)							0.0625	0.56

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 18.56 psi @ 338 °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)							0.0625	0.56

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

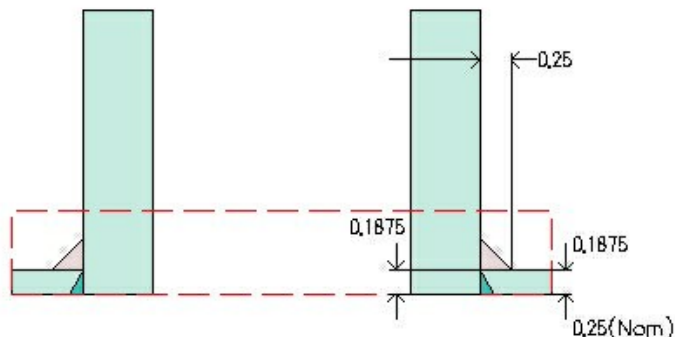
UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

CODEWARE
EXAMPLE

LEVEL RADAR (N3)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Ellipsoidal Head #1
Orientation	155°
End of nozzle to datum line	55.375"
Calculated as hillside	Yes
Distance to head center, R	16"
Passes through a Category A joint	No

Nozzle

Service	Level Indicator (LEVEL)
Access opening	No
Material specification	SB-462 Solution ann. Forgings N06022 (II-D p. 208, In. 40)
Inside diameter, new	2"
Nominal wall thickness	0.53"
Corrosion allowance	0"
Opening chord length	2.0889"
Projection available outside vessel, Lpr	4.3532"
Projection available outside vessel to flange face, Lf	5.1032"
Local vessel minimum thickness	0.1875"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
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ASME B16.5-2013 Flange	
Description	NPS 2 Class 150 LWN B462 N06022
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, In. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	218.6 psi @ 338°F
MAP rating	290 psi @ 70°F
Hydrotest rating	450 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Notes	
Flange rated MDMT per UNF-65 = -325°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UNF-65 Material Toughness Requirements Nozzle	
Rated MDMT =	-325°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 = 100 psi @ 338 °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)							0.1226	0.53

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	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 = 169.91 psi @ 338 °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	0.53

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 182 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.189	0.53

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 338 °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)							0.0625	0.53

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 18.56 psi @ 338 °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)							0.0625	0.53

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

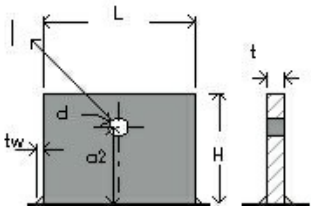
UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

CODEWARE
EXAMPLE

Lifting Lug #1

Minimum report

Geometry Inputs	
	
Attached To	Ellipsoidal Head #1
Material	304 SS
Orientation	Longitudinal
Distance of Lift Point From Datum	49.875"
Angular Position	0°
Length, L	8"
Height, H	5.75"
Thickness, t	0.5"
Hole Diameter, d	1"
Pin Diameter, Dp	0.875"
Load Eccentricity, a ₁	0"
Distance from Load to Shell or Pad, a ₂	4"
Load Angle Normal to Vessel, β	45°
Load Angle from Vertical, φ	14.01°
Welds	
Size, t _w	0.375"

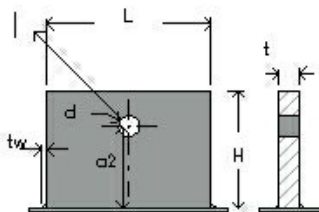
Intermediate Values	
Load Factor	1.5000
Vessel Weight (new, incl. Load Factor), W	3,164.7 lb
Lug Weight (new), W _{lug}	6.9 lb
Allowable Stress, Tensile, σ _t	19,980 psi
Allowable Stress, Shear, σ _s	13,320 psi
Allowable Stress, Bearing, σ _p	29,970 psi
Allowable Stress, Bending, σ _b	22,201 psi
Allowable Stress, Weld Shear, τ _{allowable}	13,320 psi
Allowable Stress set to 1/3 Sy per ASME B30.20	No

Summary Values	
Required Lift Pin Diameter, d _{reqd}	0.2894"
Required Lug Thickness, t _{reqd}	0.0668"
Lug Stress Ratio, σ _{ratio}	0.06
Weld Shear Stress Ratio, τ _{ratio}	0.08
Lug Design	Acceptable
Local Stresses	Unacceptable

CODEWARE
EXAMPLE

Lifting Lug #2

Minimum report

Geometry Inputs	
	
Attached To	Ellipsoidal Head #1
Material	304 SS
Orientation	Longitudinal
Distance of Lift Point From Datum	49.875"
Angular Position	180°
Length, L	8"
Height, H	5.75"
Thickness, t	0.5"
Hole Diameter, d	1"
Pin Diameter, Dp	0.875"
Load Eccentricity, a ₁	0"
Distance from Load to Shell or Pad, a ₂	4"
Load Angle Normal to Vessel, β	45°
Load Angle from Vertical, φ	14.01°
Welds	
Size, t _w	0.25"

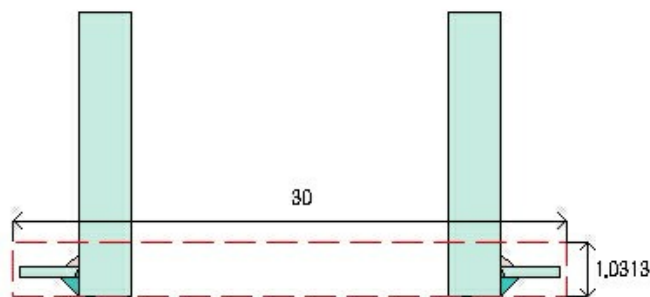
Intermediate Values	
Load Factor	1.5000
Vessel Weight (new, incl. Load Factor), W	3,164.7 lb
Lug Weight (new), W _{lug}	6.7 lb
Allowable Stress, Tensile, σ _t	19,980 psi
Allowable Stress, Shear, σ _s	13,320 psi
Allowable Stress, Bearing, σ _p	29,970 psi
Allowable Stress, Bending, σ _b	22,201 psi
Allowable Stress, Weld Shear, τ _{allowable}	13,320 psi
Allowable Stress set to 1/3 Sy per ASME B30.20	No

Summary Values	
Required Lift Pin Diameter, d _{reqd}	0.2894"
Required Lug Thickness, t _{reqd}	0.0668"
Lug Stress Ratio, σ _{ratio}	0.06
Weld Shear Stress Ratio, τ _{ratio}	0.12
Lug Design	Acceptable
Local Stresses	Unacceptable

CODEWARE
EXAMPLE

MANWAY (N5)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation	
Located on	Ellipsoidal Head #1
Orientation	225°
End of nozzle to datum line	55.875"
Calculated as hillside	Yes
Distance to head center, R	17"
Passes through a Category A joint	No
Nozzle	
Service	Manway (MW)
Access opening	Yes
Material specification	SA-182 F304 ≤ 5 (II-D p. 88, ln. 27)
Inside diameter, new	16"
Nominal wall thickness	1"
Corrosion allowance	0"
Opening chord length	16.9712"
Projection available outside vessel, L _{pr}	2.8974"
Internal projection, h _{new}	0.375"
Projection available outside vessel to flange face, L _f	4.3374"
Local vessel minimum thickness	0.1875"
User input radial limit of reinforcement	15"
Liquid static head included	0 psi
Welds	
Inner fillet, Leg ₄₁	0.25"
Lower fillet, Leg ₄₃	0.375"
Nozzle to vessel groove weld	0.1875"
Radiography	
Longitudinal seam	Seamless No RT

ASME B16.5-2013 Flange	
Description	NPS 16 Class 150 LWN A182 F304
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	199.3 psi @ 338°F
MAP rating	275 psi @ 70°F
Hydrotest rating	425 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
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	
$t_r = \frac{100 \cdot 62}{2 \cdot 27,100 \cdot 1 - 0.2 \cdot 100} =$	0.1144"
Stress ratio = $\frac{t_r \cdot E^*}{t_n - c} = \frac{0.1144 \cdot 1}{0.1875 - 0} =$	0.6103
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 = 100 psi @ 338 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
2.1443	2.1796	0.812	0.6632	0.5543	-	0.1501	0.0429	1

UG-41 Weld Failure Path Analysis Summary (lb _f)				
All failure paths are stronger than the applicable weld loads				
Weld load W	Weld load W _{1,1}	Path 1-1 strength	Weld load W _{2,2}	Path 2-2 strength
36,134.89	17,947.82	414,318.74	41,613.12	261,177.09

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Nozzle to inside shell fillet (Leg ₄₃)	0.175	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

Reinforcement Calculations for MAWP

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

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 100.94 psi @ 338 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
2.1646	2.1647	0.7974	0.6629	0.5543	--	0.1501	0.0433	1

UG-41 Weld Failure Path Analysis Summary (lb _f)				
All failure paths are stronger than the applicable weld loads				
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength
36,974.28	17,940.23	414,318.74	41,605.53	261,177.09

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Nozzle to inside shell fillet (Leg ₄₃)	0.175	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

Reinforcement Calculations for MAP

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

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 108.06 psi @ 70 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
2.1635	2.1635	0.7983	0.6618	0.5535	--	0.1499	0.0434	1

UG-41 Weld Failure Path Analysis Summary (lb _f)				
All failure paths are stronger than the applicable weld loads				
Weld load W	Weld load W ₁₋₁	Path 1-1 strength	Weld load W ₂₋₂	Path 2-2 strength
39,549.98	19,184.09	443,121.64	44,496.85	279,495.32

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 338 °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}
1.428	1.6669	0.3031	0.6594	0.5543	--	0.1501	0.0484	1

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Nozzle to inside shell fillet (Leg ₄₃)	0.175	0.2625	weld size is adequate
Combined weld check ($t_1 + t_2$)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For $P_e = 17.12$ psi @ 338 °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}
1.5255	1.5256	0.1635	0.6577	0.5543	--	0.1501	0.0508	1

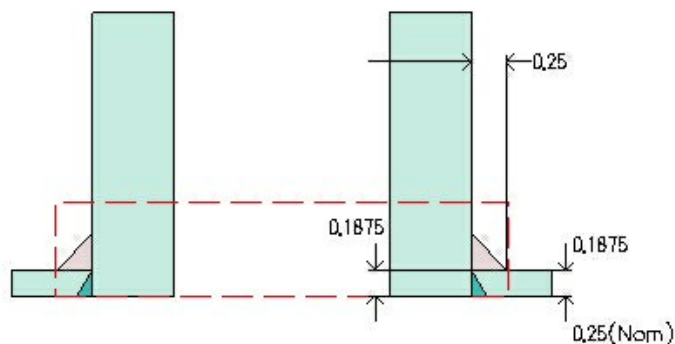
UG-41 Weld Failure Path Analysis Summary
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Nozzle to inside shell fillet (Leg ₄₃)	0.175	0.2625	weld size is adequate
Combined weld check ($t_1 + t_2$)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

CODE EXAMPLE
 EXAMPLE

Nozzle #7 (N7)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Ellipsoidal Head #1
Orientation	90°
End of nozzle to datum line	55.375"
Calculated as hillside	Yes
Distance to head center, R	16"
Passes through a Category A joint	No

Nozzle

Access opening	No
Material specification	SB-462 Solution ann. Forgings N06022 (II-D p. 208, In. 40)
Inside diameter, new	1.5"
Nominal wall thickness	0.56"
Corrosion allowance	0"
Opening chord length	1.5666"
Projection available outside vessel, Lpr	4.4717"
Projection available outside vessel to flange face, Lf	5.1617"
Local vessel minimum thickness	0.1875"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
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ASME B16.5-2013 Flange	
Description	NPS 1.5 Class 150 LWN B462 N06022
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, In. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	218.6 psi @ 338°F
MAP rating	290 psi @ 70°F
Hydrotest rating	450 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Notes	
Flange rated MDMT per UNF-65 = -325°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UNF-65 Material Toughness Requirements Nozzle	
Rated MDMT =	-325°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 = 100 psi @ 338 °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)							0.1226	0.56

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	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 = 169.91 psi @ 338 °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)							0.1776	0.56

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 182 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1776	0.56

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 338 °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)							0.0625	0.56

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 18.56 psi @ 338 °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)							0.0625	0.56

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

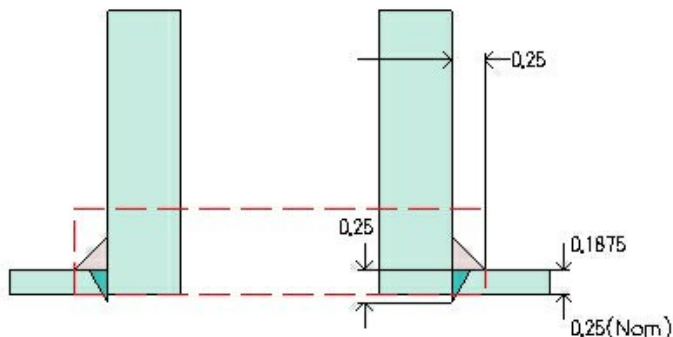
UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

CODEWARE
EXAMPLE

RELIEF (N9)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Ellipsoidal Head #1
Orientation	120°
End of nozzle to datum line	55.375"
Calculated as hillside	Yes
Distance to head center, R	16"
Passes through a Category A joint	No

Nozzle

Access opening	No
Material specification	SB-462 Solution ann. Forgings N06022 (II-D p. 208, In. 40)
Inside diameter, new	1.5"
Nominal wall thickness	0.56"
Corrosion allowance	0"
Opening chord length	1.5666"
Projection available outside vessel, Lpr	4.4717"
Projection available outside vessel to flange face, Lf	5.1617"
Local vessel minimum thickness	0.1875"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
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ASME B16.5-2013 Flange	
Description	NPS 1.5 Class 150 LWN B462 N06022
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, In. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	218.6 psi @ 338°F
MAP rating	290 psi @ 70°F
Hydrotest rating	450 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Notes	
Flange rated MDMT per UNF-65 = -325°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UNF-65 Material Toughness Requirements Nozzle	
Rated MDMT =	-325°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 = 100 psi @ 338 °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)							0.1226	0.56

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 (Le _{g41})	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 = 169.91 psi @ 338 °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)							0.1776	0.56

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 MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 182 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1776	0.56

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 338 °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)							0.0625	0.56

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

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

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 18.56 psi @ 338 °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)							0.0625	0.56

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

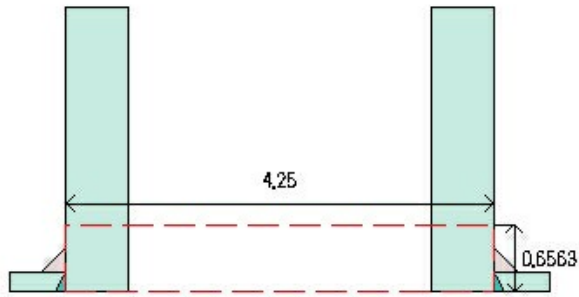
UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate

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

CODEWARE
EXAMPLE

SPRAY BALL (N1)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation	
Located on	Ellipsoidal Head #1
Orientation	0°
End of nozzle to datum line	56.125"
Calculated as hillside	No
Distance to head center, R	0"
Passes through a Category A joint	No
Nozzle	
Access opening	No
Material specification	SB-462 Solution ann. Forgings N06022 (II-D p. 208, In. 40)
Inside diameter, new	3"
Nominal wall thickness	0.625"
Corrosion allowance	0"
Projection available outside vessel, Lpr	3.159"
Projection available outside vessel to flange face, Lf	4.099"
Local vessel minimum thickness	0.1875"
User input radial limit of reinforcement	1.5"
Liquid static head included	0 psi
Welds	
Inner fillet, Leg ₄₁	0.25"
Nozzle to vessel groove weld	0.1875"
Radiography	
Longitudinal seam	Seamless No RT

ASME B16.5-2013 Flange	
Description	NPS 3 Class 150 LWN B462 N06022
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, In. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	218.6 psi @ 338°F
MAP rating	290 psi @ 70°F
Hydrotest rating	450 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Notes	
Flange rated MDMT per UNF-65 = -325°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UNF-65 Material Toughness Requirements Nozzle	
Rated MDMT =	-325°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 = 100 psi @ 338 °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)							0.1226	0.625

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	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 = 169.91 psi @ 338 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	0.625

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 182 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	0.625

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 338 °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)							0.0625	0.625

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 18.56 psi @ 338 °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)							0.0625	0.625

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

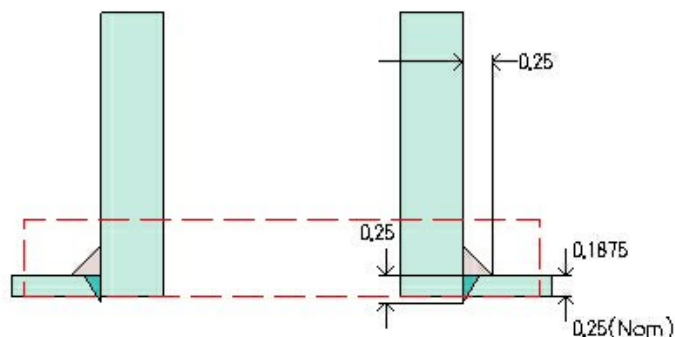
UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

CODEWARE
EXAMPLE

VENT (N4)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Ellipsoidal Head #1
Orientation	55°
End of nozzle to datum line	55.375"
Calculated as hillside	Yes
Distance to head center, R	20"
Passes through a Category A joint	No

Nozzle

Service	Vent (VENT)
Access opening	No
Material specification	SB-462 Solution ann. Forgings N06022 (II-D p. 208, In. 40)
Inside diameter, new	2"
Nominal wall thickness	0.53"
Corrosion allowance	0"
Opening chord length	2.171"
Projection available outside vessel, L _{pr}	5.6094"
Projection available outside vessel to flange face, L _f	6.3594"
Local vessel minimum thickness	0.1875"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
-------------------	----------------

ASME B16.5-2013 Flange	
Description	NPS 2 Class 150 LWN B462 N06022
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, In. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	218.6 psi @ 338°F
MAP rating	290 psi @ 70°F
Hydrotest rating	450 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Notes	
Flange rated MDMT per UNF-65 = -325°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UNF-65 Material Toughness Requirements Nozzle	
Rated MDMT =	-325°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 = 100 psi @ 338 °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)							0.1226	0.53

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 (Le _{g41})	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 = 169.91 psi @ 338 °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	0.53

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 MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 182 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.189	0.53

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 338 °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)							0.0625	0.53

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

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

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 18.56 psi @ 338 °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)							0.0625	0.53

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

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

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

CODEWARE
EXAMPLE

Cylinder #1

ASME Section VIII Division 1, 2019 Edition				
Component		Cylinder		
Material		SB-688 Sol. ann. > 3/16 N08367 (low stress) (II-D p. 240, In. 25)		
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		100	338	-20
External		15	338	
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Test horizontal		2.35	65.1826	1
Dimensions				
Inner Diameter		62"		
Length		33.375"		
Nominal Thickness		0.375"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)	Capacity (US gal)	
New		711.54	436.2	
Corroded		711.54	436.2	
Radiography				
Longitudinal seam		Full UW-11(a) Type 1		
Top Circumferential seam		Spot UW-11(b) Type 1		
Bottom Circumferential seam		Spot UW-11(b) Type 1		

Results Summary	
Governing condition	External pressure
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	0.1584"
Design thickness due to external pressure (t _e)	0.1783"
Design thickness due to combined loadings + corrosion	0.0671"
Maximum allowable working pressure (MAWP)	235.81 psi
Maximum allowable pressure (MAP)	276.64 psi
Maximum allowable external pressure (MAEP)	63.87 psi
Rated MDMT	-325 °F

UNF-65 Material Toughness Requirements	
Rated MDMT =	-325°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Design thickness, (at 338 °F) UG-27(c)(1)

$$t = \frac{P \cdot R}{S \cdot E - 0.60 \cdot P} + \text{Corrosion} = \frac{100 \cdot 31}{23,100 \cdot 0.85 - 0.60 \cdot 100} + 0 = \underline{0.1584"}$$

Maximum allowable working pressure, (at 338 °F) UG-27(c)(1)

$$P = \frac{S \cdot E \cdot t}{R + 0.60 \cdot t} - P_s = \frac{23,100 \cdot 0.85 \cdot 0.375}{31 + 0.60 \cdot 0.375} - 0 = \underline{235.81} \text{ psi}$$

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

$$P = \frac{S \cdot E \cdot t}{R + 0.60 \cdot t} = \frac{27,100 \cdot 0.85 \cdot 0.375}{31 + 0.60 \cdot 0.375} = \underline{276.64} \text{ psi}$$

External Pressure, (Corroded & at 338 °F) UG-28(c)

$$\frac{L}{D_o} = \frac{46.7083}{62.75} = 0.7444$$

$$\frac{D_o}{t} = \frac{62.75}{0.1783} = 351.8382$$

From table G: $A = 0.000282$

$$P_a = \frac{2 \cdot A \cdot E}{3 \cdot \left(\frac{D_o}{t}\right)} = \frac{2 \cdot 0.000282 \cdot 28034000}{3 \cdot \left(\frac{62.75}{0.1783}\right)} = 15 \text{ psi}$$

Design thickness for external pressure $P_a = 15$ psi

$$t_a = t + \text{Corrosion} = 0.1783 + 0 = \underline{0.1783}''$$

Maximum Allowable External Pressure, (Corroded & at 338 °F) UG-28(c)

$$\frac{L}{D_o} = \frac{46.7083}{62.75} = 0.7444$$

$$\frac{D_o}{t} = \frac{62.75}{0.375} = 167.3333$$

From table G: $A = 0.000871$

From table NFN-12: $B = 8,016.2813$ psi

$$P_a = \frac{4 \cdot B}{3 \cdot (D_o/t)} = \frac{4 \cdot 8,016.28}{3 \cdot (62.75/0.375)} = \underline{63.87} \text{ psi}$$

% Forming strain - UNF-79(a)(2)

$$EFE = \left(\frac{50 \cdot t}{R_f}\right) \cdot \left(1 - \frac{R_f}{R_o}\right) = \left(\frac{50 \cdot 0.375}{31.1875}\right) \cdot \left(1 - \frac{31.1875}{\infty}\right) = 0.6012 \%$$

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

$$P_v = \frac{W}{2 \cdot \pi \cdot R_m} + \frac{M}{\pi \cdot R_m^2} = \frac{1,635.4}{2 \cdot \pi \cdot 31.1875} + \frac{7,442}{\pi \cdot 31.1875^2} = 10.781 \text{ lb/in}$$

$$\alpha = \frac{P_v}{P_e \cdot D_o} = \frac{10.781}{15 \cdot 62.75} = 0.0115$$

$$n = 7$$

$$m = \frac{1.23}{\left(\frac{L}{D_o}\right)^2} = \frac{1.23}{\left(\frac{46.7083}{62.75}\right)^2} = 2.22$$

$$RatioP_e = \frac{n^2 - 1 + m + m \cdot \alpha}{n^2 - 1 + m} = \frac{7^2 - 1 + 2.22 + 2.22 \cdot 0.0115}{7^2 - 1 + 2.22} = 1.0005$$

$$RatioP_e \cdot P_e \leq MAEP$$

$$(1.0005 \cdot 15 = 15.01) \leq 63.87$$

Cylinder design thickness is satisfactory.

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

$$P_v = \frac{W}{2 \cdot \pi \cdot R_m} + \frac{M}{\pi \cdot R_m^2} = \frac{-303.1}{2 \cdot \pi \cdot 31.1875} + \frac{254}{\pi \cdot 31.1875^2} = -1.464 \text{ lb/in}$$

$$\alpha = \frac{P_v}{P_e \cdot D_o} = -\frac{1.464}{15 \cdot 62.75} = -0.0016$$

$$n = 7$$

$$m = \frac{1.23}{\left(\frac{L}{D_o}\right)^2} = \frac{1.23}{\left(\frac{46.7083}{62.75}\right)^2} = 2.22$$

$$RatioP_e = \frac{n^2 - 1 + m + m \cdot \alpha}{n^2 - 1 + m} = \frac{7^2 - 1 + 2.22 + 2.22 \cdot -0.0016}{7^2 - 1 + 2.22} = 1$$

$$RatioP_e \cdot P_e \leq MAEP$$

$$(1 \cdot 15 = 15) \leq 63.87$$

Cylinder design thickness is satisfactory.

Thickness Required Due to Pressure + External Loads									
Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Location	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S _t	S _c						
Operating, Hot & Corroded	100	23,100	9,641	338	0	Top	Weight	0.0668	0.0666
						Bottom	Weight	0.0671	0.0671
Operating, Hot & New	100	23,100	9,641	338	0	Top	Weight	0.0668	0.0666
						Bottom	Weight	0.0671	0.0671
Hot Shut Down, Corroded	0	23,100	9,641	338	0	Top	Weight	0.0006	0.0011
						Bottom	Weight	0.0001	0.0001
Hot Shut Down, New	0	23,100	9,641	338	0	Top	Weight	0.0006	0.0011
						Bottom	Weight	0.0001	0.0001
Empty, Corroded	0	27,100	11,090	70	0	Top	Weight	0.0005	0.001
						Bottom	Weight	0.0001	0.0001
Empty, New	0	27,100	11,090	70	0	Top	Weight	0.0005	0.001
						Bottom	Weight	0.0001	0.0001
Vacuum	-15	23,100	9,641	338	0	Top	Weight	0.0247	0.0252
						Bottom	Weight	0.0239	0.024
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0	23,100	9,641	338	0	Top	Weight	0.0006	0.0011
						Bottom	Weight	0.0001	0.0001

CODEWARE
 EXAMPLE

Legs #1

Inputs	
Leg material	304/304L SS
Leg description	4 inch sch 40 pipe
Number of legs, N	4
Overall length	40"
Base to girth seam length	37.375"
User defined leg eccentricity	0"
Effective length coefficient, K	1.5
Coefficient, C_m	0.85
Leg yield stress, F_y	36,000 psi
Leg elastic modulus, E	29,000,000 psi
Anchor Bolts	
Anchor bolt size	0.375" coarse threaded
Anchor bolt material	
Bolt circle, BC	64.75"
Anchor bolts/leg, n	1
Anchor bolt allowable stress, S_b	20,000 psi
Anchor bolt corrosion allowance	0"
Anchor bolt hole clearance	0.375"
Base Plate	
Base plate length	7"
Base plate width	7"
Base plate thickness	0.5" (0.0553" required)
Base plate allowable stress	24,000 psi
Foundation allowable bearing stress	1,658 psi
Welds	
Leg to shell fillet weld	0.25" (0.0056" required)
Legs braced	No

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

Conditions Investigated (Only Governing Condition Reported)

Weight operating corroded
 Weight empty corroded
 Weight vacuum corroded

Governing Condition : Weight operating corroded, Moment = 613.0 lb _f -ft								
Force attack angle °	Leg position °	Axial end load lb _f	Shear resisted lb _f	Axial f _a psi	Bending f _{bx} psi	Bending f _{by} psi	Ratio H ₁₋₁	Ratio H ₁₋₂
0	0	409.8	0.0	129	0	0	0.0066	0.0060
	90	527.1	0.0	166	0	0	0.0085	0.0077
	180	644.3	0.0	203	0	0	0.0104	0.0094
	270	527.1	0.0	166	0	0	0.0085	0.0077

Leg Calculations (AISC manual ninth edition)

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

$$P_1 = \frac{W}{N} + \frac{48 \cdot M_t}{N \cdot D} = \frac{2,108.27}{4} + \frac{48 \cdot 613}{4 \cdot 62.75} = 644.29 \text{ lb}_f$$

Allowable axial compressive stress, F_a (AISC chapter E)

$$C_c = \sqrt{\frac{2 \cdot \pi^2 \cdot E}{F_y}} = \sqrt{\frac{2 \cdot \pi^2 \cdot 29,000,000}{36,000}} = 126.0993$$

$$\frac{K \cdot l}{r} = \frac{1.5 \cdot 35.875}{1.5102} = 35.6323$$

$$F_a = \frac{1 \cdot \left(1 - \frac{(K \cdot l/r)^2}{2 \cdot C_c^2}\right) \cdot F_y}{\frac{5}{3} + \frac{3}{8} \cdot \frac{K \cdot l/r}{C_c} - \frac{(K \cdot l/r)^3}{8 \cdot C_c^3}} = \frac{1 \cdot \left(1 - \frac{(35.6323)^2}{2 \cdot 126.0993^2}\right) \cdot 36,000}{\frac{5}{3} + \frac{3}{8} \cdot \frac{35.6323}{126.0993} - \frac{(35.6323)^3}{8 \cdot 126.0993^3}} = 19,529 \text{ psi}$$

Allowable axial compression and bending (AISC chapter H)

$$F'_{ex} = \frac{1 \cdot 12 \cdot \pi^2 \cdot E}{23 \cdot (K \cdot l/r)^2} = \frac{1 \cdot 12 \cdot \pi^2 \cdot 29,000,000}{23 \cdot (35.6323)^2} = 117,615 \text{ psi}$$

$$F'_{ey} = \frac{1 \cdot 12 \cdot \pi^2 \cdot E}{23 \cdot (K \cdot l/r)^2} = \frac{1 \cdot 12 \cdot \pi^2 \cdot 29,000,000}{23 \cdot (35.6323)^2} = 117,615 \text{ psi}$$

$$F_b = 1 \cdot 0.66 \cdot F_y = 1 \cdot 0.66 \cdot 36,000 = 23,760 \text{ psi}$$

Compressive axial stress

$$f_a = \frac{P_1}{A} = \frac{644.29}{3.17} = 203 \text{ psi}$$

Bending stresses

$$f_{bx} = \frac{F \cdot \cos(\alpha) \cdot L}{I_x/C_x} + \frac{P_1 \cdot E_{cc}}{I_x/C_x} = \frac{0 \cdot \cos(0) \cdot 35.875}{7.23/2.25} + \frac{644.29 \cdot 0}{7.23/2.25} = 0 \text{ psi}$$

$$f_{by} = \frac{F \cdot \sin(\alpha) \cdot L}{I_y/C_y} = \frac{0 \cdot \sin(0) \cdot 35.875}{7.23/2.25} = 0 \text{ psi}$$

AISC equation H₁₋₁

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

$$= \frac{203}{19,529} + \frac{0.85 \cdot 0}{(1 - 203/117,615) \cdot 23,760} + \frac{0.85 \cdot 0}{(1 - 203/117,615) \cdot 23,760}$$

$$= 0.0104$$

AISC equation H1-2

$$H_{1-2} = \frac{f_a}{0.6 \cdot 1 \cdot F_y} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} = \frac{203}{0.6 \cdot 1 \cdot 36,000} + \frac{0}{23,760} + \frac{0}{23,760} = 0.0094$$

4, 4 inch sch 40 pipe legs are adequate.

Anchor bolts - Weight operating corroded condition governs

Tensile loading per leg (1 bolt per leg)

$$R = \frac{48 \cdot M}{N \cdot BC} - \frac{W}{N} = \frac{48 \cdot 613}{4 \cdot 64.75} - \frac{2,108.27}{4} = -413.46 \text{ lb}_f$$

There is no net uplift (R is negative).

0.375" coarse threaded bolts are satisfactory.

Check the leg to vessel fillet weld, Bednar 10.3, Weight operating corroded governs

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

$$Z_w = \frac{2 \cdot b \cdot d + d^2}{3} = \frac{2 \cdot 4.5 \cdot 4.125 + 4.125^2}{3} = 18.0469 \text{ in}^2$$

$$J_w = \frac{(b + 2 \cdot d)^3}{12} - \frac{d^2 \cdot (b + d)^2}{b + 2 \cdot d}$$

$$= \frac{(4.5 + 2 \cdot 4.125)^3}{12} - \frac{4.125^2 \cdot (4.5 + 4.125)^2}{4.5 + 2 \cdot 4.125}$$

$$= 73.444 \text{ in}^3$$

$$E = \frac{d^2}{b + 2 \cdot d} = \frac{4.125^2}{4.5 + 2 \cdot 4.125} = 1.334559 \text{ in}$$

$$\text{Governing weld load } f_x = \text{Cos}(0) \cdot 0 = 0 \text{ lb}_f$$

$$\text{Governing weld load } f_y = \text{Sin}(0) \cdot 0 = 0 \text{ lb}_f$$

$$f_1 = \frac{P_1}{L_{\text{weld}}} = \frac{644.29}{12.75} = 50.53 \text{ lb}_f/\text{in} \text{ (V}_L \text{ direct shear)}$$

$$f_2 = \frac{f_y \cdot L_{\text{leg}} \cdot 0.5 \cdot b}{J_w} = \frac{0 \cdot 35.875 \cdot 0.5 \cdot 4.5}{73.444} = 0 \text{ lb}_f/\text{in} \text{ (V}_L \text{ torsion shear)}$$

$$f_3 = \frac{f_y}{L_{\text{weld}}} = \frac{0}{12.75} = 0 \text{ lb}_f/\text{in} \text{ (V}_c \text{ direct shear)}$$

$$f_4 = \frac{f_y \cdot L_{\text{leg}} \cdot E}{J_w} = \frac{0 \cdot 35.875 \cdot 1.3346}{73.444} = 0 \text{ lb}_f/\text{in} \text{ (V}_c \text{ torsion shear)}$$

$$f_5 = \frac{f_x \cdot L_{\text{leg}} + P_1 \cdot E_{cc}}{Z_w} = \frac{0 \cdot 35.875 + 644.29 \cdot 0}{18.0469} = 0 \text{ lb}_f/\text{in} \text{ (M}_L \text{ bending)}$$

$$f_6 = \frac{f_x}{L_{\text{weld}}} = \frac{0}{12.75} = 0 \text{ lb}_f/\text{in} \text{ (Direct outward radial shear)}$$

$$f = \sqrt{(f_1 + f_2)^2 + (f_3 + f_4)^2 + (f_5 + f_6)^2}$$

$$= \sqrt{(50.53 + 0)^2 + (0 + 0)^2 + (0 + 0)^2}$$

$$= 50.53 \text{ lb}_f/\text{in} \text{ (Resultant shear load)}$$

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

$$t_w = \frac{f}{0.707 \cdot 0.55 \cdot S_a} = \frac{50.53}{0.707 \cdot 0.55 \cdot 23,100} = 0.0056 \text{ in}$$

The 0.25 in leg to vessel attachment fillet weld size is adequate.

Base plate thickness check, AISC 3-106

$$f_p = \frac{P}{B \cdot N} = \frac{640.67}{7 \cdot 7} = 13 \text{ psi}$$

$$t_b = \frac{N - (d - t_L)}{2} \cdot \sqrt{\frac{3 \cdot f_p}{S_b}} = \frac{7 - (4.5 - 0.237)}{2} \cdot \sqrt{\frac{3 \cdot 13}{24,000}} = 0.0553 \text{ in}$$

The base plate thickness is adequate.

CODEWARE
EXAMPLE

Check the leg to vessel attachment stresses, WRC 537 (Weight operating corroded governs)

Applied Loads	
Radial load, P_r	0 lb _f
Circumferential moment, M_c	0 lb _f -in
Circumferential shear, V_c	0 lb _f
Longitudinal moment, M_L	0 lb _f -in
Longitudinal shear, V_L	409.84 lb _f
Torsion moment, M_t	0 lb _f -in
Internal pressure, P	100 psi
Mean shell radius, R_m	31.1875"
Local shell thickness, T	0.375"
Design factor	3

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

$$\gamma = \frac{R_m}{T} = \frac{31.1875}{0.375} = 83.1667$$

$$C_1 = 2.25, C_2 = 3.274 \text{ in}$$

$$\text{Local circumferential pressure stress} = \frac{P \cdot R_i}{T} = 8,267 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = \frac{P \cdot R_i}{2 \cdot T} = 4,134 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 8,269 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = \pm 3 \cdot S = \pm 69,300 \text{ psi}$$

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

$$\text{Maximum local primary membrane stress } (P_L) = 8,267 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = \pm 1.5 \cdot S = \pm 34,650 \text{ psi}$$

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

Stresses at the leg edge per WRC Bulletin 537										
Figure	Y	β	A _u	A _l	B _u	B _l	C _u	C _l	D _u	D _l
3C*	11.3502	0.1044	0	0	0	0	0	0	0	0
4C*	15.4616	0.0943	0	0	0	0	0	0	0	0
1C	0.1128	0.0827	0	0	0	0	0	0	0	0
2C-1	0.0769	0.0827	0	0	0	0	0	0	0	0
3A*	3.0638	0.0818	0	0	0	0	0	0	0	0
1A	0.0894	0.0871	0	0	0	0	0	0	0	0
3B*	9.3543	0.0926	0	0	0	0	0	0	0	0
1B-1	0.0405	0.0878	0	0	0	0	0	0	0	0
Pressure stress*			8,267	8,267	8,267	8,267	8,267	8,267	8,267	8,267
Total circumferential stress			8,267	8,267	8,267	8,267	8,267	8,267	8,267	8,267
Primary membrane circumferential stress*			8,267	8,267	8,267	8,267	8,267	8,267	8,267	8,267
3C*	12.314	0.0943	0	0	0	0	0	0	0	0
4C*	15.0571	0.1044	0	0	0	0	0	0	0	0
1C-1	0.1032	0.0961	0	0	0	0	0	0	0	0
2C	0.0632	0.0961	0	0	0	0	0	0	0	0
4A*	5.5982	0.0818	0	0	0	0	0	0	0	0
2A	0.0444	0.0994	0	0	0	0	0	0	0	0
4B*	2.8871	0.0926	0	0	0	0	0	0	0	0
2B-1	0.0528	0.0989	0	0	0	0	0	0	0	0
Pressure stress*			4,134	4,134	4,134	4,134	4,134	4,134	4,134	4,134
Total longitudinal stress			4,134	4,134	4,134	4,134	4,134	4,134	4,134	4,134
Primary membrane longitudinal stress*			4,134	4,134	4,134	4,134	4,134	4,134	4,134	4,134
Shear from M _t			0	0	0	0	0	0	0	0
Circ shear from V _c			0	0	0	0	0	0	0	0
Long shear from V _L			0	0	0	0	-83	-83	83	83
Total Shear stress			0	0	0	0	-83	-83	83	83
Combined stress (P _L +P _b +Q)			8,267	8,267	8,267	8,267	8,269	8,269	8,269	8,269

* denotes primary stress.

Applied Loads	
Radial load, P _r	0 lb _f
Circumferential moment, M _c	0 lb _f -in
Circumferential shear, V _c	0 lb _f
Longitudinal moment, M _L	0 lb _f -in
Longitudinal shear, V _L	644.29 lb _f
Torsion moment, M _t	0 lb _f -in
Internal pressure, P	100 psi
Mean shell radius, R _m	31.1875"
Local shell thickness, T	0.375"
Design factor	3

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

$$\gamma = \frac{R_m}{T} = \frac{31.1875}{0.375} = 83.1667$$

$$C_1 = 2.25, C_2 = 3.274 \text{ in}$$

$$\text{Local circumferential pressure stress} = \frac{P \cdot R_i}{T} = 8,267 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = \frac{P \cdot R_i}{2 \cdot T} = 4,134 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 8,271 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = \pm 3 \cdot S = \pm 69,300 \text{ psi}$$

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

$$\text{Maximum local primary membrane stress } (P_L) = 8,267 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = \pm 1.5 \cdot S = \pm 34,650 \text{ psi}$$

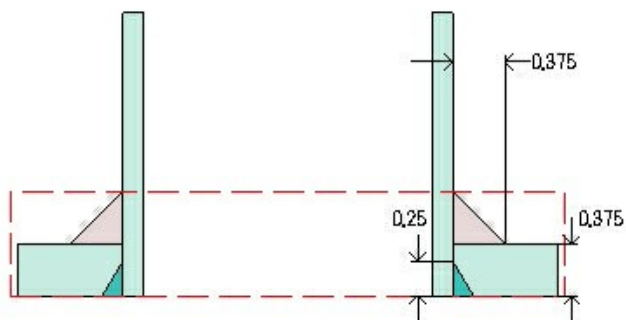
The maximum local primary membrane stress (P_L) is within allowable limits.

CODEWARE
EXAMPLE

Stresses at the leg edge per WRC Bulletin 537										
Figure	Y	β	A _u	A _l	B _u	B _l	C _u	C _l	D _u	D _l
3C*	11.3502	0.1044	0	0	0	0	0	0	0	0
4C*	15.4616	0.0943	0	0	0	0	0	0	0	0
1C	0.1128	0.0827	0	0	0	0	0	0	0	0
2C-1	0.0769	0.0827	0	0	0	0	0	0	0	0
3A*	3.0638	0.0818	0	0	0	0	0	0	0	0
1A	0.0894	0.0871	0	0	0	0	0	0	0	0
3B*	9.3543	0.0926	0	0	0	0	0	0	0	0
1B-1	0.0405	0.0878	0	0	0	0	0	0	0	0
Pressure stress*			8,267	8,267	8,267	8,267	8,267	8,267	8,267	8,267
Total circumferential stress			8,267	8,267	8,267	8,267	8,267	8,267	8,267	8,267
Primary membrane circumferential stress*			8,267	8,267	8,267	8,267	8,267	8,267	8,267	8,267
3C*	12.314	0.0943	0	0	0	0	0	0	0	0
4C*	15.0571	0.1044	0	0	0	0	0	0	0	0
1C-1	0.1032	0.0961	0	0	0	0	0	0	0	0
2C	0.0632	0.0961	0	0	0	0	0	0	0	0
4A*	5.5982	0.0818	0	0	0	0	0	0	0	0
2A	0.0444	0.0994	0	0	0	0	0	0	0	0
4B*	2.8871	0.0926	0	0	0	0	0	0	0	0
2B-1	0.0528	0.0989	0	0	0	0	0	0	0	0
Pressure stress*			4,134	4,134	4,134	4,134	4,134	4,134	4,134	4,134
Total longitudinal stress			4,134	4,134	4,134	4,134	4,134	4,134	4,134	4,134
Primary membrane longitudinal stress*			4,134	4,134	4,134	4,134	4,134	4,134	4,134	4,134
Shear from M_t			0	0	0	0	0	0	0	0
Circ shear from V_c			0	0	0	0	0	0	0	0
Long shear from V_L			0	0	0	0	-131	-131	131	131
Total Shear stress			0	0	0	0	-131	-131	131	131
Combined stress (P_L+P_b+Q)			8,267	8,267	8,267	8,267	8,271	8,271	8,271	8,271
* denotes primary stress.										

STEAM IN (N13)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	25°
Nozzle center line offset to datum line	28"
End of nozzle to shell center	32.375"
Passes through a Category A joint	No

Nozzle

Service	Inlet (INLET)
Access opening	No
Material specification	SA-182 F304 ≤ 5 (II-D p. 88, ln. 27)
Inside diameter, new	2.067"
Nominal wall thickness	0.154"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	1"
Local vessel minimum thickness	0.375"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
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UHA-51 Material Toughness Requirements Nozzle

$t_r = \frac{100 \cdot 1.0335}{20,000 \cdot 1 - 0.6 \cdot 100} =$	0.0052"
Stress ratio = $\frac{t_r \cdot E^*}{t_n - c} = \frac{0.0052 \cdot 1}{0.154 - 0} =$	0.0337
Impact test exempt per UHA-51(g) (coincident ratio = 0.0337)	
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 = 100 psi @ 338 °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)							0.1345	0.154

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.1925	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.1078	0.25	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 = 277.42 psi @ 338 °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	0.154

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.1925	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.1078	0.25	weld size is adequate

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

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 325.46 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.154

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 338 °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)							0.0625	0.154

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.1925	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.1078	0.25	weld size is adequate

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 63.87 psi @ 338 °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)							0.0859	0.154

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.1925	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.1078	0.25	weld size is adequate

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

B16.9 Reducer #1 (N13)

ASME Section VIII Division 1, 2019 Edition				
Component		ASME B16.9 Reducer		
Material		SA-403 304LN WP (II-D p. 96, ln. 5)		
Pipe NPS and Schedule		NPS 2 x 1 (Thk = 0.172")		
Attached To		STEAM IN (N13)		
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		100	338	-20
External		15	338	
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Test horizontal		0.19	5.2701	1
Dimensions				
Outer Diameter	Large	2.375"		
	Small	1.315"		
Nominal Thickness		0.172"		
Minimum Thickness¹		0.1505"		
End-to-End, H		3"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)	Capacity (US gal)	
New		0.8	0.02	
Corroded		0.8	0.02	
Radiography				
Longitudinal seam		Seamless No RT		

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

ASME B16.5-2013 Flange	
Description	NPS 1 Class 150 SO A240 304L
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, In. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	169.3 psi @ 338°F
MAP rating	230 psi @ 70°F
Hydrotest rating	350 psi @ 70°F
External fillet weld leg (UW-21)	0.2408" (0.2408" min)
Internal fillet weld leg (UW-21)	0.172" (0.172" min)
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
UW-21 Flange Welds	
$X_{\min} = \min [1.4 \cdot t_n, g_0] = [1.4 \cdot 0.172, 0.29] =$	0.2408"
External Leg $\min = X_{\min} + \frac{C_o}{0.7} = 0.2408 + \frac{0}{0.7} =$	0.2408"
Internal Leg $\min = \min \left[t_n, 0.25" + \frac{C_i}{0.7} \right] = \min \left[0.172, 0.25 + \frac{0}{0.7} \right] =$	0.172"
Notes	
Flange rated MDMT per UHA-51(d)(1)(a) = -320°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

Results Summary	
Governing condition	UG-16
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	0.0064"
Design thickness due to external pressure (t _e)	0.01"
Maximum allowable working pressure (MAWP)	2,496.54 psi
Maximum allowable pressure (MAP)	2,670.1 psi
Maximum allowable external pressure (MAEP)	957.93 psi
Rated MDMT	-320 °F

UHA-51 Material Toughness Requirements	
$t_r = \frac{100 \cdot 1.1875}{20,000 \cdot 1 + 0.4 \cdot 100} =$	0.0059"
Stress ratio = $\frac{t_r \cdot E^*}{t_n - c} = \frac{0.0059 \cdot 1}{0.1505 - 0} =$	0.0394
Impact test exempt per UHA-51(g) (coincident ratio = 0.0394)	
Rated MDMT =	-320°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Design thickness, (at 338 °F) Appendix 1-1

$$t = \frac{P \cdot R_o}{S \cdot E + 0.40 \cdot P} + \text{Corrosion} = \frac{100 \cdot 1.1875}{18,700 \cdot 1.00 + 0.40 \cdot 100} + 0 = \a href="#">0.0064"$$

Maximum allowable working pressure, (at 338 °F) Appendix 1-1

$$P = \frac{S \cdot E \cdot t}{R_o - 0.40 \cdot t} - P_s = \frac{18,700 \cdot 1.00 \cdot (0.172 \cdot 0.875)}{1.1875 - 0.40 \cdot (0.172 \cdot 0.875)} - 0 = \underline{2,496.54} \text{ psi}$$

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

$$P = \frac{S \cdot E \cdot t}{R_o - 0.40 \cdot t} = \frac{20,000 \cdot 1.00 \cdot (0.172 \cdot 0.875)}{1.1875 - 0.40 \cdot (0.172 \cdot 0.875)} = \underline{2,670.1} \text{ psi}$$

External Pressure, (Corroded & at 338 °F) UG-28(c)

$$\frac{L}{D_o} = \frac{4.1945}{2.375} = 1.7661$$

$$\frac{D_o}{t} = \frac{2.375}{0.01} = 236.7775$$

From table G: $A = 0.000205$

From table HA-1: $B = 2,663.5353 \text{ psi}$

$$P_a = \frac{4 \cdot B}{3 \cdot (D_o/t)} = \frac{4 \cdot 2,663.54}{3 \cdot (2.375/0.01)} = 15 \text{ psi}$$

Design thickness for external pressure $P_a = 15 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.01 + 0 = \underline{0.01}''$$

Maximum Allowable External Pressure, (Corroded & at 338 °F) UG-28(c)

$$\frac{L}{D_o} = \frac{4.1945}{2.375} = 1.7661$$

$$\frac{D_o}{t} = \frac{2.375}{0.172 \cdot 0.875} = 15.7807$$

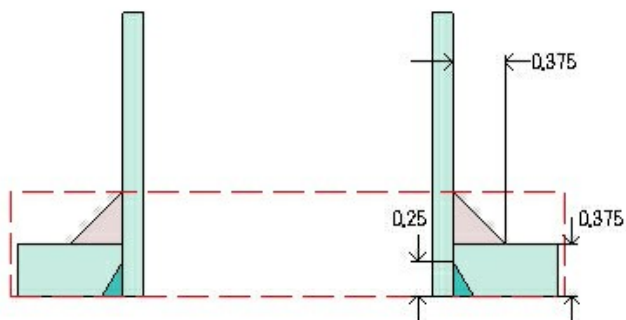
From table G: $A = 0.011905$

From table HA-1: $B = 11,337.6307 \text{ psi}$

$$P_a = \frac{4 \cdot B}{3 \cdot (D_o/t)} = \frac{4 \cdot 11,337.63}{3 \cdot (2.375/(0.172 \cdot 0.875))} = \underline{957.93} \text{ psi}$$

STEAM OUT (N14)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	25°
Nozzle center line offset to datum line	8.5"
End of nozzle to shell center	32.375"
Passes through a Category A joint	No

Nozzle

Service	Outlet (OUTLET)
Access opening	No
Material specification	SA-182 F304 ≤ 5 (II-D p. 88, ln. 27)
Inside diameter, new	2.067"
Nominal wall thickness	0.154"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	1"
Local vessel minimum thickness	0.375"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
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UHA-51 Material Toughness Requirements Nozzle

$t_r = \frac{100 \cdot 1.0335}{20,000 \cdot 1 - 0.6 \cdot 100} =$	0.0052"
Stress ratio = $\frac{t_r \cdot E^*}{t_n - c} = \frac{0.0052 \cdot 1}{0.154 - 0} =$	0.0337
Impact test exempt per UHA-51(g) (coincident ratio = 0.0337)	
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 = 100 psi @ 338 °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)							0.1345	0.154

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.1925	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.1078	0.25	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 = 277.42 psi @ 338 °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	0.154

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.1925	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.1078	0.25	weld size is adequate

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

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 325.46 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.154

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 338 °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)							0.0625	0.154

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.1925	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.1078	0.25	weld size is adequate

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 63.87 psi @ 338 °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)							0.0859	0.154

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.1078	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.1925	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.1078	0.25	weld size is adequate

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

B16.9 Reducer #1 (N14)

ASME Section VIII Division 1, 2019 Edition				
Component		ASME B16.9 Reducer		
Material		SA-403 304L (II-D p. 84, ln. 43)		
Pipe NPS and Schedule		NPS 2 x 1 Sch 40S (Std)		
Attached To		STEAM OUT (N14)		
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		100	338	-20
External		15	338	
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Test horizontal		0.19	5.2777	1
Dimensions				
Outer Diameter	Large	2.375"		
	Small	1.315"		
Nominal Thickness		0.154"		
Minimum Thickness¹		0.1348"		
End-to-End, H		3"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)	Capacity (US gal)	
New		0.72	0.03	
Corroded		0.72	0.03	
Radiography				
Longitudinal seam		Seamless No RT		

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

ASME B16.5-2013 Flange	
Description	NPS 1 Class 150 SO B462 N06022
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, In. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	218.6 psi @ 338°F
MAP rating	290 psi @ 70°F
Hydrotest rating	450 psi @ 70°F
External fillet weld leg (UW-21)	0.2156" (0.2156" min)
Internal fillet weld leg (UW-21)	0.154" (0.154" min)
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
UW-21 Flange Welds	
$X_{\min} = \min [1.4 \cdot t_n, g_0] = [1.4 \cdot 0.154, 0.29] =$	0.2156"
External Leg $\min = X_{\min} + \frac{C_o}{0.7} = 0.2156 + \frac{0}{0.7} =$	0.2156"
Internal Leg $\min = \min \left[t_n, 0.25" + \frac{C_i}{0.7} \right] = \min \left[0.154, 0.25 + \frac{0}{0.7} \right] =$	0.154"
Notes	
Flange rated MDMT per UNF-65 = -325°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

Results Summary	
Governing condition	UG-16
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	0.0073"
Design thickness due to external pressure (t _e)	0.01"
Maximum allowable working pressure (MAWP)	1,949.45 psi
Maximum allowable pressure (MAP)	1,985.11 psi
Maximum allowable external pressure (MAEP)	683.14 psi
Rated MDMT	-320 °F

UHA-51 Material Toughness Requirements	
$t_r = \frac{100 \cdot 1.1875}{16,700 \cdot 1 + 0.4 \cdot 100} =$	0.0071"
Stress ratio $= \frac{t_r \cdot E^*}{t_n - c} = \frac{0.0071 \cdot 1}{0.1348 - 0} =$	0.0526
Impact test exempt per UHA-51(g) (coincident ratio = 0.0526)	
Rated MDMT =	-320°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Design thickness, (at 338 °F) Appendix 1-1

$$t = \frac{P \cdot R_o}{S \cdot E + 0.40 \cdot P} + \text{Corrosion} = \frac{100 \cdot 1.1875}{16,400 \cdot 1.00 + 0.40 \cdot 100} + 0 = \text{0.0073"}$$

Maximum allowable working pressure, (at 338 °F) Appendix 1-1

$$P = \frac{S \cdot E \cdot t}{R_o - 0.40 \cdot t} - P_s = \frac{16,400 \cdot 1.00 \cdot (0.154 \cdot 0.875)}{1.1875 - 0.40 \cdot (0.154 \cdot 0.875)} - 0 = \underline{1,949.45} \text{ psi}$$

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

$$P = \frac{S \cdot E \cdot t}{R_o - 0.40 \cdot t} = \frac{16,700 \cdot 1.00 \cdot (0.154 \cdot 0.875)}{1.1875 - 0.40 \cdot (0.154 \cdot 0.875)} = \underline{1,985.11} \text{ psi}$$

External Pressure, (Corroded & at 338 °F) UG-28(c)

$$\frac{L}{D_o} = \frac{4.1765}{2.375} = 1.7585$$

$$\frac{D_o}{t} = \frac{2.375}{0.01} = 237.6133$$

From table G: $A = 0.000205$

From table HA-3: $B = 2,673.0379 \text{ psi}$

$$P_a = \frac{4 \cdot B}{3 \cdot (D_o/t)} = \frac{4 \cdot 2,673.04}{3 \cdot (2.375/0.01)} = 15 \text{ psi}$$

Design thickness for external pressure $P_a = 15 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.01 + 0 = \underline{0.01}''$$

Maximum Allowable External Pressure, (Corroded & at 338 °F) UG-28(c)

$$\frac{L}{D_o} = \frac{4.1765}{2.375} = 1.7585$$

$$\frac{D_o}{t} = \frac{2.375}{0.154 \cdot 0.875} = 17.6252$$

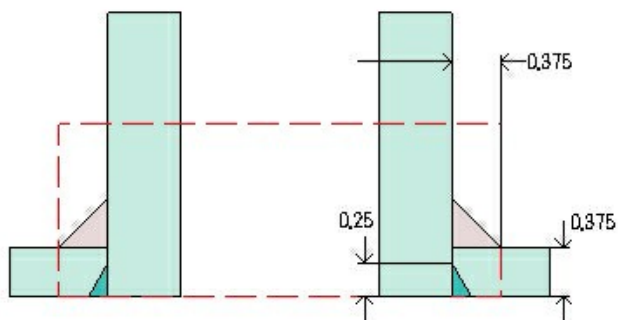
From table G: $A = 0.010339$

From table HA-3: $B = 9,030.3461 \text{ psi}$

$$P_a = \frac{4 \cdot B}{3 \cdot (D_o/t)} = \frac{4 \cdot 9,030.35}{3 \cdot (2.375/(0.154 \cdot 0.875))} = \underline{683.14} \text{ psi}$$

TEMPERATURE A (N11A)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	345°
Nozzle center/shell outer surface intersection to datum	23.5"
End of nozzle to shell center	35.1875"
Tilted	2° from radial
Passes through a Category A joint	No

Nozzle

Service	Thermocouple (T/C)
Access opening	No
Material specification	SB-462 Solution ann. Forgings N06022 (II-D p. 208, In. 40)
Inside diameter, new	1.5"
Nominal wall thickness	0.56"
Corrosion allowance	0"
Opening chord length	1.5009"
Projection available outside vessel, L _{pr}	3.0791"
Projection available outside vessel to flange face, L _f	3.7691"
Local vessel minimum thickness	0.375"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
-------------------	----------------

ASME B16.5-2013 Flange	
Description	NPS 1.5 Class 150 LWN B462 N06022
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, In. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	218.6 psi @ 338°F
MAP rating	290 psi @ 70°F
Hydrotest rating	450 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Notes	
Flange rated MDMT per UNF-65 = -325°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UNF-65 Material Toughness Requirements Nozzle	
Rated MDMT =	-325°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 = 100 psi @ 338 °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)							0.1345	0.56

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.25	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.4687	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.25	0.25	weld size is adequate

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

Reinforcement Calculations for MAWP

The attached ASME B16.5 flange limits the nozzle MAWP.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 218.6 psi @ 338 °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)							0.1776	0.56

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.25	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.4687	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.25	0.25	weld size is adequate

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

Reinforcement Calculations for MAP

The attached ASME B16.5 flange limits the nozzle MAP.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 290 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1776	0.56

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 338 °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)							0.0625	0.56

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.25	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.4687	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.25	0.25	weld size is adequate

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 63.87 psi @ 338 °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)							0.0859	0.56

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

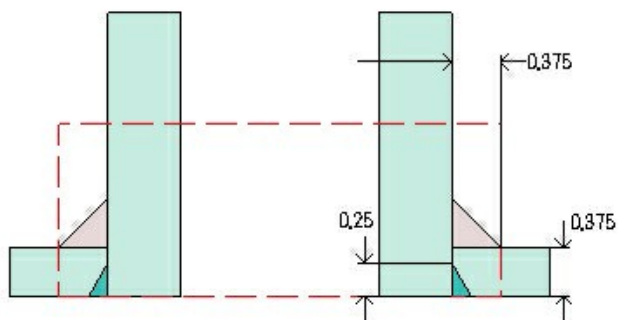
UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.25	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.4687	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.25	0.25	weld size is adequate

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

CODEWARE
EXAMPLE

TEMPERATURE B (N11B)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Cylinder #1
Orientation	345°
Nozzle center/shell outer surface intersection to datum	9.5"
End of nozzle to shell center	35.1875"
Tilted	2° from radial
Passes through a Category A joint	No

Nozzle

Service	Thermocouple (T/C)
Access opening	No
Material specification	SB-462 Solution ann. Forgings N06022 (II-D p. 208, In. 40)
Inside diameter, new	1.5"
Nominal wall thickness	0.56"
Corrosion allowance	0"
Opening chord length	1.5009"
Projection available outside vessel, L _{pr}	3.0791"
Projection available outside vessel to flange face, L _f	3.7691"
Local vessel minimum thickness	0.375"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
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ASME B16.5-2013 Flange	
Description	NPS 1.5 Class 150 LWN B462 N06022
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, In. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	218.6 psi @ 338°F
MAP rating	290 psi @ 70°F
Hydrotest rating	450 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Notes	
Flange rated MDMT per UNF-65 = -325°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UNF-65 Material Toughness Requirements Nozzle	
Rated MDMT =	-325°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 = 100 psi @ 338 °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)							0.1345	0.56

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.25	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.4687	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.25	0.25	weld size is adequate

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

Reinforcement Calculations for MAWP

The attached ASME B16.5 flange limits the nozzle MAWP.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 218.6 psi @ 338 °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)							0.1776	0.56

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.25	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.4687	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.25	0.25	weld size is adequate

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

Reinforcement Calculations for MAP

The attached ASME B16.5 flange limits the nozzle MAP.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 290 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1776	0.56

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 338 °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)							0.0625	0.56

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.25	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.4687	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.25	0.25	weld size is adequate

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 63.87 psi @ 338 °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)							0.0859	0.56

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.25	0.2625	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.4687	0.5125	weld size is adequate
Nozzle to shell groove (Lower)	0.25	0.25	weld size is adequate

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

CODEWARE
EXAMPLE

Straight Flange on Ellipsoidal Head #2

ASME Section VIII Division 1, 2019 Edition				
Component		Cylinder		
Material		SB-688 Sol. ann. > 3/16 N08367 (II-D p. 240, ln. 26)		
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		100	338	-20
External		15	338	
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Test horizontal		2.35	65.1826	1
Dimensions				
Inner Diameter		62"		
Length		1.5"		
Nominal Thickness		0.25"		
Corrosion	Inner	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)	Capacity (US gal)	
New		21.34	19.6	
Corroded		21.34	19.6	
Radiography				
Longitudinal seam		Seamless No RT		
Top Circumferential seam		Spot UW-11(b) Type 1		

Results Summary	
Governing condition	External pressure
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	0.1446"
Design thickness due to external pressure (t _e)	0.1779"
Design thickness due to combined loadings + corrosion	0.0721"
Maximum allowable working pressure (MAWP)	172.59 psi
Maximum allowable pressure (MAP)	184.87 psi
Maximum allowable external pressure (MAEP)	28.9 psi
Rated MDMT	-325 °F

UNF-65 Material Toughness Requirements	
Rated MDMT =	-325°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Design thickness, (at 338 °F) UG-27(c)(1)

$$t = \frac{P \cdot R}{S \cdot E - 0.60 \cdot P} + \text{Corrosion} = \frac{100 \cdot 31}{25,300 \cdot 0.85 - 0.60 \cdot 100} + 0 = \underline{0.1446"}$$

Maximum allowable working pressure, (at 338 °F) UG-27(c)(1)

$$P = \frac{S \cdot E \cdot t}{R + 0.60 \cdot t} - P_s = \frac{25,300 \cdot 0.85 \cdot 0.25}{31 + 0.60 \cdot 0.25} - 0 = 172.59 \text{ psi}$$

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

$$P = \frac{S \cdot E \cdot t}{R + 0.60 \cdot t} = \frac{27,100 \cdot 0.85 \cdot 0.25}{31 + 0.60 \cdot 0.25} = 184.87 \text{ psi}$$

External Pressure, (Corroded & at 338 °F) UG-28(c)

$$\frac{L}{D_o} = \frac{46.7083}{62.5} = 0.7473$$

$$\frac{D_o}{t} = \frac{62.5}{0.1779} = 351.2576$$

From table G: $A = 0.000282$

$$P_a = \frac{2 \cdot A \cdot E}{3 \cdot \left(\frac{D_o}{t}\right)} = \frac{2 \cdot 0.000282 \cdot 28034000}{3 \cdot \left(\frac{62.5}{0.1779}\right)} = 15 \text{ psi}$$

Design thickness for external pressure $P_a = 15$ psi

$$t_a = t + \text{Corrosion} = 0.1779 + 0 = 0.1779''$$

Maximum Allowable External Pressure, (Corroded & at 338 °F) UG-28(c)

$$\frac{L}{D_o} = \frac{46.7083}{62.5} = 0.7473$$

$$\frac{D_o}{t} = \frac{62.5}{0.25} = 250.0000$$

From table G: $A = 0.000454$

From table NFN-12: $B = 5,418.2556 \text{ psi}$

$$P_a = \frac{4 \cdot B}{3 \cdot (D_o/t)} = \frac{4 \cdot 5,418.26}{3 \cdot (62.5/0.25)} = 28.9 \text{ psi}$$

% Forming strain - UNF-79(a)(2)

$$EFE = \left(\frac{50 \cdot t}{R_f}\right) \cdot \left(1 - \frac{R_f}{R_o}\right) = \left(\frac{50 \cdot 0.25}{31.125}\right) \cdot \left(1 - \frac{31.125}{\infty}\right) = 0.4016 \%$$

Thickness Required Due to Pressure + External Loads								
Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S _t	S _c					
Operating, Hot & Corroded	100	25,300	8,619	338	0	Weight	0.0721	0.0721
Operating, Hot & New	100	25,300	8,619	338	0	Weight	0.0721	0.0721
Hot Shut Down, Corroded	0	25,300	8,619	338	0	Weight	0.0001	0.0001
Hot Shut Down, New	0	25,300	8,619	338	0	Weight	0.0001	0.0001
Empty, Corroded	0	27,100	9,697	70	0	Weight	0.0001	0.0001
Empty, New	0	27,100	9,697	70	0	Weight	0.0001	0.0001
Vacuum	-15	25,300	8,619	338	0	Weight	0.0268	0.0268
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0	25,300	8,619	338	0	Weight	0.0001	0.0001

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EXAMPLE

Ellipsoidal Head #2

ASME Section VIII Division 1, 2019 Edition				
Component		Ellipsoidal Head		
Material		SB-688 Sol. ann. > 3/16 N08367 (II-D p. 240, ln. 26)		
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		100	338	-20
External		15	338	
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Test horizontal		2.35	65.1826	1
Dimensions				
Inner Diameter		62"		
Head Ratio		2		
Minimum Thickness		0.1875"		
Corrosion	Inner	0"		
	Outer	0"		
Length L_{sf}		1.5"		
Nominal Thickness t_{sf}		0.25"		
Weight and Capacity				
		Weight (lb)¹	Capacity (US gal)¹	
New		262.94	154.66	
Corroded		262.94	154.66	
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	external pressure
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	0.1443"
Design thickness due to external pressure (t _e)	0.1633"
Maximum allowable working pressure (MAWP)	129.99 psi
Maximum allowable pressure (MAP)	139.24 psi
Maximum allowable external pressure (MAEP)	18.56 psi
Straight Flange governs MDMT	-325°F

Design thickness for internal pressure, (Corroded at 338 °F) UG-32(c)(1)

$$t = \frac{P \cdot D}{2 \cdot S \cdot E - 0.2 \cdot P} + \text{Corrosion} = \frac{100 \cdot 62}{2 \cdot 25,300 \cdot 0.85 - 0.2 \cdot 100} + 0 = \underline{0.1442"}$$

Maximum allowable working pressure, (Corroded at 338 °F) UG-32(c)(1)

$$P = \frac{2 \cdot S \cdot E \cdot t}{D + 0.2 \cdot t} - P_s = \frac{2 \cdot 25,300 \cdot 0.85 \cdot 0.1875}{62 + 0.2 \cdot 0.1875} - 0 = \underline{129.99} \text{ psi}$$

Maximum allowable pressure, (New at 70 °F) UG-32(c)(1)

$$P = \frac{2 \cdot S \cdot E \cdot t}{D + 0.2 \cdot t} - P_s = \frac{2 \cdot 27,100 \cdot 0.85 \cdot 0.1875}{62 + 0.2 \cdot 0.1875} - 0 = 139.24 \text{ psi}$$

Design thickness for external pressure, (Corroded at 338 °F) UG-33(d)

Equivalent outside spherical radius

$$R_o = K_o \cdot D_o = 0.8946 \cdot 62.375 = 55.802 \text{ in}$$

$$A = \frac{0.125}{R_o / t} = \frac{0.125}{55.802 / 0.163273} = 0.000366$$

A falls to left of chart

$$P_a = \frac{0.0625 \cdot E}{(R_o / t)^2} = \frac{0.0625 \cdot 2.8034E+07}{(55.802 / 0.1633)^2} = 15 \text{ psi}$$

$$t = 0.1633'' + \text{Corrosion} = 0.1633'' + 0'' = 0.1633''$$

Check the external pressure per UG-33(a)(1) UG-32(c)(1)

$$t = \frac{1.67 \cdot P_e \cdot D}{2 \cdot S \cdot E - 0.2 \cdot 1.67 \cdot P_e} + \text{Corrosion} = \frac{1.67 \cdot 15 \cdot 62}{2 \cdot 25,300 \cdot 1 - 0.2 \cdot 1.67 \cdot 15} + 0 = 0.0307''$$

The head external pressure design thickness (t_e) is 0.1633''.**Maximum Allowable External Pressure, (Corroded at 338 °F) UG-33(d)**

Equivalent outside spherical radius

$$R_o = K_o \cdot D_o = 0.8946 \cdot 62.375 = 55.802 \text{ in}$$

$$A = \frac{0.125}{R_o / t} = \frac{0.125}{55.802 / 0.1875} = 0.00042$$

From Table NFN-12: B = 5,523.4179 psi

$$P_a = \frac{B}{R_o / t} = \frac{5,523.4179}{55.802 / 0.1875} = 18.5592 \text{ psi}$$

Check the Maximum External Pressure, UG-33(a)(1) UG-32(c)(1)

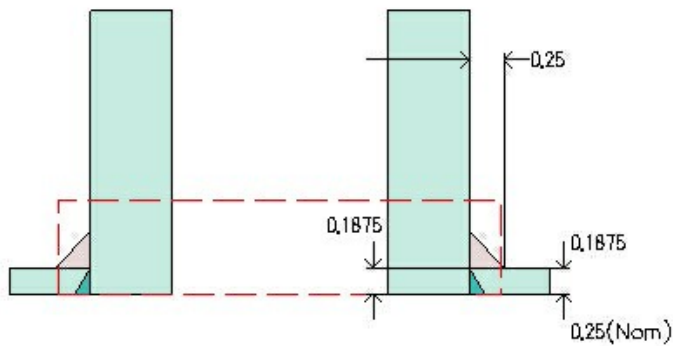
$$P = \frac{2 \cdot S \cdot E \cdot t}{(D + 0.2 \cdot t) \cdot 1.67} = \frac{2 \cdot 25,300 \cdot 1 \cdot 0.1875}{(62 + 0.2 \cdot 0.1875) \cdot 1.67} = 91.58 \text{ psi}$$

The maximum allowable external pressure (MAEP) is 18.56 psi.**% Forming strain - UNF-79(a)(2)**

$$EFE = \left(\frac{75 \cdot t}{R_f} \right) \cdot \left(1 - \frac{R_f}{R_o} \right) = \left(\frac{75 \cdot 0.25}{10.665} \right) \cdot \left(1 - \frac{10.665}{\infty} \right) = 1.7581 \%$$

LEVEL B (N10B)

ASME Section VIII Division 1, 2019 Edition



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

Location and Orientation

Located on	Ellipsoidal Head #2
Orientation	345°
Nozzle center line offset to datum line	-1.5"
Calculated as hillside	Yes (perpendicular)
Distance to head center, R	34.1875"
Passes through a Category A joint	No

Nozzle

Service	Level Indicator (LEVEL)
Access opening	No
Material specification	SB-462 Solution ann. Forgings N06022 (II-D p. 208, In. 40)
Inside diameter, new	1.5"
Nominal wall thickness	0.56"
Corrosion allowance	0"
Opening chord length	1.5277"
Projection available outside vessel, L _{pr}	2.3123"
Projection available outside vessel to flange face, L _f	3.0023"
Local vessel minimum thickness	0.1875"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
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ASME B16.5-2013 Flange	
Description	NPS 1.5 Class 150 LWN B462 N06022
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 398, In. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	218.6 psi @ 338°F
MAP rating	290 psi @ 70°F
Hydrotest rating	450 psi @ 70°F
PWHT performed	No
Produced to Fine Grain Practice and Supplied in Heat Treated Condition	No
Impact Tested	No
Notes	
Flange rated MDMT per UNF-65 = -325°F Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UNF-65 Material Toughness Requirements Nozzle	
Rated MDMT =	-325°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 = 100 psi @ 338 °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)							0.1226	0.56

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	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 = 152.93 psi @ 338 °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)							0.1776	0.56

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 163.81 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1776	0.56

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 15 psi @ 338 °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)							0.0625	0.56

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

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P _e = 18.56 psi @ 338 °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)							0.0625	0.56

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

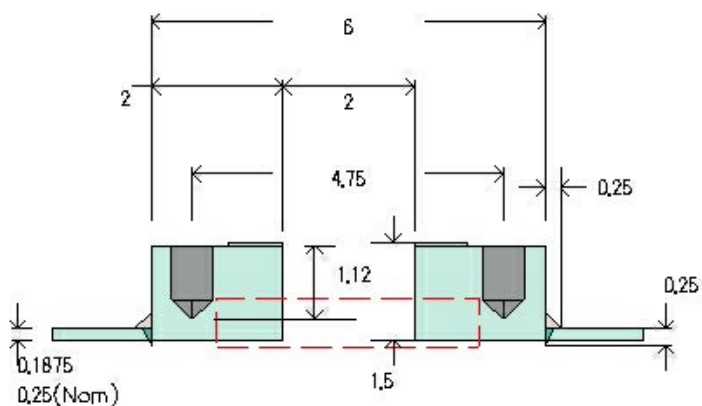
UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.175	0.175	weld size is adequate
Combined weld check (t ₁ + t ₂)	0.3125	0.3625	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

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

CODEWARE
EXAMPLE

OUTLET (N12)

ASME Section VIII Division 1, 2019 Edition



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

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

Location and Orientation

Located on	Ellipsoidal Head #2
Orientation	0°
End of nozzle to datum line	-16.9273"
Calculated as hillside	No
Distance to head center, R	0"
Passes through a Category A joint	No
Nozzle	
Service	Outlet (OUTLET)
Description	Studding Outlet NPS 2 Class 150 Contoured
Access opening	No
Material specification	SB-462 Solution ann. Forgings N06022 (II-D p. 208, In. 40)
Bolt material specification	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 398, In. 32)
Bolt rated MDMT	-55°F
Pad inner diameter	2"
Pad outer diameter, D _p	6"
Pad thickness	1.5"
Figure UG-40 thickness, t _e	1.2525"
Tapped hole diameter	0.625"
Tapped hole depth	1.12"
Tapped hole bolt circle	4.75"
Raised face height	0.06"
Raised face outer diameter	3.62"
Corrosion allowance	0"
Projection available outside vessel, L _{pr}	1.2525"
Local vessel minimum thickness	0.1875"
Liquid static head included	0 psi

Welds

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

Radiography

Longitudinal seam	Seamless No RT
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UNF-65 Material Toughness Requirements Pad	
Rated MDMT =	-325°F
Bolts rated MDMT per Fig UCS-66 note (c) =	-55°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 = 100 psi @ 338 °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)							0.1226	2

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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Pad to shell fillet (Leg 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 = 169.91 psi @ 338 °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)							0.2083	2

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

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

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

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 182 psi @ 70 °F							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2083	2

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

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

Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 15 psi @ 338 °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)							0.0625	2

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

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

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

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For Pe = 18.56 psi @ 338 °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)							0.0625	2

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

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

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