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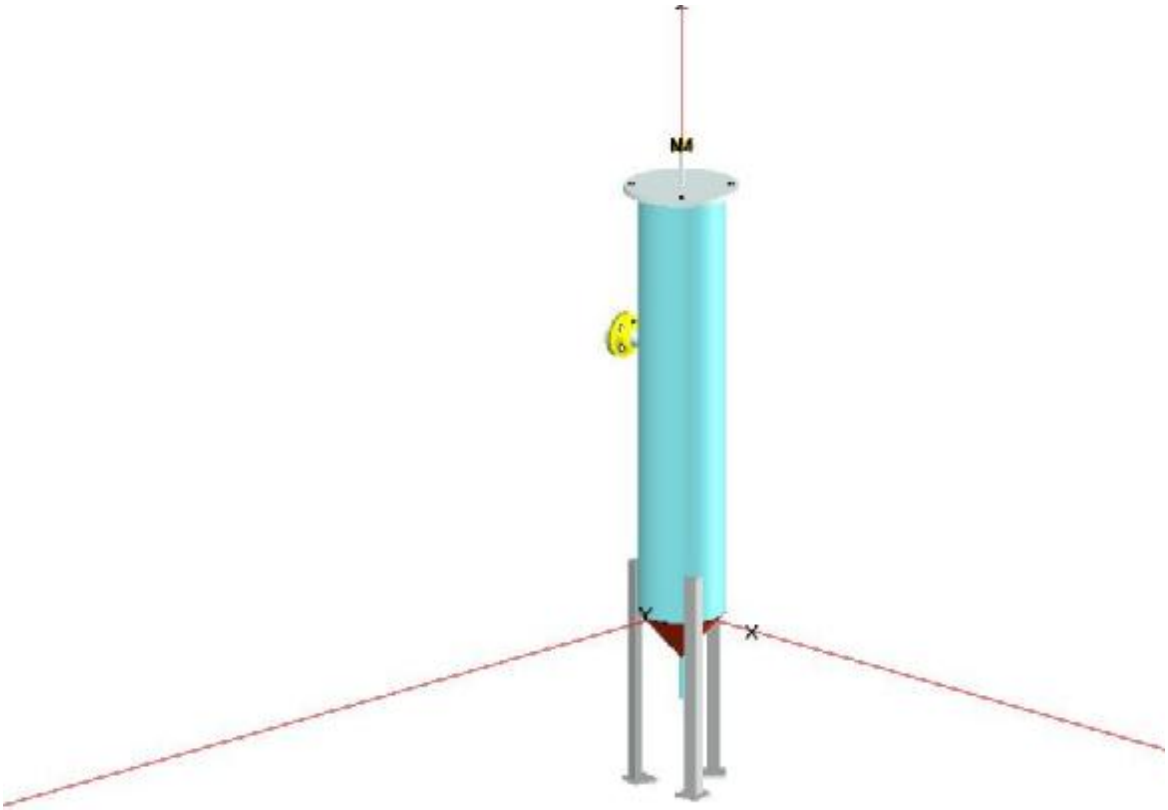

COMPRESS Pressure Vessel Design Calculations

Vessel No: V-03
Customer: FIUBA
Contract:
Designer: HRI/SEG
Date: lunes, agosto 09, 2004

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Deficiencies Summary

No deficiencies found.

Nozzle Schedule

Nozzle mark	Service	Size	Materials								
			Nozzle	Impact	Norm	Fine Grain	Pad	Impact	Norm	Fine Grain	Flange
N4	VENT	0,500" Sch 40S (Std) DN 15	SA-312 TP304 Wld pipe	No	No	No	N/A	N/A	N/A	N/A	SW A182 F304 150#
N5	U.C.	2" Sch 10S DN 50	SA-312 TP304 Wld pipe	No	No	No	N/A	N/A	N/A	N/A	WN A182 F304 150#

Nozzle Summary

Nozzle mark	OD (mm)	t_n (mm)	Req t_n (mm)	A_1?	A_2?	Shell			Reinforcement Pad		Corr (mm)	A_a/A_r (%)
						Nom t (mm)	Design t (mm)	User t (mm)	Width (mm)	t_{pad} (mm)		
N4	21,34	2,77	2,42	Yes	Yes	9,00*	N/A		N/A	N/A	0,00	Exempt
N5	60,32	2,77	2,60	Yes	Yes	9,52	N/A		N/A	N/A	0,00	Exempt

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

* Head minimum thickness after forming

Pressure Summary

Pressure Summary for Chamber bounded by Bolted Cover #1 and Bolted Cover #1

Identifier	P Design (kg/cm²)	T Design (°C)	MAWP (kg/cm²)	MAP (kg/cm²)	MDMT Rating		Corrosion Allowance (mm)	Impact Test
					MDMT (°C)	Exemption		
Bolted Cover #1	2,0	80,0	2,41	2,41	-48,3	Note 1	0,00	No
Cylinder #1	2,0	80,0	53,36	53,36	0,0	Note 2	0,00	No
Transition #1	2,0	80,0	21,88	21,88	0,0	Note 3, 4	0,00	No
Cylinder #2	2,0	80,0	157,75	157,75	-195,6	Note 5	0,00	No
Flange #1	2,0	80,0	5,94	5,94	0,0	Note 6	0,00	No
Legs #1	2,0	80,0	2,00	N/A	N/A	N/A	N/A	N/A
VENT (N4)	2,0	80,0	2,41	2,41	0,0	Note 7	0,00	No
U.C. (N5)	2,0	80,0	16,93	19,33	0,0	Note 8	0,00	No

Chamber design MDMT is 0,00°C
Chamber rated MDMT is 0,00°C
Chamber MAWP was used in the MDMT determination

Chamber MAWP hot & corroded is 2,00 kg/cm^2 @ 80,0°C

Chamber MAP cold & new is 2,41 kg/cm^2 @ 21,1°C

This pressure chamber is not designed for external pressure.

Notes for MDMT Rating:

Note #	Exemption	Details
1.	Bolted cover is impact test exempt per UCS-66(d) Fig UCS-66.1 MDMT reduction = 9,5 °C, (coincident ratio = 0,828649)	UCS-66 governing thickness = 8,858268E-02 in (2,25 mm).
2.	Impact test exempt per UHA-51(g)(coincident ratio = 0,0325)	
3.	Not a UCS-66 material.	
4.	Impact test exempt per UHA-51(g)(coincident ratio = 0,07068)	
5.	Impact test exempt per UHA-51(d)	
6.	Impact test exempt per UHA-51(g)(coincident ratio = 0,33653)	
7.	Impact test exempt per UHA-51(g)(coincident ratio = 0,00478)	
8.	Impact test exempt per UHA-51(g)(coincident ratio = 0,01657)	

Design notes are available on the Settings Summary page.

Revision History

No.	Date	Operator	Notes
0	10/30/2004	aep0130	New vessel created ASME Division 1 [Build 6231]

Settings Summary

COMPRESS Build 6231

Units: MKS

Datum Line Location: 304,00 mm from bottom seam

Design

ASME Section VIII Division 1, 2001 Edition, A03 Addenda

Design or Rating:	Get Thickness from Pressure
Minimum thickness:	1/16" per UG-16(b)
Design for cold shut down only:	No
Design for lethal service (full radiography required):	No
Design nozzles for:	Design P, find nozzle MAWP and MAP
Corrosion weight loss:	100% of theoretical loss
UG-23 Stress Increase:	1,20
Skirt/legs stress increase:	1,3
Minimum nozzle projection:	0,99 mm
Juncture calculations for $\alpha > 30$ only:	Yes
Preheat P-No 1 Materials > 1,25" and <= 1,50" thick:	No

Pipe under-tolerance is not applied to nozzle wall thicknesses.
Butt welds are tapered per Figure UCS-66.3(a).

Hydro/Pneumatic Test

Shop Hydrotest Pressure:	1,3 times vessel MAWP
Test liquid specific gravity:	1,00
Maximum stress during test:	90% of yield

Code Interpretations

Apply interpretation VIII-1-83-66:	Yes
Apply interpretation VIII-1-86-175:	Yes
Apply interpretation VIII-1-83-115:	Yes
Apply interpretation VIII-1-01-37:	Yes
Disallow UG-20(f) exemptions:	No

UG-22 Loadings

UG-22 (a) Internal or External Design Pressure :	Yes
UG-22 (b) Weight of the vessel and normal contents under operating or test conditions:	Yes
UG-22 (c) Superimposed static reactions from weight of attached equipment (external loads):	No
UG-22 (d)(2) Vessel supports such as lugs, rings, skirts, saddles and legs:	Yes
UG-22 (f) Wind reactions:	No
UG-22 (f) Seismic reactions:	No

Note: UG-22 (b),(c) and (f) loads only considered when supports are present.

Thickness Summary

Component Identifier	Material	Diameter (mm)	Length (mm)	Nominal t (mm)	Design t (mm)	Joint E	Load
Bolted Cover #1	SA-516 70	431,00 OD	9,00	9,00*	8,19	1,0000	Internal
Cylinder #1	SA-312 TP304 Wld pipe	323,85 OD	1460,00	9,52	0,32	0,8500	Internal
Transition #1	SA-240 304	21,34/323,85 OD	154,00	5,00	0,46	0,7000	Internal
Cylinder #2	SA-312 TP304L Wld pipe	21,34 OD	150,00	2,11	0,03	0,8500	Internal

Nominal t: Vessel wall nominal thickness
Design t: Required vessel thickness due to governing loading + corrosion
Joint E: Longitudinal seam joint efficiency
* Head minimum thickness after forming

Load
internal: Circumferential stress due to internal pressure governs
external: External pressure governs
Wind: Combined longitudinal stress of pressure + weight + wind governs
Seismic: Combined longitudinal stress of pressure + weight + seismic governs

Weight Summary

Component	Weight (kg) Contributed by Vessel Elements						
	Metal New*	Metal Corroded*	Insulation & Supports	Lining	Piping + Liquid	Operating Liquid	Test Liquid
Bolted Cover #1	10,26	10,26	0,00	0,00	0,00	0,00	0,03
Cylinder #1	109,96	109,96	0,00	0,00	0,00	0,00	107,34
Transition #1	4,51	4,51	0,00	0,00	0,00	0,00	3,96
Cylinder #2	0,15	0,15	0,00	0,00	0,00	0,00	0,03
Legs #1	17,97	17,97	0,00	0,00	0,00	0,00	0,00
TOTAL:	**142,85**	**142,85**	**0,00**	**0,00**	**0,00**	**0,00**	**111,36**

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

Component	Weight (kg) Contributed by Attachments						
	Body Flanges (new)	Nozzles & Flanges (new)	Packed Beds	Ladders & Platforms	Trays & Supports	Rings & Clips	Vertical Loads
Bolted Cover #1	0,00	0,64	0,00	0,00	0,00	0,00	0,00
Cylinder #1	5,85	5,83	0,00	0,00	0,00	0,00	0,00
Transition #1	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Cylinder #2	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Legs #1	0,00	0,00	0,00	0,00	0,00	0,00	0,00
TOTAL:	**5,85**	**6,48**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**

Vessel operating weight, Corroded: 155 kg
Vessel empty weight, Corroded: 155 kg
Vessel empty weight, New: 155 kg
Vessel test weight, New: 267 kg

Vessel center of gravity location (from datum)

Vessel Lift Weight, New: 155 kg
Center of Gravity: 682,90 mm

Vessel Capacity

Vessel Capacity** (New): 111 liters
Vessel Capacity** (Corroded): 111 liters
**The vessel capacity does not include volume of nozzle, piping or other attachments.

Hydrostatic Test

Shop test pressure determination for Chamber bounded by Bolted Cover #1 and Bolted Cover #1 based on MAWP per UG-99(b)

Shop hydrostatic test gauge pressure is 2,60 kg/cm^2 at 21,11 °C (the chamber MAWP = 2,00 kg/cm^2)

The shop test is performed with the vessel in the horizontal position.

Identifier	Local test pressure kg/cm^2	Test liquid static head kg/cm^2	UG-99 stress ratio	UG-99 pressure factor	Stress during test kg/cm^2	Allowable test stress kg/cm^2	Stress excessive?
Cylinder #1 (1)	2,63	0,03	1,0000	1,30	49,435	1.898,286	No
Transition #1	2,63	0,03	1,0000	1,30	114,258	1.898,286	No
Cylinder #2	2,62	0,02	1,0000	1,30	13,396	1.581,905	No
Bolted Cover #1	2,63	0,03	1,0000	1,30	1.532,643	3.606,744	No
Flange #1	2,63	0,03	1,0000	1,30	711,973	2.847,429	No
U.C. (N5)	2,65	0,05	1,0000	1,30	82,671	2.847,429	No
VENT (N4)	2,62	0,02	1,0000	1,30	NI	NI	NI

Notes:
(1) Cylinder #1 limits the UG-99 stress ratio.
(2) P_L stresses at nozzle openings have been estimated using the method described in PVP-Vol. 399, pages 77-82.
(3) NI indicates that test stress was not investigated.
(4) VIII-2, AD-151.1(b) used as the basis for nozzle allowable test stress.

The field test condition has not been investigated.

The test temperature of 21,11 °C is warmer than the minimum recommended temperature of -31,67 °C so the brittle fracture provision of UG-99(h) has been met.

Bolted Cover #1

ASME Section VIII Division 1, 2001 Edition, A03 Addenda

Component: Bolted Cover
Material specification: SA-516 70 (ASME II-D p. 14, ln. 31)
Bolted cover is impact test exempt per UCS-66(d)
Fig UCS-66.1 MDMT reduction = 9,5 °C, (coincident ratio = 0,828649)
UCS-66 governing thickness = 8,858268E-02 in (2,25 mm).

Internal design pressure: P = 2,0000 kg/cm^2 @ 80,00°C

Static liquid head:

P_{th}=0,0155 kg/cm^2(SG=1,0000, H_s=154,92 mm, Horizontal test head)

Corrosion allowance: Inner C = 0,00 mm Outer C = 0,00 mm

Design MDMT = 0,00°C
Rated MDMT = -48,33°C

No impact test performed
Material is not normalized
Material is not produced to Fine Grain Practice
PWHT is not performed

Radiography: Category A joints - Seamless No RT

Estimated weight: New = 10,3 kg corr = 10,3 kg

Head outside diameter = 431,00 mm
Cover thickness = 9,00 mm

Design thickness, (at 80,00 °C) UG-34 (c)(2), flange operating

$t = d*Sqr(C*P/(S*E) + 1,9*W*h_G/(S*E*d^3)) + Corrosion$
$= 13,77953*Sqr(0,3*28,44669/(20.000,00*1) + 1,9*4.240,041*0,7874017/(20.000,00*1*13,77953^3)) + 0$
= 0,3225 in (8,19 mm)

Design thickness, (at 21,11 °C) UG-34 (c)(2), gasket seating

$t = d*Sqr(1,9*W*h_G/(S*E*d^3)) + Corrosion$
$= 13,77953*Sqr(1,9*8.420,021*0,7874017/(20.000,00*1*13,77953^3)) + 0$
= 0,2138 in (5,43 mm)

Maximum allowable working pressure, (at 80,00 °C)

$P = (S*E/C)*((t/d)^2 - (1,9*W*h_G/(S*E*d^3))) - P_s$
$= (20.000,00*1/0,3)*((0,3543307/13,77953)^2 - (1,9*5.116,812*0,7874017/(20.000,00*1*13,77953^3))) - 0$
= 34,329 psi (2,41 kg/cm^2)

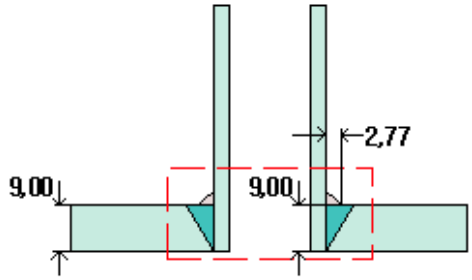
Maximum allowable pressure, (At 21,11 °C)

$P = (S*E/C)*((t/d)^2 - (1,9*W*h_G/(S*E*d^3)))$
$= (20.000,00*1/0,3)*((0,3543307/13,77953)^2 - (1,9*5.116,812*0,7874017/(20.000,00*1*13,77953^3)))$
= 34,329 psi (2,41 kg/cm^2)

VENT (N4)

ASME Section VIII Division 1, 2001 Edition, A03 Addenda

$t_{w(lower)}$ = 9,00 mm
Leg_{41} = 2,77 mm



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

Located on:	Bolted Cover #1
Liquid static head included:	0 psi (0,00 kg/cm^2)
Nozzle material specification:	SA-312 TP304 Wld pipe (ASME II-D p. 86, ln. 29)
Nozzle description:	0,500" Sch 40S (Std) DN 15
Flange description:	0,5 inch 150# SW A182 F304
Bolt Material:	SA-193 B7 Bolt <= 2 1/2
Flange rated MDMT: (Per UHA-51(d)(1)(a))	-320,00 °F (-195,56°C)
Liquid static head on flange:	0 psi (0,00 kg/cm^2)
ASME B16.5 flange rating MAWP:	240,80 psi @ 176,00°F (16,93 kg/cm^2 @ 80,00°C)
ASME B16.5 flange rating MAP:	275,00 psi @ 70,00°F (19,33 kg/cm^2 @ 21,11°C)
ASME B16.5 flange hydro test:	425,00 psi @ 70,00°F (29,88 kg/cm^2 @ 21,11°C)
Nozzle orientation:	0 °
Local vessel minimum thickness:	0,3543 in (9,00 mm)
Nozzle inside diameter, new:	0,6220 in (15,80 mm)
Nozzle nominal wall thickness:	0,1090 in (2,77 mm)
Nozzle corrosion allowance:	0,0000 in (0,00 mm)
Projection available outside vessel, Lpr:	5,5512 in (141,00 mm)
Distance to head center, R:	0,0000 in (0,00 mm)

Reinforcement Calculations for Internal Pressure

The vessel wall thickness governs the MAWP of this nozzle.

UG-39 Area Calculation Summary (cm^2) For P = 2,41 kg/cm^2 @ 80,00 °C							**UG-45 Nozzle Wall Thickness Summary (mm)** 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)							2,42	2,77

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

UW-16 Weld Sizing Summary			
	Required weld	**Actual weld**	

Weld description	throat size (mm)	throat size (mm)	Status
Nozzle to shell fillet (Leg_{41})	1,94	1,94	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-39 Area Calculation Summary (cm^2) For P = 2,41 kg/cm² @ 21,11 °C							UG-45 Nozzle Wall Thickness Summary (mm) 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)							2,42	2,77

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 (mm)	Actual weld throat size (mm)	Status
Nozzle to shell fillet (Leg_{41})	1,94	1,94	weld size is adequate

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

Cylinder #1

ASME Section VIII Division 1, 2001 Edition, A03 Addenda

Component:	Cylinder
Material specification:	SA-312 TP304 Wld pipe (ASME II-D p. 86, ln. 29)
Pipe NPS and Schedule:	12" Sch 40S (Std) DN 300

Impact test exempt per UHA-51(g)(coincident ratio = 0,0325)

Internal design pressure: P = 2 kg/cm^2 @ 80°C

Static liquid head:

P_{th}=0,0307 kg/cm^2(SG=1,0000, H_s=307,32 mm, Horizontal test head)

Corrosion allowance: Inner C = 0,00 mm Outer C = 0,00 mm

Design MDMT = 0,00°C
Rated MDMT = 0,00°C

No impact test performed
Material is not normalized
Material is not produced to Fine Grain Practice
PWHT is not performed

Radiography:	Longitudinal joint -	Seamless No RT
	Top circumferential joint -	N/A
	Bottom circumferential joint -	None UW-11(c) Type 1

Estimated weight: New = 110,1763 kg corr = 110,1763 kg
Capacity: New = 106,5372 liters corr = 106,5372 liters

OD = 323,85 mm
Length L_c = 1460,00 mm
t = 9,52 mm

Design thickness, (at 80,00°C) Appendix 1-1

t = $P*R_o/(S*E + 0,40*P)$ + Corrosion
= 2,0000*161,93/(1195,2190*0,85 + 0,40*2,0000) + 0,00
= 0,3200 mm

Maximum allowable working pressure, (at 80,00°C) Appendix 1-1

P = $S*E*t/(R_o - 0,40*t) - P_s$
= 1195,2190*0,85*8,3300 / (161,93 - 0,40*8,3300) - 0,0000
= 53,3614 kg/cm^2

Maximum allowable pressure, (at 21,11°C) Appendix 1-1

P = $S*E*t/(R_o - 0,40*t)$
= 1195,2190*0,85*8,3300 / (161,93 - 0,40*8,3300)
= 53,3614 kg/cm^2

Design thickness = 0,32 mm

The governing condition is due to internal pressure.

The cylinder thickness of 9,52 mm is adequate.

Thickness Required Due to Pressure + External Loads

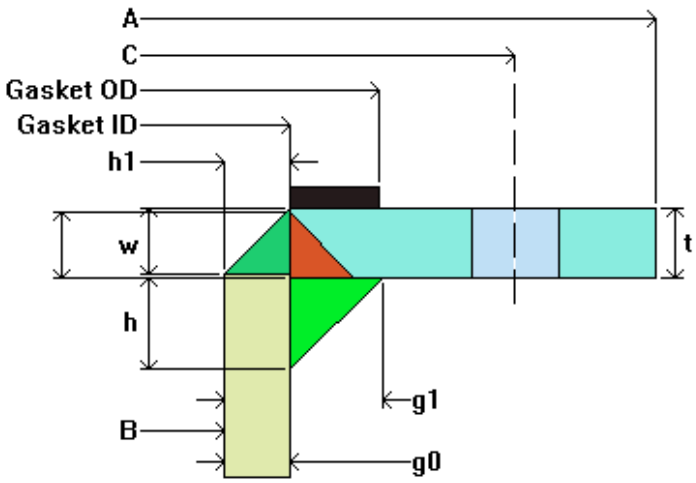
Condition	Pressure P (kg/cm²)	Allowable Stress Before UG-23 Stress Increase (kg/cm²)		Temperature (°C)	Corrosion C (mm)	Location	Load	Req'd Thk Due to Tension (mm)	Req'd Thk Due to Compression (mm)
		S_t	S_c						
Operating, Hot & Corroded	2,00	1406,14	880,96	80,00	0,0000	top	Weight	0,1006	0,0973
						Bottom	Weight	0,0989	0,0989
Operating, Hot & New	2,00	1406,14	880,96	80,00	0,0000	top	Weight	0,1006	0,0973
						Bottom	Weight	0,0989	0,0989
Hot Shut Down, Corroded	0,00	1406,14	880,96	80,00	0,0000	top	Weight	0,0124	0,0177
						Bottom	Weight	0,0150	0,0150
Hot Shut Down, New	0,00	1406,14	880,96	80,00	0,0000	top	Weight	0,0124	0,0177
						Bottom	Weight	0,0150	0,0150
Empty, Corroded	0,00	1406,14	944,23	-17,78	0,0000	top	Weight	0,0116	0,0165
						Bottom	Weight	0,0140	0,0140
Empty, New	0,00	1406,14	944,23	-17,78	0,0000	top	Weight	0,0116	0,0165
						Bottom	Weight	0,0140	0,0140
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0,00	1406,14	880,96	80,00	0,0000	top	Weight	0,0017	0,0026
						Bottom	Weight	0,0000	0,0000

Flange #1

ASME VIII-1, 2001 Edition, A03 Addenda, Appendix 2 Flange Calculations

Flange is attached to:	Cylinder #1 (Top)	
Flange material specification:	SA-240 304 (ASME II-D p. 86, ln. 16)	
Bolt material specification:	SA-193 B7 Bolt <= 2 1/2 (ASME II-D p. 382, ln. 37)	
Internal design pressure, P:	28,44669 psi @ 176 °F	(2,00 kg/cm^2 @ 80,00 °C)
Required flange thickness: t_r=	9,52 mm	
Maximum allowable working pressure, MAWP:	84,52965 psi @ 176 °F	(5,94 kg/cm^2 @ 80,00 °C) (bolting limits)
Maximum allowable pressure, MAP:	84,52965 psi @ 70 °F	(5,94 kg/cm^2 @ 21,11 °C)
Corrosion allowance:	Bore = 0,00 mm	Flange = 0,00 mm
Bolt corrosion (root), C_{bolt}:	0,00 mm	
Design MDMT:	0,00 °C	No impact test performed
Rated MDMT:	0,00 °C	Flange material is not normalized
		PWHT is not performed
Estimated weight:	New = 5,851342 kg	corroded = 5,851342 kg

Flange dimensions, new



flange OD	A	= 431,00 mm
bolt circle	C	= 390,00 mm
gasket OD		= 350,00 mm
gasket ID		= 323,85 mm
flange ID	B	= 304,81 mm
thickness	t	= 10,00 mm
bolting		4- 0,5 in dia
hub thickness	g_1	= 23,12 mm
hub thickness	g_0	= 9,52 mm
lower fillet weld	h	= 13,60 mm
upper fillet weld	h1	= 9,52 mm
length	e	= 9,52 mm
fillet weld	w	= 9,52 mm
gasket factor	m	= 0
seating stress	y	= 0 kg/cm^2

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

Longitudinal bending moment on flange

$P_m = 16*M_b/(\pi*G^3)$
$= 16*0/(\pi*13{,}77953^3)$
$= 0{,}0000$ psi (0,00 kg/cm^2)

Axial load on flange

$P_r = -4*F/(\pi*G^2)$

= -4*24,09709/(π*13,77953^2)
= -0,1616 psi (-0,01 kg/cm^2)

Total design load on flange (used for H - ref. III-1 NC-3658.1)

= P + P_s + P_m + P_r
= 28,44669 + 0 + 0 + -0,1616
= 28,4467 psi (2,00 kg/cm^2)

Negative values of P_m + P_r are conservatively ignored.

The static head of liquid has not been included in the total design load because the vessel is supported below the flange.

Gasket details from facing sketch 1(a) or (b)

Gasket width N = 13,08 mm

b_0 = N/2 = 0,2573819 in (6,54 mm)

Effective gasket seating width, b = 0,5*$b_0^{1/2}$ = 0,2537 in (6,44 mm)

G = OD of contact face = 13,77953 in (per VIII-1, Appendix 2-5 (c)3(a) for self energizing gaskets) (350,00 mm)

h_G = (C - G)/2 = (15,35433 - 13,77953)/2 = 0,7874017 in (20,00 mm)

h_D = R + g_1/2 = 0,7667323 + 0,9102362/2 = 1,22185 in (31,04 mm)

h_T = (R + g_1 + h_G)/2 = (0,7667323 + 0,9102362 + 0,7874017)/2 = 1,232185 in (31,30 mm)

H_p = 0 per VIII-1, Appendix 2-5 (c)3(a) for self energizing gaskets.

H = 0,785*G^2*P
= 0,785*13,77953^2*28,44669
= 4.240,0400 lb (1.923,25 kg$_f$)

H_D = 0,785*B^2*P
= 0,785*12,00039^2*28,44669
= 3.215,8245 lb (1.458,673 kg$_f$)

H_T = H - H_D
= 4.240,04 - 3.215,824
= 1.024,2156 lb (464,5764 kg$_f$)

W_{m1} = H + H_p
= 4.240,04 + 0
= 4.240,0400 lb (1.923,25 kg$_f$)

W_{m2} = 3,14*b*G*y
= 3,14*0,2537*13,77953*0
= 0,0000 lb (0 kg$_f$)

Required bolt area, A_m = greater of A_{m1}, A_{m2} = 1,094202 cm^2

A_{m1} = W_{m1}/S_b = 4.240,04/25.000,00 = 0,1696016 in^2 (1,094202 cm^2)

A_{m2} = W_{m2}/S_a = 0/25.000,00 = 0 in^2 (0 cm^2)

Total area for 4- 0,5 in dia bolts, corroded, A_b = 0,504 in^2

W = (A_m + A_b)*S_a/2
= (0,1696016 + 0,504)*25.000,00/2
= 8.420,0205 lb (3.819,257 kg$_f$)

$M_D = H_D * h_D = 3.215,824 * 1,22185 = 3.929,256$ lb-in (45,26975 kg-m)
$M_T = H_T * h_T = 1.024,216 * 1,232185 = 1.262,023$ lb-in (14,54002 kg-m)

$H_G = W_{m1} - H = 4.240,04 - 4.240,04 = 0$ lb (0 kg_f)

$M_G = H_G * h_G = 0 * 0,7874017 = 0$ lb-in (0 kg-m)

$M_o = M_D + M_T + M_G = 3.929,256 + 1.262,023 + 0 = 5.191,28$ lb-in (59,80977 kg-m)

$M_g = W * h_G = 8.420,021 * 0,7874017 = 6.629,938$ lb-in (76,38484 kg-m)

Hub and Flange Factors

$h_0 = (B*g_0)^{1/2} = (12,00039*0,3748032)^{1/2} = 2,120798$ in (53,87 mm)

From FIG. 2-7.1, where K = A/B = 16,9685/12,00039 = 1,413996

T = 1,748134 Z = 3,001234 Y = 5,771012 U = 6,341757

$h/h_0 = 0,25247$ $g_1/g_0 = 2,42857$

F = 0,8798515 V = 0,3003367 $e = F/h_0 = 0,4148681$

$d = (U/V)*h_0*g_0^2 = (6,341757/0,3003367)*2,120798*0,3748032^2$
= 6,290817

Stresses at operating conditions - VIII-1, Appendix 2-7

f = 3,449075

$L = (t*e + 1)/T + t^3/d$
$= (0,3937008*0,4148681 + 1)/1,748134 + 0,3937008^3/6,290817$
= 0,6751722

$S_H = f*M_o/(L*g_1^2*B)$
$= 3,449075*5.191,28/(0,6751722*0,9102362^2*12,00039)$
= 2.667,22 psi (187,5239 kg/cm^2)

$S_R = (1,33*t*e + 1)*M_o/(L*t^2*B)$
$= (1,33*0,3937008*0,4148681 + 1)*5.191,28/(0,6751722*0,3937008^2*12,00039)$
= 5.031,60 psi (353,756 kg/cm^2)

$S_T = Y*M_o/(t^2*B) - Z*S_R$
$= 5,771012*5.191,28/(0,3937008^2*12,00039) - 3,001234*5.031,598$
= 1.005,39 psi (70,68616 kg/cm^2)

Allowable stress S_{fo} = 20.000,00 psi (1.406,138 kg/cm^2)

S_T does not exceed S_{fo}
S_H does not exceed $1,5*S_{fo}$ = 30.000,00 psi (2.109,207 kg/cm^2)
S_R does not exceed S_{fo}
$0,5(S_H + S_R)$ = 3.849,409 psi (270,64 kg/cm^2) does not exceed S_{fo}
$0,5(S_H + S_T)$ = 1.836,307 psi (129,105 kg/cm^2) does not exceed S_{fo}

Stresses at gasket seating - VIII-1, Appendix 2-7

$S_H = f*M_g/(L*g_1^2*B)$
$= 3,449075*6.629,938/(0,6751722*0,9102362^2*12,00039)$
= 3.406,39 psi (239,4924 kg/cm^2)

$S_R = (1,33*t*e + 1)*M_g/(L*t^2*B)$
$= (1,33*0,3937008*0,4148681 + 1)*6.629,938/(0,6751722*0,3937008^2*12,00039)$
= 6.426,00 psi (451,7924 kg/cm^2)

$S_T = Y*M_g/(t^2*B) - Z*S_R$
$= 5,771012*6.629,938/(0,3937008^2*12,00039) - 3,001234*6.426,004$
= 1.284,02 psi (90,27548 kg/cm^2)

Allowable stress S_{fa} = 20.000,00 psi (1.406,138 kg/cm^2)

S_T does not exceed S_{fa}
S_H does not exceed $1,5*S_{fa}$ = 30.000,00 psi (2.109,207 kg/cm^2)

S_R does not exceed S_{fa}
$0,5(S_H + S_R)$ = 4.916,195 psi (345,6424 kg/cm^2) does not exceed S_{fa}
$0,5(S_H + S_T)$ = 2.345,203 psi (164,884 kg/cm^2) does not exceed S_{fa}

Legs #1

Leg material:		SA-36
Leg description:		2x2x3/8 Equal Angle (Leg in)
Number of legs:	N =	3
Overall length:		30,0394 in (763,00 mm)
Base to girth seam length:		23,6220 in (600,00 mm)
Bolt circle:		10,7244 in (272,40 mm)
Anchor bolt size:		0,375 inch series 8 threaded
Anchor bolt material:		SA-193 B7
Anchor bolts/leg:		1
Anchor bolt allowable stress:	S_b =	20.000,000 psi (1.406,14 kg/cm^2)
Anchor bolt corrosion allowance:		0,0000 in (0,00 mm)
Anchor bolt hole clearance:		0,0000 in (0,00 mm)
Base plate width:		3,9370 in (100,00 mm)
Base plate length:		3,9370 in (100,00 mm)
Base plate thickness:		0,3750 in (9,53 mm) (0,0527 in required)
Base plate allowable stress:		24.000,000 psi (1.687,37 kg/cm^2)
Foundation allowable bearing stress:		750,000 psi (52,73 kg/cm^2)
Effective length coefficient:	K =	1,2
Coefficient:	C_m =	0,85
Leg yield stress:	F_y =	36.000,000 psi (2.531,05 kg/cm^2)
Leg elastic modulus:	E =	29.000.000,000 psi (2.038.900,00 kg/cm^2)
Leg to shell fillet weld:		0,0831 in (2,11 mm) (0,0014 in required)

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

Loading	Force attack angle °	Leg position °	Axial end load kg_f	Shear resisted kg_f	Axial f_a kg/cm^2	Bending f_{bx} kg/cm^2	Bending f_{by} kg/cm^2	Ratio H_{1-1}	Ratio H_{1-2}
Governing Condition		0	44,3	0,0	5,047	8,837	0,000	0,0091	0,0086
Weight operating corroded	**0**	120	59,2	0,0	6,744	11,808	0,000	0,0121	0,0115
Moment = 1,8 kg-m		240	59,2	0,0	6,744	11,808	0,000	0,0121	0,0115

Note: Formulae are taken from the AISC manual ninth edition.

$P_1 = W/N + 48*M_t/(N*D)$
$= 342,1151/ 3 + 48*13,0781/(3*12,75)$
$= 130,4501$ lb (59,17117 kg_f)

Allowable axial compressive stress, F_a (AISC chapter E)

Local buckling check (AISC 5-99)

$b/t = (2/0,375) < (76 / Sqr(36))$ so $Q_s = 1$

Flexural-torsional buckling (AISC 5-317)

Shear center distance $w_o = 0,6342745$
$r_o^2 = w_o^2 + (I_z + I_w)/A$
$= 0,6342745^2 + (0,2058227 + 0,7521589)/1,36$
$= 1,106702$

Torsional constant J = 0,06375
Shear modulus G = 11.165,00 $kips/in^2$

$F_{ej} = G*J / (A*r_o^2)$
$= 11.165,00*0,06375 / (1,36*1,106702)$
$= 472,8998$

$K*l/r_w = 1,2*24,62205/0,7436787 = 39,73014$

$F_{ew} = \pi^2*E/(Kl/r_w)^2$
$= \pi^2*29.000,00/(39,73014)^2$
$= 181,325$

$H = 1 - (w_o^2 / r_o^2)$
$= 1 - (0,6342745^2 / 1,106702)$
$= 0,6364839$

$F_e = ((F_{ew} + F_{ej})/(2*H))*(1 - Sqr(1 - (4*F_{ew}*F_{ej}*H)/(F_{ew} + F_{ej})^2))$
$= ((181,325 + 472,8998)/(2*0,6364839))*(1 - Sqr(1 - (4*181,325*472,8998*0,6364839)/(181,325 + 472,8998)^2))$
$= 154,2025$

Equivalent slenderness ratio

$Kl/r = \pi*Sqr(E/F_e)$
$= \pi*Sqr(29.000,00/154,2025)$
$= 43,08272$

$C_c = Sqr(2*\pi^2*E/(F_y*Q_s))$
$= Sqr(2*\pi^2*29.000.000/(36.000,00*1))$
$= 126,0993$

K*l/r= 1,2*24,62205/0,3890247 = 75,95008

$F_a = 1 * (1 - (Kl/r)^2/(2*C_c^2))*F_y / (5/3 + 3*(Kl/r)/(8*C_c)-(Kl/r)^3/(8*C_c^3))$
$= 1 * (1 - (75,95008)^2/(2*126,0993^2))*36.000,00 / (5/3 + 3*(75,95008)/(8*126,0993)-(75,95008)^3/(8*126,0993^3))$
= 15.799,83 psi (1.110,837 kg/cm^2)

Allowable axial compression and bending (AISC chapter H)

Note: r is divided by 1,35 - See AISC 6.1.4, pg. 5-314

$F'_{ex} = 1*12*\pi^2*E/(23*(Kl/r)^2)$
$= 1*12*\pi^2*29.000.000/(23*(102,5326)^2)$
= 14.204,54 psi (998,677 kg/cm^2)

$F'_{ey} = 1*12*\pi^2*E/(23*(Kl/r)^2)$
$= 1*12*\pi^2*29.000.000/(23*(53,63568)^2)$
= 51.909,11 psi (3.649,568 kg/cm^2)

$F_b = 1*0,66*F_y$
= 23.760,00 psi (1.670,492 kg/cm^2)

Compressive axial stress

$f_a = P_1/A$
= 130,4501/1,36
= 95,91919 psi (6,744 kg/cm^2)

Bending stresses

$f_{bx} = F*Cos(\alpha)*L/(I_x/C_x) + P_1*E_{cc}/(I_x/C_x)$
$= 0*Cos(120)*24,62205/(0,2058227/0,5147605) + 130,4501*0,5148/(0,2058227/0,5147605)$
= 167,9558 psi (11,808 kg/cm^2)

$f_{by} = F*Sin(\alpha)*L/(I_y/C_y)$
$= 0*Sin(120)*24,62205/(0,7521589/1,4142)$
= 0 psi (0,000 kg/cm^2)

AISC equation H_{1-1}

$H_{1-1} = f_a/F_a + C_{mx}*f_{bx}/((1 - f_a/F'_{ex})*F_{bx}) + C_{my}*f_{by}/((1 - f_a/F'_{ey})*F_{by})$
$= 95,91919/15.799,83 + 0,85*167,9558/((1 - 95,91919/14.204,54)*23.760,00) + 0,85*0/((1 - 95,91919/51.909,11)$
$*23.760,00)$
= 1,212027E-02

AISC equation H_{1-2}

$H_{1-2} = f_a/(0,6*1*F_y) + f_{bx}/F_{bx} + f_{by}/F_{by}$
$= 95,91919/(0,6*1*36.000,00) + 167,9558/23.760,00 + 0/23.760,00$
= 1,150955E-02

3, 2x2x3/8 Equal Angle legs are adequate.

Anchor bolts - Weight operating corroded condition governs

Tensile loading per leg (1 bolt per leg)

R = 48*M/(N*BC) - W/N
= 48*13,0781/(3*10,72441) - 342,1151/3
= -94,52685 lb$_f$ (-42,87666 kg$_f$)
There is no net uplift (R is negative).

0,375 inch series 8 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.

The following leg attachment weld analysis assumes the fillet weld is present on three sides (leg top closure plate is used).

$Z_w = (2*b*d + d^2)/3$
$= (2*2,8284*5,417322 + 5,417322^2)/3$
$= 19,99736$

$J_w = (b + 2*d)^3/12 - d^2*(b + d)^2/(b + 2*d)$
$= (2,8284 + 2*5,417322)^3/12 - 5,417322^2*(2,8284 + 5,417322)^2/(2,8284 + 2*5,417322)$
$= 66,50754$

$E = d^2/(b + 2*d)$
$= 5,417322^2/(2,8284 + 2*5,417322)$
$= 2,147938$

Governing weld load $f_x = Cos(120)*0 = 0\ lb_f$
Governing weld load $f_y = Sin(120)*0 = 0\ lb_f$

$f_1 = P_1/L_{weld}$
$= 130,4501/13,66304$
$= 9,547661\ lb_f/in$ (1,705017 Kg_f/cm) (V_L direct shear)

$f_2 = f_y*L_{leg}*0,5*b/J_w$
$= 0*24,62205*0,5*2,8284/66,50754$
$= 0\ lb_f/in$ (0 Kg_f/cm) (V_L torsion shear)

$f_3 = f_y/L_{weld}$
$= 0/13,66304$
$= 0\ lb_f/in$ (0 Kg_f/cm) (V_c direct shear)

$f_4 = f_y*L_{leg}*E/J_w$
$= 0*24,62205*2,147938/66,50754$
$= 0\ lb_f/in$ (0 Kg_f/cm) (V_c torsion shear)

$f_5 = f_x*L_{leg}/Z_w$
$= 0*24,62205/19,99736$
$= 0\ lb_f/in$ (0 Kg_f/cm) (M_L bending)

$f_6 = f_x/L_{weld}$
$= 0/13,66304$
$= 0\ lb_f/in$ (0 Kg_f/cm) (Direct outward radial shear)

$f = Sqr((f_1 + f_2)^2 + (f_3 + f_4)^2 + (f_5 + f_6)^2)$
$= Sqr((9,547661 + 0)^2 + (0 + 0)^2 + (0 + 0)^2)$
$= 9,547661\ lb_f/in$ (1,705017 Kg_f/cm) (Resultant shear load)

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

$t_w = f / (0,707*0,55*S_a)$
$= 9,547661 / (0,707*0,55*17.000,00)$
$= 0,0014$ in (0,0367 mm)

The 2,11 mm leg to vessel attachment fillet weld size is adequate.

Base plate thickness check, AISC 3-106

$f_p = P/(B*N)$
$= 133,5499/(3,937008*3,937008)$
$= 8,616105$ psi (0,606 kg/cm^2)

Required base plate thickness is the largest of the following: (0,0527 in)

$t_b = Sqr(0,5*P/S_b)$

= Sqr(0,5*133,5499/24.000,00)
= 0,0527 in (1,3398 mm)

t_b = 0,5*(N - d)*Sqr(3*f_p/S_b)
= 0,5*(3,937008 - 2)*Sqr(3*8,616105/24.000,00)
= 0,0318 in (0,8073 mm)

The base plate thickness is adequate.

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

Applied Loads

Radial load:	P_r =	0,00 kg_f
Circumferential moment:	M_c =	0,00 kg-m
Circumferential shear:	V_c =	0,00 kg_f
Longitudinal moment:	M_L =	0,77 kg-m
Longitudinal shear:	V_L =	59,17 kg_f
Torsion moment:	M_t =	0,00 kg-m
Internal pressure:	P =	2,00 kg/cm^2
Mean shell radius:	R_m =	157,17 mm
Local shell thickness:	t =	9,52 mm
Shell yield stress:	S_y =	1.815,04 kg/cm^2

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

R_m/t =16,5089

C_1 = 35,92, C_2 = 68,80 mm

Local circumferential pressure stress = $P*R_i/t$ = 455 psi (31,98964 kg/cm^2)

Local longitudinal pressure stress = $P*R_i/2t$ = 228 psi (16,02997 kg/cm^2)

Maximum combined stress (P_L+P_b+Q) = 35,65 kg/cm^2
Allowable combined stress (P_L+P_b+Q) = +-3*S = +-3.585,65 kg/cm^2

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

Maximum local primary membrane stress (P_L) = 33,33 kg/cm^2
Allowable local primary membrane (P_L) = +-1,5*S = +-1.792,83 kg/cm^2

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

Stresses at the leg edge per WRC Bulletin 107										
Figure	**value**	b	**A_u**	**A_l**	**B_u**	**B_l**	**C_u**	**C_l**	**D_u**	**D_l**
3C*	1,1683	0,4131	0	0	0	0	0	0	0	0
4C*	2,1688	0,3566	0	0	0	0	0	0	0	0
1C	0,0653	0,2921	0	0	0	0	0	0	0	0
2C-1	0,0367	0,2921	0	0	0	0	0	0	0	0
3A*	0,7154	0,2838	0	0	0	0	0	0	0	0
1A	0,0803	0,3100	0	0	0	0	0	0	0	0
3B*	1,6339	0,3525	-1,336	-1,336	1,336	1,336	0	0	0	0
1B-1	0,0240	0,3331	-2,320	2,320	2,320	-2,320	0	0	0	0
Pressure stress*			31,990	31,990	31,990	31,990	31,990	31,990	31,990	31,990
Total circumferential stress			28,334	32,974	35,646	31,005	31,990	31,990	31,990	31,990
Primary membrane circumferential stress*			30,654	30,654	33,325	33,325	31,990	31,990	31,990	31,990
3C*	1,3775	0,3566	0	0	0	0	0	0	0	0
4C*	1,9549	0,4131	0	0	0	0	0	0	0	0
1C-1	0,0485	0,3667	0	0	0	0	0	0	0	0
2C	0,0300	0,3667	0	0	0	0	0	0	0	0
4A*	1,3548	0,2838	0	0	0	0	0	0	0	0
2A	0,0355	0,3830	0	0	0	0	0	0	0	0
4B*	0,7016	0,3525	-0,844	-0,844	0,844	0,844	0	0	0	0
2B-1	0,0339	0,3933	-2,812	2,812	2,812	-2,812	0	0	0	0
Pressure stress*			16,030	16,030	16,030	16,030	16,030	16,030	16,030	16,030
Total longitudinal stress			12,374	17,999	19,686	14,061	16,030	16,030	16,030	16,030
Primary membrane longitudinal stress*			15,186	15,186	16,874	16,874	16,030	16,030	16,030	16,030
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	-2,250	-2,250	2,250	2,250
Total Shear stress			0	0	0	0	-2,250	-2,250	2,250	2,250
Combined stress (P_L+P_b+Q)			28,334	32,974	35,646	31,005	32,271	32,271	32,271	32,271

Note: * denotes primary stress.

U.C. (N5)

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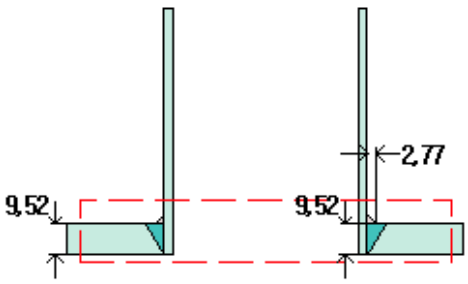
$t_{w(lower)}$ = 9,52 mm
Leg_{41} = 2,77 mm



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

Located on:	Cylinder #1
Liquid static head included:	0 psi (0,00 kg/cm^2)
Nozzle material specification:	SA-312 TP304 Wld pipe (ASME II-D p. 86, ln. 29)
Nozzle description:	2" Sch 10S DN 50
Flange description:	2 inch 150# WN A182 F304
Bolt Material:	SA-193 B7 Bolt <= 2 1/2
Flange rated MDMT: (Per UHA-51(d)(1)(a))	-320,00 °F (-195,56°C)
Liquid static head on flange:	0 psi (0,00 kg/cm^2)
ASME B16.5 flange rating MAWP:	240,80 psi @ 176,00°F (16,93 kg/cm^2 @ 80,00°C)
ASME B16.5 flange rating MAP:	275,00 psi @ 70,00°F (19,33 kg/cm^2 @ 21,11°C)
ASME B16.5 flange hydro test:	425,00 psi @ 70,00°F (29,88 kg/cm^2 @ 21,11°C)
Nozzle orientation:	180 °
Local vessel minimum thickness:	0,3280 in (8,33 mm)
Nozzle center line offset to datum line:	35,4331 in (900,00 mm)
End of nozzle to shell center:	12,2047 in (310,00 mm)
Nozzle inside diameter, new:	2,1570 in (54,79 mm)
Nozzle nominal wall thickness:	0,1090 in (2,77 mm)
Nozzle corrosion allowance:	0,0000 in (0,00 mm)
Projection available outside vessel, Lpr:	5,8297 in (148,08 mm)

Reinforcement Calculations for Internal Pressure

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

UG-37 Area Calculation Summary (cm^2) **For P = 16,93 kg/cm^2 @ 80,00 °C**							**UG-45 Nozzle Wall Thickness Summary (mm)** **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)							2,28	2,77

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 (mm)**	**Actual weld throat size (mm)**	**Status**
Nozzle to shell fillet (Leg_{41})	1,94	1,94	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 (cm^2) For P = 19,33 kg/cm^2 @ 21,11 °C							UG-45 Nozzle Wall Thickness Summary (mm) 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)							2,60	2,77

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 (mm)**	**Actual weld throat size (mm)**	**Status**
Nozzle to shell fillet (Leg_{41})	1,94	1,94	weld size is adequate

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

Transition #1

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Component: Transition
Material specification: SA-240 304 (ASME II-D p. 86, ln. 16)
Not a UCS-66 material.
Impact test exempt per UHA-51(g)(coincident ratio = 0,07068)

Internal design pressure: P = 2,0000 kg/cm^2 @ 80,00°C

Static liquid head:

P_{th}=0,0158 kg/cm^2(SG=1,0000, H_s=158,58 mm, Horizontal test head at small end)
P_{th}=0,0310 kg/cm^2(SG=1,0000, H_s=309,83 mm, Horizontal test head at large end)

Corrosion allowance: Inner C = 0,00 mm Outer C = 0,00 mm

Design MDMT = 0,00°C

No impact test performed
Material is not normalized
Material is not produced to Fine Grain Practice
PWHT is not performed

Radiography: Category A joints - None UW-11(c) Type 1
Circ. joint top/left - None UW-11(c) Type 1
Circ. joint right/bottom - None UW-11(c) Type 1

Estimated weight: New = 4,5 kg corr = 4,5 kg
Capacity: New = 4,0 liters corr = 4,0 liters

Axial length = 154,00 mm
Large End OD = 323,8500 mm
Small End OD = 21,3400 mm
Cone t_c = 5,00 mm

Design thickness, (at 80,00°C) App 1-4(e) (Large End)

t = $P*D_o / (2*Cos(\alpha)*(S*E + 0,40*P)) + C$
= 2,0000*323,8500 / (2*Cos(44,484783)*(1406,1400*0,70 + 0.4*2,0000)) + 0,0000
= 0,46 mm

Small End design thickness (t = 0,03 mm) does not govern.

MAWP, (Corroded at 80,00°C) App 1-4(e) (Large End)

P = $2*S*E*t*Cos(\alpha) / (D_o - 0,80*t*Cos(\alpha)) - P_s$
= 2*1406,1400*0,70*5,0000*Cos(44,484783) / (323,8500 - 0,80*5,0000*Cos(44,484783)) - 0,0000
= 21,8767 kg/cm^2

Small End MAWP (379,8683 kg/cm^2) does not govern.

MAP, (New at 21,11°C) App 1-4(e) (Large End)

P = $2*S*E*t*Cos(\alpha) / (D_o - 0,80*t*Cos(\alpha)) - P_s$
= 2*1406,1400*0,70*5,0000*Cos(44,484783) / (323,8500 - 0,80*5,0000*Cos(44,484783)) - 0,0000
= 21,8767 kg/cm^2

Small End MAP (379,8683 kg/cm^2) does not govern.

% Extreme fiber elongation - UHA-44

= (50 * t / Rf) * (1 - Rf / Ro)
= (50 * 7,0083 / 7,1658) * (1 - 7,1658 / ∞)
= 48,9010

Transition design thickness = 0,46 mm

The governing condition is due to internal pressure.

The transition thickness of 5,00 mm is adequate.

Thickness Required Due to Pressure + External Loads

Condition	Pressure P (kg/cm²)	Allowable Stress Before UG-23 Stress Increase (kg/cm²)		Temperature (°C)	Corrosion C (mm)	Location	Load	Req'd Thk Due to Tension (mm)	Req'd Thk Due to Compression (mm)
		S_t	S_c						
Operating, Hot & Corroded	2,00	1406,14	795,88	80,00	0,0000	top	Weight	0,2212	0,2212
						Bottom	Weight	0,0057	0,0057
Operating, Hot & New	2,00	1406,14	795,88	80,00	0,0000	top	Weight	0,2212	0,2212
						Bottom	Weight	0,0057	0,0057
Hot Shut Down, Corroded	0,00	1406,14	795,88	80,00	0,0000	top	Weight	0,0007	0,0007
						Bottom	Weight	0,0005	0,0005
Hot Shut Down, New	0,00	1406,14	795,88	80,00	0,0000	top	Weight	0,0007	0,0007
						Bottom	Weight	0,0005	0,0005
Empty, Corroded	0,00	1406,14	863,49	21,11	0,0000	top	Weight	0,0007	0,0007
						Bottom	Weight	0,0005	0,0005
Empty, New	0,00	1406,14	863,49	21,11	0,0000	top	Weight	0,0007	0,0007
						Bottom	Weight	0,0005	0,0005
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0,00	1406,14	795,88	80,00	0,0000	top	Weight	0,0007	0,0007
						Bottom	Weight	0,0005	0,0005

Appendix 1-5(g), U-2(g) analysis of large end juncture, stress in the cylinder Internal pressure = 21,88 kg/cm^2									
Loading	**s_L (windward, MPa)**		**s_L (leeward, MPa)**		**Allowable s_L (MPa)**		**s_{tm} (MPa)**		
	outer	**inner**	**outer**	**inner**	**compressive**	**tensile**	**windward**	**leeward**	**allowable**
Weight Corroded	-341,441	702,701	-341,441	702,701	3.585,652	3.585,652	-394,190	-394,190	1.792,826

Appendix 1-5(g), U-2(g) analysis of large end juncture, stress in the cone Internal pressure = 21,88 kg/cm^2									
Loading	**s_L (windward, MPa)**		**s_L (leeward, MPa)**		**Allowable s_L (MPa)**		**s_{tm} (MPa)**		
	outer	**inner**	**outer**	**inner**	**compressive**	**tensile**	**windward**	**leeward**	**allowable**
Weight Corroded	-1.410,625	2.374,763	-1.410,625	2.374,763	4.218,414	4.218,414	208,523	208,523	2.109,207

Appendix 1-5(g), U-2(g) analysis of small end juncture, stress in the cylinder Internal pressure = 21,88 kg/cm^2									
Loading	**s_L (windward, MPa)**		**s_L (leeward, MPa)**		**Allowable s_L (MPa)**		**s_{tm} (MPa)**		
	inner	**outer**	**inner**	**outer**	**compressive**	**tensile**	**windward**	**leeward**	**allowable**
Weight Corroded	-44,325	144,255	-44,325	144,255	2.995,074	2.995,074	133,045	133,045	1.497,537

Appendix 1-5(g), U-2(g) analysis of small end juncture, stress in the cone Internal pressure = 21,88 kg/cm^2									
Loading	**s_L (windward, MPa)**		**s_L (leeward, MPa)**		**Allowable s_L (MPa)**		**s_{tm} (MPa)**		
	inner	**outer**	**inner**	**outer**	**compressive**	**tensile**	**windward**	**leeward**	**allowable**
Weight Corroded	12,763	46,345	12,763	46,345	4.218,414	4.218,414	92,321	92,321	2.109,207

Appendix 1-5(g), U-2(g) analysis of large end juncture, stress in the cylinder Internal pressure = 21,88 kg/cm^2 (MAP)									
Loading	**s_L (windward, MPa)**		**s_L (leeward, MPa)**		**Allowable s_L (MPa)**		**s_{tm} (MPa)**		
	outer	**inner**	**outer**	**inner**	**compressive**	**tensile**	**windward**	**leeward**	**allowable**
Pressure	-341,348	702,508	0,000	0,000	3.585,652	3.585,652	-393,983	0,000	1.792,826

Appendix 1-5(g), U-2(g) analysis of large end juncture, stress in the cone Internal pressure = 21,88 kg/cm^2 (MAP)									
Loading	**s_L (windward, MPa)**		**s_L (leeward, MPa)**		**Allowable s_L (MPa)**		**s_{tm} (MPa)**		
	outer	**inner**	**outer**	**inner**	**compressive**	**tensile**	**windward**	**leeward**	**allowable**
Pressure	-1.410,237	2.374,111	0,000	0,000	4.218,414	4.218,414	208,730	0,000	2.109,207

Appendix 1-5(g), U-2(g) analysis of small end juncture, stress in the cylinder Internal pressure = 21,88 kg/cm^2 (MAP)									
Loading	**s_L (windward, MPa)**		**s_L (leeward, MPa)**		**Allowable s_L (MPa)**		**s_{tm} (MPa)**		
	inner	**outer**	**inner**	**outer**	**compressive**	**tensile**	**windward**	**leeward**	**allowable**
Pressure	-44,218	143,907	0,000	0,000	2.995,074	2.995,074	132,964	0,000	1.497,537

Appendix 1-5(g), U-2(g) analysis of small end juncture, stress in the cone Internal pressure = 21,88 kg/cm^2 (MAP)									
Loading	**s_L (windward, MPa)**		**s_L (leeward, MPa)**		**Allowable s_L (MPa)**		**s_{tm} (MPa)**		
	inner	**outer**	**inner**	**outer**	**compressive**	**tensile**	**windward**	**leeward**	**allowable**
Pressure	12,732	46,233	0,000	0,000	0,000	4.218,414	92,241	0,000	2.109,207

Cylinder #2

ASME Section VIII Division 1, 2001 Edition, A03 Addenda

Component:	Cylinder
Material specification:	SA-312 TP304L Wld pipe (ASME II-D p. 82, ln. 12)
Pipe NPS and Schedule:	0,500" Sch 10S DN 15
Impact test exempt per UHA-51(d)	

Internal design pressure: P = 2 kg/cm^2 @ 80°C

Static liquid head:

P_{th}=0,0163 kg/cm^2(SG=1,0000, H_s=163,48 mm, Horizontal test head)

Corrosion allowance: Inner C = 0,00 mm Outer C = 0,00 mm

Design MDMT = 0,00°C
Rated MDMT = -195,56°C

No impact test performed
Material is not normalized
Material is not produced to Fine Grain Practice
PWHT is not performed

Radiography:	Longitudinal joint -	Seamless No RT
	Top circumferential joint -	None UW-11(c) Type 1
	Bottom circumferential joint -	None UW-11(c) Type 1

Estimated weight: New = 0,1535 kg corr = 0,1535 kg
Capacity: New = 0,0345 liters corr = 0,0345 liters

OD = 21,34 mm
Length L_c = 150,00 mm
t = 2,11 mm

Design thickness, (at 80,00°C) Appendix 1-1

t = $P*R_o/(S*E + 0,40*P)$ + Corrosion
= 2,0000*10,67/(998,3594*0,85 + 0,40*2,0000) + 0,00
= 0,0254 mm

Maximum allowable working pressure, (at 80,00°C) Appendix 1-1

P = $S*E*t/(R_o - 0,40*t) - P_s$
= 998,3594*0,85*1,8462 / (10,67 - 0,40*1,8462) - 0,0000
= 157,7544 kg/cm^2

Maximum allowable pressure, (at 21,11°C) Appendix 1-1

P = $S*E*t/(R_o - 0,40*t)$
= 998,3594*0,85*1,8462 / (10,67 - 0,40*1,8462)
= 157,7544 kg/cm^2

Design thickness = 0,03 mm

The governing condition is due to internal pressure.

The cylinder thickness of 2,11 mm is adequate.

Thickness Required Due to Pressure + External Loads

Condition	Pressure P (kg/cm²)	Allowable Stress Before UG-23 Stress Increase (kg/cm²)		Temperature (°C)	Corrosion C (mm)	Load	Req'd Thk Due to Tension (mm)	Req'd Thk Due to Compression (mm)
		S_t	S_c					
Operating, Hot & Corroded	2,00	1174,54	892,47	80,00	0,0000	Weight	0,0107	0,0107
Operating, Hot & New	2,00	1174,54	892,47	80,00	0,0000	Weight	0,0107	0,0107
Hot Shut Down, Corroded	0,00	1174,54	892,47	80,00	0,0000	Weight	0,0003	0,0003
Hot Shut Down, New	0,00	1174,54	892,47	80,00	0,0000	Weight	0,0003	0,0003
Empty, Corroded	0,00	1174,54	991,51	-17,78	0,0000	Weight	0,0003	0,0003
Empty, New	0,00	1174,54	991,51	-17,78	0,0000	Weight	0,0003	0,0003
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0,00	1174,54	892,47	80,00	0,0000	Weight	0,0003	0,0003